Fitness Equipment Design Based on Web User Text Mining

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***Abstract*—To propose home fitness equipment that meets modern users' needs, this study employs web user text mining, combined with the Fuzzy Analytic Hierarchy Process (FAHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), to design and evaluate home fitness equipment that aligns with contemporary demands. First, we used crawler data to collect user reviews of home fitness equipment from a well-known Chinese shopping platform. The data were cleaned and processed to extract key user needs and preferences. Next, the FAHP method was used to prioritize these requirements, and TOPSIS was applied for the comprehensive evaluation of design proposals. This process allowed us to identify the solution that best meets user needs, completing the development of the product design. The results indicate that the second design, with its features targeting lumbar health, efficient space utilization, rich interactive experience, integration of smart technology, and minimalist appearance, has significant market potential and social value. Finally, the SUS (System Usability Scale) was used to validate the design, showing excellent user satisfaction and usability for the second scheme. This study establishes a design process incorporating web scraping, FAHP, and TOPSIS, demonstrating the effectiveness of this theoretical integration in the field of home fitness equipment design.**

Keywords—Home fitness equipment; crawler data; FAHP; TOPSIS; product design

I. Introduction

In contemporary society, especially after the COVID-19 pandemic, health has become a significant topic of concern for the public [1] [2] [3]. Fitness equipment can enhance users' physical health, such as fitness levels, muscle strength, and weight loss, as well as their mental well-being. In China, fitness venues are generally located in outdoor parks or gyms. Outdoor parks are open fitness venues that have the advantage of being accessible to people of all ages. However, their disadvantages include high usage rates and difficulty of use in extreme temperatures. Gyms, on the other hand, offer more specialized equipment but require users to pay for access. Home fitness equipment combines the advantages of both outdoor parks and gyms while addressing their shortcomings. The types of equipment used in homes are similar to those found in gyms, such as treadmills, stair mills, rowing machines, and spin bikes, which support a variety of aerobic exercise [4]. In contemporary society, especially after the COVID-19 pandemic, Consumers bought equipment for home use and switched to different types of online or outdoor workouts [5]. In the current market context, China's home fitness equipment industry has significant growth potential. However, despite the promising market outlook, the industry still struggles to fully meet users' fitness expectations [6],family fitness equipment has a lot of research space in the Chinese market.A study on the design of a fitness furniture and its finite element analysis.To address this issue, our research team has decided to start by focusing on users' needs [7] [8].In the design of indoor fitness equipment, it is crucial to focus on and analyze users' needs，user characteristic analysis emerges as a pivotal step within the realms of product design and enhancement [7].

Data is very important for businesses and organizations as it assists their decision making [9].In the design of indoor fitness equipment, it is crucial to focus on and analyze users' needs. Using web crawlers to gather information about users' needs for indoor fitness equipment is an effective approach. A web crawler is a program or script that automatically captures web information based on specific rules, enabling automatic data collection. Web crawlers are widely used in various fields, such as crawling and indexing sites for search engines, collecting data for analysis and mining, and gathering financial data for financial analysis. Ramachandran et al. [10] used generalized logistic regression to analyze Amazon datasets, confirming the presence of negative bias in online consumer reviews. They found that negative emotions in review texts influence product ratings more significantly than positive emotions of the same intensity. This suggests that in all management decisions, interventions to reduce negative performance disconfirmation should be prioritized over those causing positive performance disconfirmation. Cao et al. [11] used web crawlers to collect a large number of product reviews, conducted word frequency analysis to identify key product elements, and categorized reviews based on the results. They extracted adjectives from the reviews and, after expert summarization, performed sentiment analysis on sentences containing adjectives to obtain information on user needs. This information can guide the generation of subsequent design plans through the application of kansei engineering principles.

After extracting the information, we can identify different user needs by analyzing user comments and summarizing keywords, thereby determining the characteristics of user requirements. Data cleaning can reveal key information from user evaluations, which can be transformed into decision criteria for the Analytic Hierarchy Process (AHP). AHP is a systematic method for multi-criteria, multi-option decision-making, involving decomposition, comparative judgment, and synthesis for decision-making (weighting) and overall ranking. The Fuzzy Analytic Hierarchy Process (FAHP) improves and extends traditional AHP by incorporating fuzzy mathematics theory, making judgments more accurate and applicable to a broader range of scenarios. Using data obtained from web crawlers, we can introduce FAHP theory to handle the fuzziness and uncertainty in data when solving complex problems. For example, Wang et al. [12] used FAHP to identify key factors in the design of bone marrow puncture needles after conducting surveys and expert interviews. The final design effectively improved patient experience during surgery. Mouhassine et al. [13] proposed integrating Fuzzy-AHP with VIKOR in SDN controllers, successfully applying it to optimize the wireless network handover process. FAHP effectively addresses fuzziness and uncertainty in evaluations, using fuzzy linguistic variables to express preferences for evaluation factors, thus enhancing the objectivity and accuracy of the assessments. Wu et al. [14] combined FAHP with a continuous fuzzy Kano model to prioritize attractiveness factors for electric scooters, demonstrating that this approach reliably meets consumer perception needs.

Based on FAHP hierarchical ranking, the optimal design scheme must be determined. The TOPSIS method can fully utilize the information from raw data, with the analysis results accurately reflecting the gaps between evaluation schemes. Zulkefli et al. [15] developed a more robust and effective CSP selection model by combining TOPSIS, entropy-based weight determination, and Single Valued Neutrosophic (SVN) handling of uncertainty, highlighting its contributions to solving RRP and decision-making ambiguity. Liu et al. [16] proposed the Z-AHP and Z-TOPSIS theories to optimize the design of kitchen waste containers. Z-TOPSIS considers the fuzziness of evaluation criteria and the confidence of decision-makers, making the assessment results more reasonable and reliable. Hameed et al. [17] integrated FMEA, QFD, TRIZ, LCA, and fuzzy TOPSIS to develop sustainable products. They used fuzzy TOPSIS to reassess designs, and the final design was selected for prototyping.

Currently, many scholars have used web crawlers, FAHP, and TOPSIS methods in their research. However, these methods have not yet been applied to the design of indoor fitness equipment, highlighting the scientific and innovative nature of this study. The remainder of this paper is structured as follows: Section II describes the design experiments based on the proposed methods. Section III presents the results and discussion of the indoor fitness equipment design, determining the feasibility of the final scheme. Section IV summarizes the experimental process of this study.

II. METHOD

A. Crawler Data Collection

To delve deeper into Chinese users' opinions and feedback on indoor fitness equipment, this study selected a purchasing platform with a large number of active users in China as the data source. Special attention was given to user reviews of indoor fitness equipment purchases, as these reviews are crucial for reflecting overall evaluations and expectations of fitness equipment. They provide insights into user satisfaction, user experience, and suggestions for improvement.

To ensure the accuracy and effectiveness of the study, data collection focused on key areas such as review content, descriptions related to fitness equipment, and the number of reviewers. This foundation supports subsequent research. The overall experimental process is shown in Fig. 1.

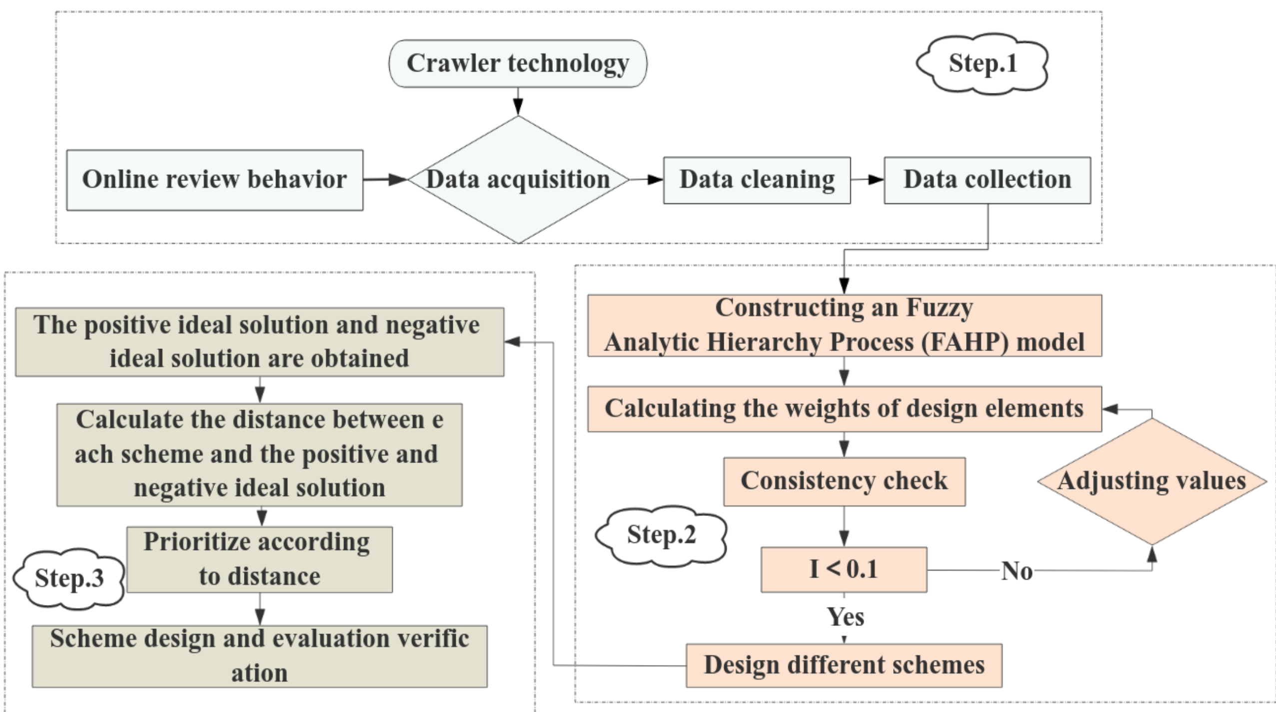

Fig. 1. Experimental design flowchart.

B. Procedure Design

The main processes include data collection (via web scraping), data cleaning, and data visualization analysis, detailed as follows:

1) *Data collection:* Using Python web scraping technology, information about indoor fitness equipment is collected from a well-known Chinese shopping platform.

2) *Data cleaning:* Filtering the collected data to organize the relevant comment content.

3) *Data collection:* Analyzing the cleaned data and employing charts to visualize user evaluation data from multiple perspectives, thereby enhancing the understanding and presentation of the data. After organizing the collected data, the following results were obtained: Very (3682), It's good (2645), Installation (2182), Quality (2085), Convenience (1701), Exercise (1572), Simple (1114), Logistics (995), Packaging (997)……Kids (100), Accessories (100), Weight (100).

By extracting keywords with a frequency exceeding 100, a total of 352 keywords were identified, which were then visualized as shown in Fig. 2. These keywords need to be introduced into the FAHP for evaluation, and the data must be filtered to exclude unnecessary influencing factors. Based on the results, a refined set of evaluation criteria can ultimately be determined.

C. Design Transformation based on FAHP

The Analytic Hierarchy Process (AHP) is a commonly used multi-criteria decision-making (MCDM) technique initially proposed by Saaty [18]. Combining the fuzzy matrix with the Analytic Hierarchy Process allows for addressing the fuzziness and uncertainty among various factors when dealing with complex problems. This method of combining AHP with fuzzy mathematical theory is called the Fuzzy Analytic Hierarchy Process (FAHP), which aims to address the human subjective effect of ambiguity on the decision factors of a problem [19]. Firstly, the user reviews obtained through web scraping need to be summarized and analyzed. The team invited five fitness equipment development engineers to an online meeting to filter the data. Then, a fuzzy analytic hierarchy process matrix is constructed. The matrix is divided into the goal layer (A) Home Fitness Equipment Program, the criteria layer (B) Appearance, the scheme layer (C) Functional Requirement, the scheme layer (D) Economy, and the scheme layer (E) Quality of Experience. The sub-criteria layer includes (B1) Fine Workmanship, (B2) Simplicity, (B3) Household Size, (C1) Multipurpose Uses, (C2) Adjustable, (C3) Intelligent Manipulation, (D1) Quality-price ratio, (D2) Fructification, (D3) Wear-well, (D4) Environmental protection, (E1) Safety, (E2) Simple operation, (E3) Relax the body, (E4) Relax the body, (E5) Ergonomics Compliance as shown in Fig. 3.

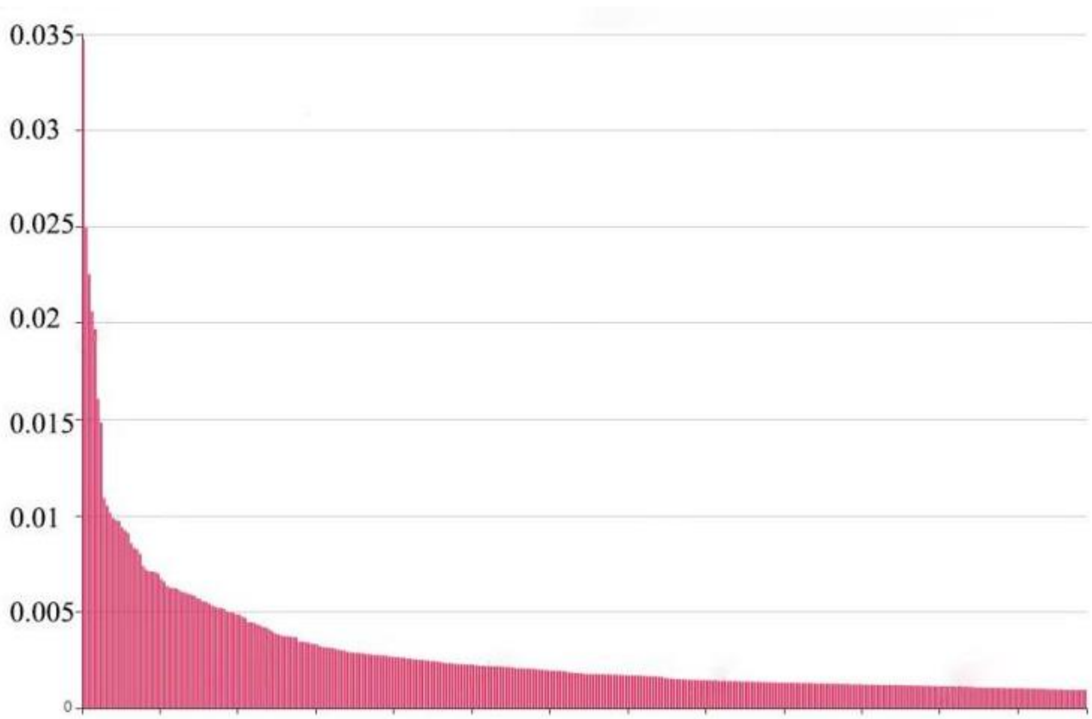

Fig. 2. Data cleaning visualization chart.

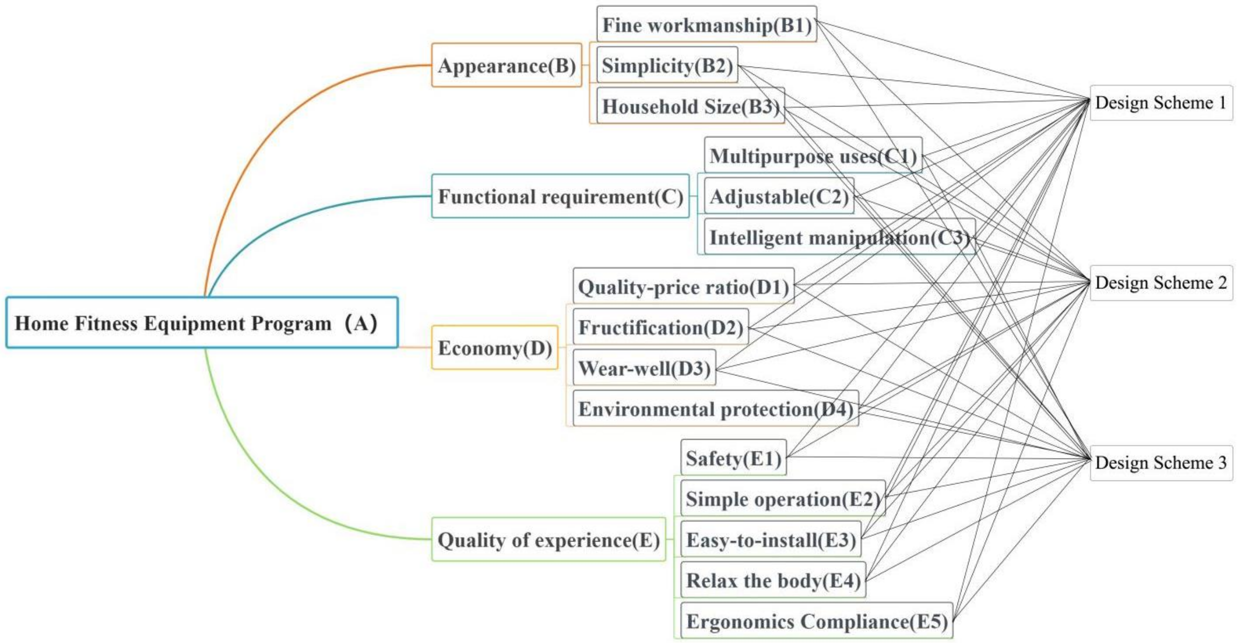

Fig. 3. Fuzzy analytic hierarchy process model of user demand.

D. Constructing Fuzzy Judgment Matrix

Referring to the scaling method of 0.1 to 0.9 levels, a fuzzy judgment matrix is constructed [20] [21], as shown in Table I. Pairwise comparison judgments of different elements of home fitness equipment are made to construct the judgment matrix, as shown in Eq. (1), and its properties are given in Eq. (2) and (3).

TABLE I. INDEX IMPORTANCE SCALE OF FUZZY JUDGMENT MATRIX

Scale	Level of importance	Implication
0.5	Equally important	Indicator a and indicator b are equally important
0.6	Slightly important	Indicator a is marginally more important than indicator b
0.7	Significantly important	Indicator a is significantly more important than indicator b
0.8	Very important	Indicator a is very important compared to indicator b
0.9	Absolutely important	Indicator a is more important than indicator b
0.1,0.2,0.3,0.4	Anti-comparison	Factor b inverse comparison, q_{ab} = 1-q_{ab}

$$A=(a_{ij})n\times n=\begin{bmatrix} a_{11} & a_{12} & \cdots\cdots & a_{1n} \\ a_{21} & a_{22} & \cdots\cdots & a_{2n} \\ \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\ a_{n1} & a_{n2} & \cdots\cdots & a_{nn} \end{bmatrix} \tag{1}$$

$$a_{ij}+a_{ji}=1 \tag{2}$$

$$a_{ii}=0.5 \tag{3}$$

To achieve more objective weight results for each indicator characteristic, the experiment invited seven experts to hold a discussion meeting (including two fitness coaches, three graduate students in design studies, and two fitness equipment merchants) [22] [23]. An expert discussion meeting was organized in the laboratory, and the experts scored the different factors based on the discussion results. The judgment matrices for each level are shown in Tables II to VI. The weights of each fuzzy judgment matrix were calculated according to Eq. (4).

TABLE II. A-LEVEL FUZZY JUDGMENT MATRIX

A	B	C	D	E
B	0.5	0.3	0.4	0.3
C	0.7	0.5	0.6	0.4
D	0.6	0.4	0.5	0.3
E	0.7	0.6	0.7	0.5

TABLE III. B-LEVEL FUZZY JUDGMENT MATRIX

B	B1	B2	B3
B1	0.5	0.5	0.2
B2	0.5	0.5	0.3
B3	0.8	0.7	0.5

TABLE IV. C-LEVEL FUZZY JUDGMENT MATRIX

C	C1	C2	C3
C1	0.5	0.7	0.5
C2	0.3	0.5	0.3
C3	0.5	0.7	0.5

TABLE V. D-LEVEL FUZZY JUDGMENT MATRIX

D	D1	D2	D3	D4
D1	0.5	0.6	0.7	0.8
D2	0.4	0.5	0.5	0.6
D3	0.3	0.5	0.5	0.6
D4	0.2	0.4	0.4	0.5

TABLE VI. E-LEVEL FUZZY JUDGMENT MATRIX

E	E1	E2	E3	E4	E5
E1	0.5	0.5	0.7	0.7	0.5
E2	0.5	0.5	0.3	0.6	0.4
E3	0.3	0.7	0.5	0.6	0.3
E4	0.3	0.4	0.4	0.5	0.3
E5	0.5	0.6	0.7	0.7	0.5

The calculated weight vectors of the fuzzy judgment matrices are as follows: 0.208, 0.267, 0.233, 0.292.

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$$w_i = \frac{\sum_{j=1}^{n} a_{ij} + \frac{n}{2} - 1}{n(n-1)}, i = 1,2,\ldots\ldots n \quad (4)$$

Where $\sum_{j=1}^{n} a_{ij}$ is the sum of the elements in the i-throw.

E. Consistency Check of the Fuzzy Judgment Matrix

To ensure the rigor of the calculation results, a consistency check of the fuzzy judgment matrix is required, as shown in Eq. (5).

$$W_i^* = \frac{Wi}{W_i + W_j}, (i, j = 1,2,\ldots\ldots n) \quad (5)$$

Using the weight vectors, construct the characteristic matrix $W=(W_{ij})n \times n$ of the fuzzy judgment matrix. Then, the compatibility index of the fuzzy judgment matrix with its eigenvalue matrix is calculated using Eq. (7). If the compatibility index (I)$\leqslant$0.1, the fuzzy judgment matrix is considered reasonable.

$$I(A,W^*) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|a_{ij} + w_{ij} - 1\right|}{n^2}, (i, j = 1,2,\ldots\ldots n) \quad (6)$$

The calculated characteristic matrix is as follows:

$$W_A^* = \begin{bmatrix} 0.500 & 0.439 & 0.472 & 0.417 \\ 0.561 & 0.500 & 0.533 & 0.478 \\ 0.528 & 0.467 & 0.500 & 0.444 \\ 0.583 & 0.522 & 0.556 & 0.500 \end{bmatrix}$$

$$W_B^* = \begin{bmatrix} 0.500 & 0.486 & 0.404 \\ 0.514 & 0.500 & 0.419 \\ 0.595 & 0.581 & 0.500 \end{bmatrix}$$

$$W_C^* = \begin{bmatrix} 0.500 & 0.579 & 0.500 \\ 0.421 & 0.500 & 0.421 \\ 0.500 & 0.579 & 0.500 \end{bmatrix}$$

$$W_D^* = \begin{bmatrix} 0.500 & 0.545 & 0.554 & 0.590 \\ 0.454 & 0.500 & 0.508 & 0.545 \\ 0.446 & 0.492 & 0.500 & 0.537 \\ 0.410 & 0.455 & 0.463 & 0.500 \end{bmatrix}$$

$$W_E^* = \begin{bmatrix} 0.500 & 0.537 & 0.530 & 0.564 & 0.494 \\ 0.463 & 0.500 & 0.494 & 0.528 & 0.458 \\ 0.470 & 0.506 & 0.500 & 0.534 & 0.464 \\ 0.436 & 0.472 & 0.466 & 0.500 & 0.430 \\ 0.506 & 0.542 & 0.536 & 0.570 & 0.500 \end{bmatrix}$$

The calculated compatibility indices:

$I(A,W_A*)=0.07696<0.1$,

$I(B,W_B*)=0.07503<0.1$,$I(C,WC*)=0.0538<0.1$,

$I(D,W_D*)=0.06706<0.1$,

$I(E,W_E*)=0.08256<0.1$.

All these fuzzy judgment matrices have compatibility indices less than 0.1, thus passing the consistency check and confirming that the data is reliable and valid.

F. Calculating FAHP Comprehensive Index Weights

Based on the hierarchical results of the weight vectors from the fuzzy judgment matrices, the comprehensive weights of each indicator factor in FAHP are obtained and summarized in Table VII. In the design of indoor fitness equipment, E (Quality of experience) > C (Functional requirement) > D (Economy) > B (Appearance). The design should prioritize the user's experience, as it is the key factor in stimulating purchase intentions. Next is the product's functionality, ensuring the equipment can precisely meet users' exercise needs, providing an efficient and safe fitness experience. Economy follows user experience and functionality, aiming to meet users' low-price demands while ensuring experience and functionality. Although appearance is an aspect that attracts users' attention, it is not the primary focus in the overall design priority.

TABLE VII. FUZZY COMPREHENSIVE WEIGHT RANKING

		Element layer	Weight	Comprehensive weight	Rank
Home Fitness Equipment Program	Appearance (0.208)	B1	0.283	0.0588	9
		B2	0.300	0.0624	8
		B3	0.417	0.0867	3
	Functional requirement (0.267)	C1	0.367	0.0980	1
		C2	0.267	0.0712	4
		C3	0.367	0.0979	2
	Economy (0.233)	D1	0.300	0.0699	5
		D2	0.250	0.0583	10
		D3	0.242	0.0564	12
		D4	0.208	0.0485	15
	Quality of experience (0.292)	E1	0.220	0.0642	6
		E2	0.190	0.0555	13
		E3	0.195	0.0569	11
		E4	0.170	0.0496	14
		E5	0.225	0.0657	7

The comprehensive ranking results are: C1 ＞ C3 ＞ B3 ＞ C2 ＞ D1 ＞ E1 ＞ E5 ＞ B2 ＞ B1 ＞ D2 ＞ E3 ＞ D3 ＞ E2 ＞ E4 ＞ D4. Modular or convertible structures should be considered to support various exercise modes. Advanced intelligent systems should be integrated for control, supporting remote control via mobile apps, personalized training plans, real-time exercise data monitoring, and analysis. Since Chinese home spaces cannot support large equipment, the design needs to be compact and easy to store. The equipment's adjustability should accommodate different family members' height, weight, exercise levels, and goals. In terms of materials, product quality and performance must be ensured while optimizing material selection, production processes, and supply chain management for higher cost-effectiveness. High-strength, wear-resistant materials should be used for key components to ensure equipment stability and durability. Additionally, ergonomic principles should be considered in the design to ensure users maintain correct posture and movement trajectories during exercise. See Fig. 4 to 6 for the design diagram.

Fig. 4. Scheme 1: Multifunctional cardio cycle.

Fig. 5. Scheme 2: Compact multifunctional elliptical trainer.

Fig. 6. Scheme 3: Multifunctional rowing machine.

In the FAHP analysis, user experience holds a weight of 0.292, ranking first, indicating that users typically prioritize the experiential aspect of a product. The functional requirements, with a weight of 0.267, suggest that fitness equipment must meet users' daily needs while also accommodating their specific requirements. Economic considerations rank third, with a weight of 0.233, recommending the use of cost-effective materials in home fitness equipment to minimize the financial burden on consumers. Although aesthetic design ranks lowest, with a weight of 0.208, it should still be considered during the design process to ensure that the product is visually appealing while meeting its primary functional requirements.

G. Comprehensive TOPSIS Design Evaluation

Three design schemes were included in a questionnaire, with the design points of each scheme introduced. The 15 sub-criterion elements in FAHP are treated as whole indicators, thus defining 15 evaluation indicators using these design elements [24]. To ensure the final evaluation results' authenticity and rigor, 10 evaluators were invited to form a decision-making group to score each scheme's indicators using a Likert 7-point scale (1 for very poor, 2 for poor, 3 for slightly poor, 4 for neutral, 5 for good, 6 for very good, and 7 for excellent). The final results were statistically averaged and are shown in Table VIII.

TABLE VIII. INITIAL EVALUATION MATRIX8

	B1	B2	B3	C1	C2	C3	D1	D2	D3	D4	E1	E2	E3	E4	E5
1	0.0311	0.0308	0.0412	0.0575	0.0422	0.0532	0.0403	0.0355	0.0349	0.0260	0.0345	0.0290	0.0262	0.0284	0.0390
2	0.0358	0.0422	0.0596	0.0566	0.0438	0.0644	0.0390	0.0332	0.0327	0.0308	0.0412	0.0354	0.0399	0.0310	0.0375
2	0.0347	0.0341	0.0476	0.0556	0.0341	0.0511	0.0417	0.0321	0.0299	0.0270	0.0351	0.0314	0.0310	0.0268	0.0368

The data of the three collected design schemes were weighted and standardized according to Eq. (7) and (8). The weighted standardized evaluation matrix is shown in Table IX [25].

$$Y_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^{2}}}, (i = 1,2\ldots\ldots m,\ j = 1,2,\ldots\ldots n) \tag{7}$$

$$Z_{ij} = W_j Y_{ij}, (i = 1,2\ldots\ldots m,\ j = 1,2,\ldots\ldots n) \tag{8}$$

TABLE IX. WEIGHTED STANDARDIZED EVALUATION

	B1	B2	B3	C1	C2	C3	D1	D2	D3	D4	E1	E2	E3	E4	E5
1	5.3	4.6	4.5	6.1	5.5	5.2	6.1	6.2	6.3	5.5	5.1	5.1	4.4	5.2	6.1
2	6.1	6.3	6.5	6.0	5.4	6.3	5.9	5.8	5.9	6.5	6.1	6.2	6.7	5.6	5.8
3	5.9	5.1	5.2	5.9	4.2	5.0	6.3	5.6	5.4	5.7	5.2	5.5	5.2	4.9	5.7

Calculate the positive and negative ideal solutions of the evaluation objects. The positive ideal solution is calculated according to Eq. (9), and the negative ideal solution is calculated according to Eq. (10).

$$Z^{+} = (Z_1^{+}, Z_2^{+}, \ldots\ldots Z_n^{+}) \tag{9}$$

$$Z^{-} = (Z_1^{-}, Z_2^{-}, \ldots\ldots Z_n^{-}) \tag{10}$$

The positive ideal solution Z^+ = (0.0358, 0.0422, 0.0596, 0.0575, 0.0438, 0.0644, 0.0417, 0.0355, 0.0349, 0.0308, 0.0412, 0.0354, 0.0399, 0.0310, 0.0390) and the negative ideal solution Z^- = (0.0311, 0.0308, 0.0412, 0.0556, 0.0341, 0.0511, 0.0390, 0.0321, 0.0299, 0.0260, 0.0345, 0.0290, 0.0262, 0.0268, 0.0368) for the evaluation objects are calculated.

The optimal solution's distance to the positive and negative ideal solutions Z^+ and Z^- (i.e., D^+ and D^-) is calculated according to Eq. (11), (12), and (13), as shown in Table X.

$$D_i^{+} = \sqrt{\sum_{j=1}^{n} (Z^{+} - Z_{ij})^2} \tag{11}$$

$$D_i^{-} = \sqrt{\sum_{j=1}^{n} (Z^{-} - Z_{ij})^2} \tag{12}$$

$$C_i = \frac{D_i^{+}}{D_i^{+} + D_i^{-}}, (i = 1,2,\ldots\ldots,\ m) \tag{13}$$

TABLE X. COMPARISON OF EUCLIDEAN DISTANCE AND RELATIVE CLOSENESS

Index	Positive ideal solution distance Di +	Negative ideal solution distance Di-	Relative proximity Ci	Rank
scheme 1	0.030	0.011	0.264	3
scheme 2	0.005	0.033	0.879	1
scheme 3	0.026	0.010	0.278	2

Closeness is an important indicator for evaluating how close a design scheme is to the ideal solution. When the closeness approaches 0, it means the design scheme is closer to the negative ideal solution, indicating poor performance across multiple evaluation criteria and potential significant deficiencies or shortcomings. Conversely, when the closeness approaches 1, it means the design scheme performs excellently across multiple evaluation criteria, meeting or exceeding expected needs and expectations.

III. RESULT

This study comprehensively applied web scraping technology, the Fuzzy Analytic Hierarchy Process (Fuzzy AHP), and the TOPSIS method to accurately identify the most favored home fitness equipment among Chinese people. Through collaboration with fitness experts, the research team developed a comprehensive evaluation model that not only covers user needs, scheme rationality, and optimal scheme selection but also refines the comprehensive consideration of each sub-criterion. Based on the most popular types of fitness equipment in the market, the three home fitness devices designed were primarily focused on multifunctionality. This evaluation criterion (C1) was assigned a comprehensive weight of 0.0980 in the FAHP analysis, ranking it as the top priority and underscoring its critical importance. Additionally, the devices were required to feature intelligent control capabilities and be suitable for home use, with these criteria carrying comprehensive weights of 0.0979 and 0.0867, respectively. Most importantly, user experience was identified as the core requirement, holding a weight of 0.292 in the FAHP analysis. According to the TOPSIS analysis results, the second design achieved a C_i value of 0.879, significantly higher than the other two designs and the closest to 1. Therefore, the second design demonstrates a clear and distinct advantage. To verify the effectiveness of the experimental process, we used the SUS (System Usability Scale) to evaluate this design practice [26]. Based on the keywords extracted from the data, the research team has developed the following ten survey questions.

a) Question 1: I find this fitness equipment suitable for home use.

b) Question 2: I find this fitness equipment difficult to use at home.

c) Question 3: I find this fitness equipment easy to operate.

d) Question 4: I find that expert guidance is necessary to use this fitness equipment.

e) Question 5: I find that this fitness equipment incorporates the features I need.

f)Question 6: I find this fitness equipment to be cumbersome.

g) Question 7: I feel confident that this fitness equipment is safe to use.

h) Question 8: I have concerns about the safety of this fitness equipment.

i)Question 9: I find this fitness equipment aesthetically pleasing.

j)Question 10: I find the design of this fitness equipment does not align with my aesthetic preferences.

We distributed the SUS questionnaires to seven employed individuals and statistically analyzed the collected data, as shown in Table IX. The usability test scores were all $\geqslant$80, which, according to the SUS score curve classification range, is rated as A, as shown in Table XI. The results demonstrate that Scheme Two meets users' preferences and needs, as shown in Fig. 7.

TABLE XI. SUS TEST SCORES

Participant	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	Score
P1	5	1	5	1	4	1	5	2	4	2	90.0
P2	4	2	5	2	4	1	4	1	5	2	85.0
P3	5	2	5	1	5	1	5	1	5	1	97.5
P4	5	4	4	1	5	1	5	1	5	1	90.0
P5	5	2	4	1	4	2	4	1	4	1	85.0
P6	5	1	4	1	4	1	4	1	4	2	87.5
P7	5	2	5	1	5	2	5	1	5	1	95.0

IV. DISCUSSION

In the in-depth discussion of Scheme Two within the group, we identified several significant advantages across multiple dimensions. Firstly, addressing the prevalent concern for lumbar health in today's society, Scheme Two offers a stretching function for the back muscles when not in use, effectively relieving stiffness and discomfort caused by prolonged sitting or standing. Additionally, this scheme provides effective full-body training during workouts, particularly through pedal exercises, fully meeting users' diverse functional needs.

Regarding space utilization, considering the limited living space common in Chinese households, Scheme Two features a miniaturized design that can be flexibly placed in various corners of the home, making it easy to store without occupying much space. This greatly enhances the convenience and comfort of home life. The introduction of an intelligent control system perfectly integrates modern technology with healthy living. Users can connect via Bluetooth to track exercise data in real-time, including workout progress and energy consumption, providing scientific support for personalized training plans.

In terms of aesthetics, Scheme Two incorporates soft colors and rounded shapes, making the fitness process no longer cold but full of fun and challenges. This design stimulates users' enthusiasm for exercise and promotes the formation of a sustained workout habit. Especially for the youth, this creative design can effectively arouse their curiosity and exploratory desire, turning fitness activities into an enjoyable rather than burdensome task. Designing home fitness equipment that meets modern people's needs is a complex task. This study integrates web scraping technology with FAHP (Fuzzy Analytic Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) theories. These methods can accurately pinpoint design focuses and address the problem of translating user needs into design practice by combining qualitative and quantitative approaches to capture the true expectations and preferences of users.

Fig. 7. Scheme 2 uses partial use display.

V. CONCLUSION

This study innovatively combines web scraping, FAHP, and TOPSIS theories and successfully applies them to the field of home fitness equipment. Through FAHP analysis, we systematically prioritized design requirements. Subsequently, among the three proposed potential design schemes, we combined FAHP's weight factors with the TOPSIS model to select the design scheme that most closely meets users' actual needs. To further validate the practical effectiveness of this design scheme, we used the SUS (System Usability Scale) as an evaluation tool. The results demonstrated the high effectiveness and user satisfaction of this design scheme.

In future research, further studies will be conducted on home fitness equipment, with a focus on making new breakthroughs in analyzing user needs. Meanwhile, the current application of FAHP and TOPSIS theories in our research has limitations. Although web scraping can improve the user feedback dataset, the decision-making process is still inevitably influenced by subjective expert judgments. Therefore, future research will focus on enhancing the standardization and objectivity of the decision-making process by introducing more quantitative indicators and objective verification methods. Additionally, attention needs to be paid to engineering and technical issues to promote the design of home fitness equipment towards a more scientific and precise direction.

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