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# Research on GRA and AHP Evaluation of Chinese-Style Cultural Products Based on AIGC

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***Abstract:*** *To achieve efficiency, diversity, and cultural authenticity in cultural product design and meet users' deep-seated needs, this study leverages AIGC-assisted design, combined with Grey Relational Analysis (GRA) and Analytic Hierarchy Process (AHP) for comprehensive evaluation, to develop a process and methodology for optimizing the pattern design of Chinese-style cultural products. The approach is validated through an assessment of refrigerator magnet pattern designs. Initially, the optimized design process and methodology are defined. Subsequently, user and expert prompts for representative Chinese-style refrigerator magnet pattern samples are collected through questionnaires and expert interviews. Next, design solutions are generated using Midjourney based on these representative samples and prompts. Finally, representative design solutions from each category are selected and evaluated by designers and consumers using a combined GRA and AHP approach, revealing that historical artifact-themed designs best align with user preferences. The AIGC-assisted generation of Chinese-style refrigerator magnet pattern designs effectively meets diverse user demands and enhances designers' productivity, while the combined GRA and AHP evaluation method ensures the reliability of the optimal solution selection. This design process for Chinese-style cultural product patterns offers valuable insights for related design fields.*

***Keywords:*** *Chinese-Style Cultural Product Design; Artificial Intelligence Generated Content (AIGC); Grey Relational Analysis (GRA); Analytic Hierarchy Process (AHP)*

## 1. Introduction

In recent years, with the increasing aesthetic standards of the public for cultural products, a trend of cultural product design has emerged. Cultural products, as key elements that embody cultural meanings, play an important role in enhancing cultural awareness and highlighting cultural characteristics. Pattern is one of the core elements of cultural product design, which can effectively reflect the style characteristics and cultural connotations of cultural products. In the era of emotional consumption, emotional elements such as cultural product pattern design have become one of the key factors affecting users' purchasing decisions. Although cultural product design has significantly increased the attention to Chinese culture, in practical design applications, there are still problems such as outdated design methods, direct use of design symbols, and insufficient exploration of user needs, resulting in low design efficiency, failure to convey the deep values of Chinese culture in design schemes, and ineffective satisfaction of user needs[1].

For example, how to achieve human-machine collaboration and efficiently create pattern designs with Chinese characteristics to meet the diverse needs of users; How to effectively convey the spiritual connotation of Chinese culture through design and create products that resonate emotionally with users needs to be addressed. In this context, the rapid development of Artificial Intelligence Generated Content (AIGC) technology has provided new tools for the expression and dissemination of cultural images. It has gradually been applied in the field of cultural product design, providing more intelligent and humanized ideas and methods for the design and optimization of Chinese style cultural product patterns[2]. Through AIGC technology, designers can quickly generate design solutions that meet user preferences based on prompt words, providing technical support and inspiration, aiming to create more intelligent and personalized Chinese cultural product patterns.

Although AIGC has received positive feedback in many creative fields, its application in the design of Chinese cultural product patterns is still insufficient, mainly due to the following issues.

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1) There are various types of pattern elements in Chinese cultural products, and the current generative design lacks specific prompt word templates that match them. Most of them are random combinations of Chinese cultural patterns, presenting a style that is inconsistent and unpredictable, and cannot meet user needs well.

2) Lack of AIGC assisted design process for Chinese cultural product patterns. Although AIGC has been applied in many fields, such as furniture design [3], packaging design [4], textile design [5], pattern design [6], etc., using AIGC assisted technology to explore intelligent design methods and strategies. However, in the field of pattern design for Chinese cultural products, there is not much research on using AIGC technology to generate designs. Cultural products belong to the category of visual communication design combined with product design, characterized by comprehensiveness, complexity, and differentiation. Consumers' design needs are complex and varied, and traditional design processes are difficult to meet the diverse needs of modern users.

3) In the design evaluation stage, there is a lack of comprehensive evaluation methods to verify the AIGC generated design scheme. Traditional design evaluation methods often use single methods such as sensory engineering and semantic difference methods, which have advantages in information collection efficiency, but are susceptible to external environmental influences, resulting in insufficient satisfaction of user needs and other issues [7]. Based on AIGC, a massive number of design schemes can be generated, which is more random and flexible. The application of comprehensive evaluation methods to extract the optimal scheme is a necessary step to ensure the quality of the scheme. Therefore, in order to solve the problem of how to use AIGC technology for human-machine collaboration and meet user preferences for design output, a Chinese style cultural product pattern design method combining AIGC with grey relational analysis and analytic hierarchy process comprehensive evaluation is proposed. Taking the design of Chinese style refrigerator sticker patterns as an example, the practical application and evaluation of design methods are carried out to provide feasible guidance for the design and development of Chinese cultural product patterns [8].

## 2. Research Framework and Process

The research adopts AIGC technology to assist designers in collaborative design of Chinese cultural product patterns, mainly divided into the first stage of research preparation, which mainly includes the determination of representative samples and the construction of integrated prompt words; The second stage is the design practice phase, where design solutions are generated in batches using the Midjourney platform; The third stage is the optimal solution stage, which involves evaluating the solution and finally outputting the solution. The specific research framework is shown in Figure 1.

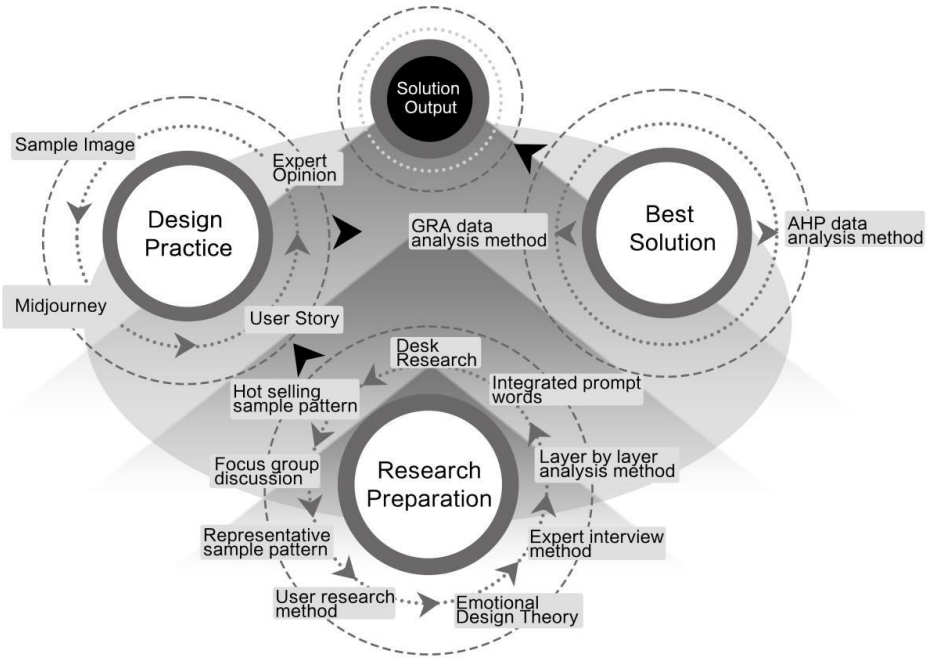


*Figure 1: Research framework*

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### *2.1 Research Sample Acquisition*

To effectively evaluate the design quality and market adaptability of Chinese-style cultural product patterns, it is essential to obtain a set of research samples with broad representativeness and high typicality. Initially, samples are extensively collected through methods such as desk research and case studies to form a comprehensive sample library. Subsequently, techniques including focus groups and sample clustering are employed to screen and categorize the samples based on predefined criteria, ultimately finalizing the selection of research samples.

### *2.2 Construction of AIGC Integrated Prompt Templates*

An integrated prompt template is a structured approach that combines multidimensional instructions—including task objectives, contextual information, constraints, and output requirements—into a unified prompt. Its core purpose is to enable AI to comprehend user demands more precisely and comprehensively, minimizing iterative communication and directly generating expected results [9]. To ensure the comprehensiveness of prompts for cultural product patterns and enhance both design quality and efficiency, this study adopts an integrated prompt method by merging user-evaluative prompts with expert-evaluative prompts. The framework for constructing these integrated prompts is illustrated in Figure 2.

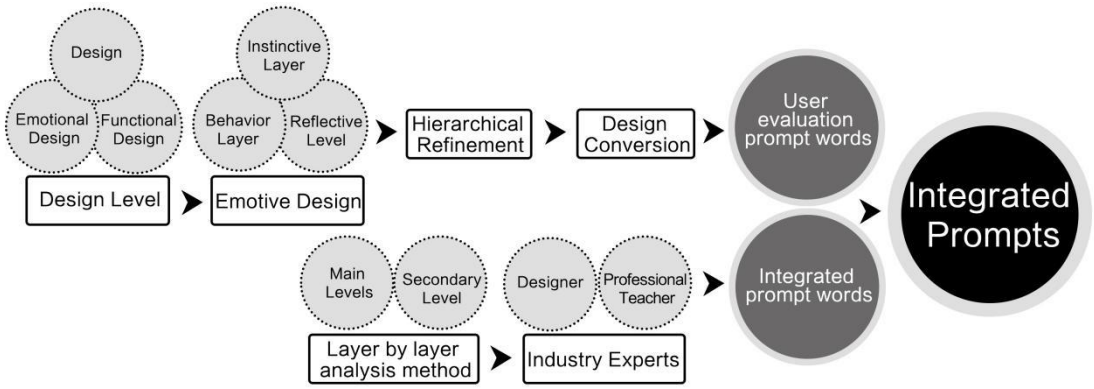


*Figure 2: Construction of integrated prompt words*

#### *2.2.1 Construction of User-Evaluative Prompt Templates*

Donald Norman proposed in "Emotional Design" that emotional design is a design method that integrates emotional elements into the design of products and endows them with emotional connotations. In this theoretical system, Norman, based on interdisciplinary theories such as cognitive psychology, divides human cognition into three levels: instinctual, behavioral, and reflective. In the three-level theory of emotionalization, the instinctive layer mainly focuses on the translation of external symbols of the product, that is, extracting representative visual factors of the product and emphasizing the user's direct feelings[10]. From the perspective of refinement of the design level, the instinctive layer is specifically manifested in appearance design. The appearance design can be further broken down into external elements such as the form, color, and material of the product, which directly affect the user's senses and stimulate their instinctive first impression; The design of the behavioral layer integrates humanistic care for users through the functionality and utility of the product, and the design level is refined into functional design. The functional design is refined into key elements such as aesthetics and pleasure of the product, covering not only the functional experience of the product, but also paying more attention to the interactive fun of the product, thereby triggering a profound feeling after the user experience; The design core of the reflective layer is to stimulate emotional resonance among users and convey deep spiritual values. This level is refined into emotional design, which takes the cultural connotation and emotional value carried by the product as important attributes. Emotional design can be further subdivided into natural connotations and Chinese cultural elements. The cultural symbols and spiritual connotations contained in it can convey emotional identification with traditional culture to users. In order to enhance user experience, the emotional hierarchy in the theory of emotionalization is applied to obtain users' emotional demands, which are then transformed into clear design elements [11]. Finally, combined with natural language processing (NLP) and machine translation technology, they are translated into professional terms recognizable by AIGC, that is, to

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obtain user evaluation prompt words.

Firstly, obtain user evaluations of Chinese cultural product patterns through user research methods; Secondly, integrating the three-level theory of emotionalization, user evaluation is divided into instinctive layer, behavioral layer, and reflective layer, establishing a relationship of "sample category user evaluation emotionalization level"; Again, in order to better clarify the emotional hierarchy as specific design features, it is necessary to further refine the design hierarchy and construct a logical framework of "sample category user evaluation emotional hierarchy design hierarchy hierarchical subdivision design features user demand prompt words", as shown in Figure 3.

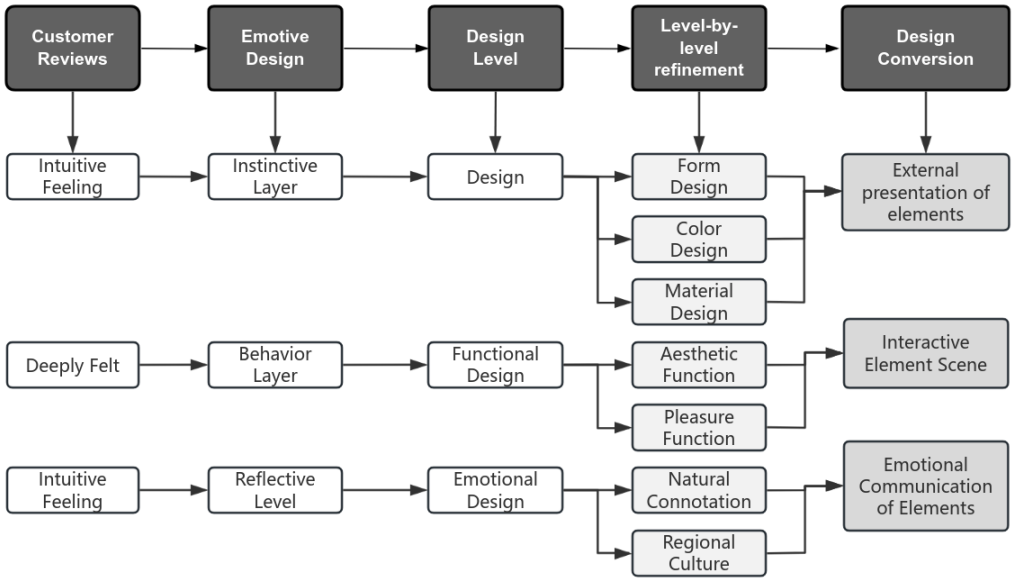


*Figure 3: Design hierarchy refinement framework diagram*

### *2.2.2 Construction of Expert-Evaluative Prompt Templates*

Cultural product design experts have rich professional knowledge and practical experience in this field, and the evaluation of cultural product designers has a certain degree of authority. Firstly, experts' evaluations of the patterns of Chinese cultural products are obtained through interview methods. Then, based on the evaluation results, the transformation of "expert evaluation design features expert evaluation prompt words" is carried out. Finally, after language translation, expert evaluation prompt words are obtained.

### *2.2.3 Construction of Integrated Prompt Templates*

Integrate user evaluation prompts and expert evaluation prompts, apply layer by layer analysis to divide the integrated prompts into primary and secondary levels, determine the key elements and features of each level, and conduct comprehensive evaluation to construct integrated prompts.

## *2.3 Generative Pattern Design Practice*

In order to verify the rationality and applicability of the conversion process of integrated prompt words in the design of Chinese cultural product patterns, it is necessary to use a creative collaborative system based on semantic understanding and focusing on image processing for design practice. At present, Midjourney (Version 7) is easy to operate and has the highest popularity, so MJ platform is chosen for design practice. Due to the limited number of existing models for cultural product patterns on the MJ platform, parameter settings are required. The method of generating images using graph generated images combined with prompt words is adopted, which involves inputting sample style images and then training to generate representative design schemes after inputting integrated prompt words. After the scheme is generated, experts are invited to screen through KJ method to determine representative design schemes for each category.

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### *2.4 Evaluation and Discussion*

The evaluation model combining GRA and AHP provides a comprehensive framework that combines scientific quantification and humanistic understanding for highly subjective aesthetic decision-making. The GRA method can objectively and data-driven analyze the advantages and disadvantages of design schemes. The AHP method can systematically construct an evaluation system and assign importance weights that meet project objectives through expert evaluation. This combination not only greatly improves the efficiency of evaluation, but also integrates the designer's experience and wisdom with the objective insight of data, making the final selected design not only carry profound cultural connotations and aesthetic intentions, but also undergo rigorous quantitative verification, especially suitable for complex design scenarios that require balancing cultural inheritance, artistic innovation, and market acceptance.

#### *2.4.1 Grey Relational Analysis (GRA)*

Grey Relational Analysis (GRA), a key branch of Grey System Theory, serves as a quantitative method for evaluating similarities between different sequences within a system by calculating their relational degrees [12]. In this study, GRA is employed to identify the optimal design solution through systematic comparison of performance indicators. The computational procedure for GRA consists of the following steps:

Step 1: Set the optimal data sequence. After initial value normalization of the raw data in the system, the processed data can be represented as a set of comparative sequences.

$$\begin{cases} \mathbf{x}_1 = \{x_1(1), x_1(2), \cdots, x_1(m)\} \\ \mathbf{x}_2 = \{x_2(1), x_2(2), \cdots, x_2(m)\} \\ \quad \vdots \\ \mathbf{x}_n = \{x_n(1), x_n(2), \cdots, x_n(m)\} \end{cases}, \quad m \geq 3;\ n \geq 3 \tag{1}$$

Subsequently, based on the principle of relative optimization, an optimal sequence can be selected from the comparative sequences to serve as the reference sequence *x*0, that is,

$$\boldsymbol{x}_0 = \{x_0(1), x_0(2), \cdots, x_0(m)\} \tag{2}$$

Where *x*0(1) to *x*0(*m*) represent the data elements of the reference sequence, with the calculation formula expressed as:

$$\begin{cases} x_0(1) = \max x_i(1) \\ x_0(2) = \max x_i(2) \\ \vdots \\ x_0(m) = \max x_i(m) \end{cases}, \quad i = 1, 2, \cdots, n \tag{3}$$

Step 2: Calculate the grey relational coefficients between comparative and reference sequences. First, compute the difference sequence for each comparative sequence relative to the reference sequence at corresponding elements, as follows:

$$\Delta_i(k) = |x_0(k) - x_i(k)|, \quad k \in \{1, 2, \cdots, m\} \tag{4}$$

Then, calculate the maximum difference and minimum difference across all comparative sequences and evaluation points.

$$\begin{aligned} \Delta_{\max} &= \max_{i \in I} \max_{k} |x_0(k) - x_i(k)| \\ \Delta_{\min} &= \min_{i \in I} \min_{k} |x_0(k) - x_i(k)| \end{aligned} \tag{5}$$

Finally, calculate the grey relational coefficient for each corresponding element between every

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comparative sequence and the reference sequence.

$$\xi_i(k) = \frac{\min_{i\in I}\min_k |x_0(k) - x_i(k)| + \rho \max_{i\in I}\max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_{i\in I}\max_k |x_0(k) - x_i(k)|} \tag{6}$$

Here, $\rho$ represents the distinguishing coefficient, with a value range of [0, 1]. A smaller $\rho$ value leads to greater differences among relational coefficients and stronger differentiation capability.

Step 3: determine the priority ranking of the comparative sequences. First, calculate the grey relational coefficient for each corresponding element between the comparative sequence $x_i$ and the reference sequence $x_0$ across all evaluation indicators. Then, obtain the grey relational degree $r_i$ for each comparative sequence $x_i$ by taking the average of these relational coefficients.

$$r_i = \frac{1}{n}\sum_{k=1}^{m} \xi_i(k), \quad i = 1, 2, \cdots, n \tag{7}$$

Finally, the comparative sequences can be ranked based on the calculated grey relational degrees.

### *2.4.2 Analytic Hierarchy Process (AHP)*

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method proposed by American operations researcher Saaty in the 1970s. By decomposing complex problems into different hierarchical levels and conducting quantitative comparisons of elements at each level, AHP enables a comprehensive evaluation to identify the optimal solution. This study integrates AHP with Grey Relational Analysis (GRA) to evaluate product forms and select the best design alternative. The operational steps of AHP are as follows:

Step 1. Construct a hierarchical structure. The hierarchy is organized from top to bottom into three levels: the overall objective, evaluation criteria, and alternative solutions.

Step 2. Develop pairwise comparison matrices. Using the relative scale reference table (Table 1), conduct pairwise comparisons of alternative solutions based on each evaluation criterion.

*Table 1: Evaluation scales and their meanings in AHP*

| Evaluation Scale | Meaning |
|---|---|
| 1 | Equal Importance |
| 3 | Slightly Important |
| 5 | Important |
| 7 | Very Important |
| 9 | Absolutely Important |
| 2, 4, 6, 8 | Intermediate Values |

Step 3. Calculate Relative Weights , Multiple methods are available for calculating relative weights, such as the geometric mean method, theoretical analysis method, and vector averaging method. This study employs the geometric mean method to compute weight values.

Step 4. Consistency Check , The Consistency Ratio (C.R.) is commonly used to assess the validity of calculation results. The C.R. value can be computed using Equation (8), and a result of C.R. < 0.1 indicates that the judgment matrix is acceptable.

$$C.R. = C.I./R.I. \tag{8}$$

Here, R.I. represents the Random Index (refer to Table 2), and C.I. denotes the Consistency Index, which can be calculated using Equation (9).

$$C.I. = \frac{\lambda_{\max} - n}{n - 1} \tag{9}$$

Here, $\lambda$max denotes the maximum eigenvalue of the pairwise comparison matrix; n represents the order (or dimension) of the matrix.

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*Table 2: Random consistency index (R.I.)*

| Order | R.I. |
|---|---|
| 3 | 0.58 |
| 4 | 0.90 |
| 5 | 1.12 |
| 6 | 1.24 |
| 7 | 1.32 |
| 8 | 1.41 |
| 9 | 1.46 |
| 10 | 1.49 |

### *2.5 Output of the Optimal Solution*

First, designers are invited to evaluate eight categories of design proposals based on predefined evaluation criteria. The Grey Relational Analysis (GRA) method is applied to screen and identify the best design scheme. Subsequently, consumers are invited to participate in the evaluation process, and the Analytic Hierarchy Process (AHP) is employed to analyze and select the optimal solution that best aligns with user needs.

## 3. Case Study: Practical Application in Chinese Cultural Product Pattern Design for Fridge Magnets

As microcarriers of cultural symbols, fridge magnets serve as lightweight media for cultural dissemination and emotional connection, enabling cost-effective and high-penetration transmission of cultural connotations. Rational selection and combination of pattern elements not only enhance the cultural symbolism of cultural products but also constitute an essential means of achieving cultural identity construction [13]. Therefore, this study takes Chinese-style fridge magnets as the practical subject, applying the aforementioned research framework and methodologies to pattern design to verify their rationality and feasibility.

### *3.1 Sample Acquisition of Fridge Magnet Patterns*

First, a total of 48 popular Chinese-style fridge magnet pattern samples were extensively collected through online platforms. To minimize visual interference from product shape, color, and material during evaluation, all pattern samples were standardized to a uniform size of 40mm × 40mm and converted to grayscale using Photoshop. Subsequently, five cultural product design experts were invited via focus group discussion to classify and screen the processed samples, resulting in eight major categories: landmark architecture, regional culture, historical artifacts, animal motifs, local cuisine, festival events, seasonal changes, and traditional culture. The most representative samples from each category were ultimately selected (see Figure 4).

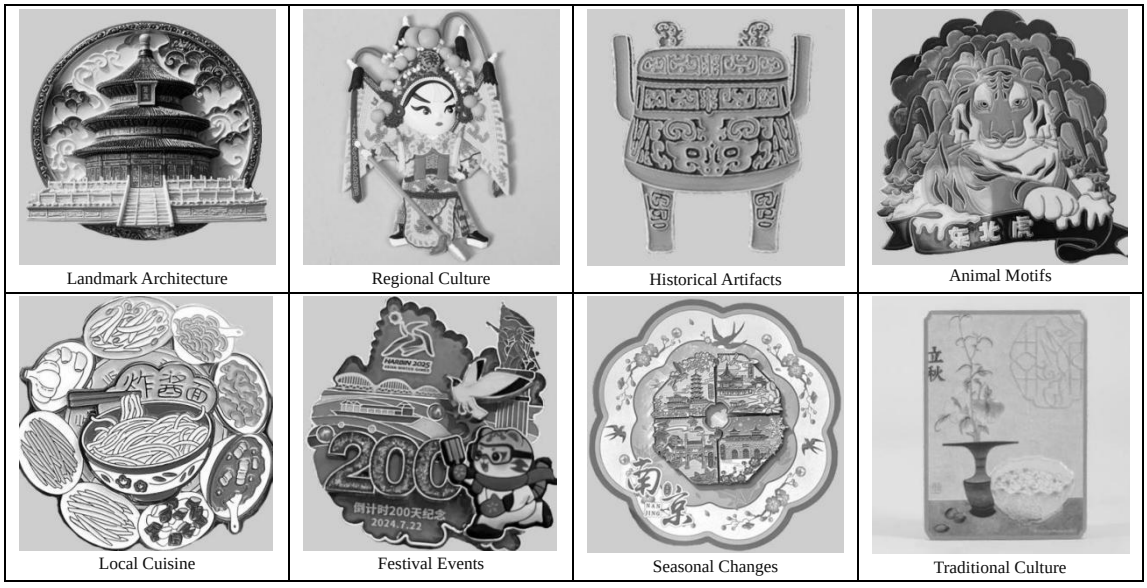


*Figure 4: Representative samples*

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### *3.2 Construction of Integrated Design Prompts*

#### *3.2.1 User Need Prompt Induction and Organization*

To facilitate systematic research, a preliminary survey framework with structured questions (Table 3) was developed. Twenty-eight users of Chinese-style cultural products (14 males and 14 females, all with prior purchase experience of Chinese-style fridge magnets) were selected as survey participants. After observing the pattern samples (Figure 5) and collecting qualitative feedback, user evaluations were systematically organized and analyzed using the Three-Level Model of Emotional Design (visceral, behavioral, and reflective levels), design hierarchy segmentation, and design translation processes (Figure 3). The results are presented in Table 4.

Visceral-Level Design (Aesthetic Form) Focuses on morphological beauty and visual harmony of patterns to enhance initial visual impressions and sensory experiences. This requires strengthening detail refinement in pattern.

Behavioral-Level Design (Functional Interaction) Emphasizes aesthetic appeal and playfulness, necessitating enhanced interactivity and layered composition to elevate user engagement during pattern observation.

Reflective-Level Design (Cultural Resonance) Prioritizes cultural symbolism and narrative depth to foster emotional connections. This aims to enable users to perceive the elegant cultural attributes embedded in Chinese-style patterns, thereby strengthening cultural identity.

Following this three-tiered framework, user evaluations were translated into design hierarchy segments, refined into actionable design features, and standardized into technical terminology. The final output comprises user-driven design prompts (Table 4-5), representing perceptual needs for fridge magnet pattern development.

*Table 3: User survey outline*

| No. | Survey Questions |
|---|---|
| 1 | Do these eight pattern categories meet your needs? |
| 2 | Do you perceive each pattern category as having distinct thematic focus and clear stylistic presentation? |
| 3 | Please elaborate on your satisfaction or dissatisfaction with the design of each pattern category. |
| 4 | Which of the eight pattern categories do you prefer? Please explain your choice. |
| 5 | What visual characteristics do you expect for each category of Chinese-style fridge magnet patterns? |
| 6 | What innovative breakthroughs do you expect in Chinese-style fridge magnet designs? |

*Table 4: User Evaluation (partial)*

| Category | User Evaluation | Emotional Level | Design Level | Hierarchical Refinement | Design Conversion |
|---|---|---|---|---|---|
| Landmark Architecture | The screen is single and lacks elements | Instinctive Layer | Design | Form Design | Depicting architectural details and adding floral and plant elements |
| Regional Culture | Insufficient atmosphere with a single subject | Instinctive Layer | Design | Form Design | Pay attention to the combination of cultural elements |
| Historical Artifacts | Overall monotonic Rough details | Instinctive Layer | Design | Form Design | Add relevant patterns and pay attention to exquisite details |
| Animal Motifs | Not vivid enough | Behavior Layer | Functional Design | Aesthetic Function | Enhance the dynamic form of animals |
| Local Cuisine | Chinese style is not prominent | Behavior Layer | Functional Design | Aesthetic Function | Chinese style elements |
| Festival Events | The screen is too full Leave appropriate blank space | Instinctive Layer | Design | Form Design | Highlight key points and rich color |
| Seasonal Changes | Overall complexity | Behavior Layer | functional Design | Pleasure Function | Highlight seasonal elements |
| Traditional Culture | Simple pattern Insufficient details | Reflective Level | Emotional Design | Extraction of regional cultural elements | Add traditional cultural elements |

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*Table 5: User evaluation prompt words (partial)*

| Category | User evaluation prompt words |
|---|---|
| Landmark Architecture | Depicting architectural details, floral and plant elements |
| Regional Culture | The combination of cultural elements |
| Historical Artifacts | Relevant patterns and pay attention to exquisite details |
| Animal Motifs | The dynamic form of animals |
| Local Cuisine | Chinese style elements |
| Festival Events | Highlight key points and rich color |
| Seasonal Changes | Highlight seasonal elements |
| Traditional Culture | Traditional cultural elements |

### *3.2.2 Summary and organization of expert evaluation prompt words*

Through expert interviews, semi-structured interviews were conducted with 5 industry experts, including 3 female and 2 male experts. After collecting professional opinions, they were sorted, analyzed, and translated to obtain statistical results of industry expert opinions, namely expert evaluation prompts (Table 6).

*Table 6: Expert evaluation (partial)*

| Expert | Category | Expert evaluation | Design Conversion | Expert evaluation prompt words |
|---|---|---|---|---|
| Expert1 | Landmark Architecture | Lack of auxiliary elements to enhance the effect | Add Chinese style elements such as peonies, flying birds, and auspicious clouds | Chinese style elements such as peonies, flying birds, and auspicious clouds |
| | Regional Culture | No background | Add Beijing Opera elements to the background | Beijing Opera elements to the background |
| | Historical Artifacts | Rough details | Add patterns and create exquisite | Patterns and create exquisite depictions |
| | Animal Motifs | The pattern is dull and stiff | Pay attention to changes in movements | Changes in movements |
| | Local Cuisine | Insufficient Chinese style | Highlight Chinese style elements | Chinese style elements |
| | Festival Events | Screen crowding | Simplify elements | Simplify elements |
| | Seasonal Changes | Overall complexity | Emphasize simplicity | Emphasize simplicity |
| | Traditional Culture | Single pattern | Add distinctive details | Distinctive details |

### *3.2.3 Construction of integrated prompt words for cultural product patterns*

In order to avoid repetition and similarity of integrated prompt words, according to the statistical results in Table 2-3, a layer by layer analysis method was used to screen and merge user evaluation prompt words and expert evaluation prompt words. Based on the frequency and frequency of prompt words, they were summarized into primary and secondary levels, with the primary levels including Chinese style, composition form, and cultural connotation; The secondary level includes visual focus, decorative elements, and background design. Finally, the two parts of the content were organized to obtain integrated prompts for cultural products, as shown in Table 7.

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*Table 7: Integrated Prompts*

| Category | Integrated Prompts |
|---|---|
| Landmark Architecture | Generate 3D stereoscopic refrigerator stickers, Chinese style, enamel material, with the Temple of Heaven as the main body, prominent main body, symmetrical composition, surrounded by peonies, flying birds and auspicious clouds, high details, exquisite depiction, simple design, rich colors, white background. |
| Regional Culture | Generate 3D stereoscopic refrigerator stickers with Chinese style and enamel material, featuring the regional culture of Beijing Opera as the main theme. The main theme is prominent, and Beijing Opera elements are added to the background of the main theme. The high details, exquisite depiction, unique design, rich colors, and white background. |
| Historical Artifacts | Generate 3D refrigerator stickers with Chinese style and enamel material, featuring the historical relics as the main body. The main body is prominent, and bronze patterns are added around the main body, with high details, exquisite depiction and a white background. |
| Animal Motifs | Generate 3D stereoscopic refrigerator stickers with Chinese style and enamel material, featuring the Northeast tiger as the main body. The main body is prominent, with a sense of dynamics, high detail, exquisite depiction and a white background. |
| Local Cuisine | Generate 3D stereoscopic refrigerator stickers with Chinese cuisine as the theme, featuring a Chinese style elements and prominent main body surrounded by graphic elements. Highly detailed, intricately depicted, colorful, and has a white background. |
| Festival Events | Generate 3D stereoscopic refrigerator stickers with the theme of China's National Day, featuring a Chinese style and prominent main body, surrounded by graphic elements to create an atmosphere. Highly detailed, simplify elements, and comes in a rich color scheme with a white background. |
| Seasonal Changes | Generate 3D stereoscopic refrigerator stickers with Chinese style and enamel material, themed around the four seasons. The design is simple, with high details, emphasize simplicity, rich colors, and a white background. |
| Traditional Culture | Generate 3D stereoscopic refrigerator stickers with bronze historical relics as the main body, Chinese style, prominent main body, adding bronze patterns around the main body, distinctive detail, exquisite depiction, rich colors, and white background. |

### *3.3 Practice of Generative Pattern Design*

Represented by landmark buildings, input landmark building sample images and integrated prompt words on the MJ platform. The generation process and design scheme are shown in Figure 5. According to this process, operate other categories in sequence to generate a large number of design solutions. Filter out 3 design proposals for each category, totaling 24 design proposals for 8 major categories, as shown in Figure 6. Experts discussed, classified, merged, and voted on the design schemes using the KJ method , resulting in a total of 8 representative pattern schemes, as shown in Figure 7.

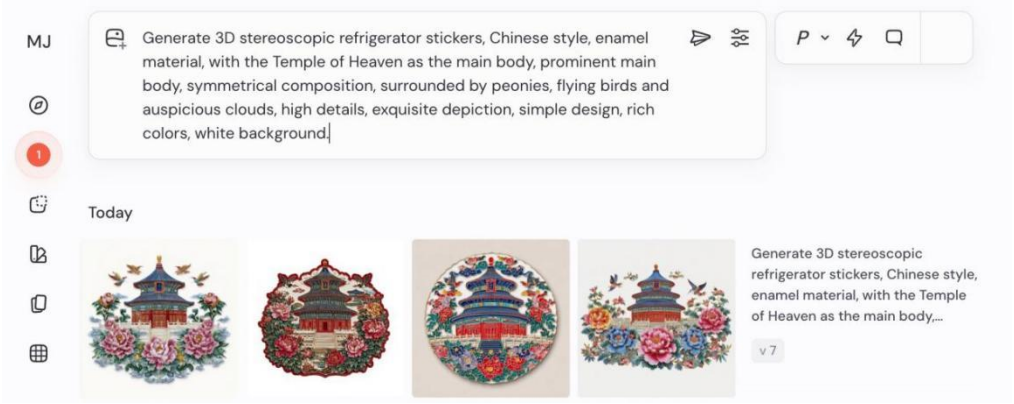


*Figure 5: The generation process of landmark building design schemes*

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| Landmark Architecture | | | Regional Culture | | |
|---|---|---|---|---|---|
|  L01 |  L02 |  L03 |  R01 |  R02 |  R03 |
| Historical Artifacts | | | Animal Motifs | | |
|  H01 |  H02 |  H03 |  A01 |  A02 |  A03 |
| Local Cuisine | | | Festival Events | | |
|  C01 |  C02 |  C03 |  F01 |  F02 |  F03 |
| Seasonal Changes | | | Traditional Culture | | |
|  S01 |  S02 |  S03 |  T01 |  T02 |  T03 |

*Figure 6: Design scheme*

| | | | |
|---|---|---|---|
|  L01 |  R02 |  H01 |  A01 |
|  C02 |  F01 |  S02 |  T03 |

*Figure 7: Design scheme after screening*

## 4. Evaluation and Discussion of Three Pattern Design Proposals

### *4.1 GRA evaluation*

To select the optimal solution, invite designers to apply GRA to evaluate 8 types of design schemes. Firstly, following the principles of scientific, comprehensive, and typical pattern evaluation, and

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combining with the culture, aesthetics, style, empathy, details, and craftsmanship of refrigerator sticker design, six evaluation indicators were set, as shown in Table 8. Then, 10 designers were invited to use evaluation metrics to rate the proposal, with a rating range of 0 to 1. The average rating results are shown in Table 9. Subsequently, the average scores of the 8 schemes were used as the comparison sequence, and the highest score under each evaluation indicator was used to form the reference sequence $x_0$. Finally, according to equations (1) to (7), the comparison and reference values were calculated to be less than 0.1, indicating that the evaluation results were acceptable.

*Table 8: The six evaluation indicators of GRA*

| **Target layer** | Evaluation of Chinese style refrigerator sticker pattern design | |
|---|---|---|
| **Indicator Level** | **Evaluation Dimension** | **Specific Content** |
| | **B1** Cultural element compatibility | Measure the appropriate and harmonious integration of cultural elements and product design goals. |
| | **B2** Comply with the rules of formal beauty | It has a sense of order and harmony in elements such as composition, color, and shape. |
| | **B3** Highlight Chinese style | Utilize unique symbols, colors, and aesthetic concepts of Chinese culture in the design. |
| | **B4** Triggering emotional associations | Design elements such as form, color, and narrative to evoke the viewer's inner emotions and memories. |
| | **B5** Exquisite depiction of details | Deeply shaping and striving for excellence in local elements in design. |
| | **B6** Technological adaptability | Consider the material characteristics and technical feasibility in production. |

*Table 9: Evaluation results of technological forms based on GRA*

| **Evaluation Metric** | **Comparison Sequence** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Reference Sequence $x_0$=1.000 | | | | | | | |
| | **L01** | **R02** | **H01** | **A01** | **C02** | **F01** | **S02** | **T03** |
| **B1** | 0.88 | 0.96 | 0.85 | 0.83 | 0.93 | 0.82 | 0.75 | 0.90 |
| **B2** | 0.80 | 0.88 | 0.95 | 0.70 | 0.83 | 0.84 | 0.87 | 0.92 |
| **B3** | 0.86 | 0.90 | 0.78 | 0.76 | 0.91 | 0.88 | 0.70 | 0.99 |
| **B4** | 0.79 | 0.87 | 0.82 | 0.86 | 0.90 | 0.94 | 0.73 | 0.84 |
| **B5** | 0.85 | 0.89 | 0.92 | 0.74 | 0.78 | 0.83 | 0.80 | 0.86 |
| **B6** | 0.83 | 0.85 | 0.98 | 0.65 | 0.72 | 0.84 | 0.88 | 0.80 |
| Grey relational grade($r_i$) | 0.768 | 0.842 | 0.865 | 0.685 | 0.761 | 0.797 | 0.725 | 0.835 |
| Rank | 5 | 2 | 1 | 8 | 6 | 4 | 7 | 3 |

### *4.2 AHP Analytic Hierarchy Process Evaluation*

To verify the effectiveness of GRA evaluation results, consumers are invited to use AHP to evaluate 8 types of schemes. The evaluation criteria are shown in Figure 8, and the evaluation scale is shown in Table 2. 30 consumers were invited to participate in the evaluation, and the evaluation results are shown in Table 10, Table 11, and Table 12. After consistency testing, the C.R. values of the data are all less than 0.1, therefore the evaluation results are acceptable.

*Table 10: Evaluation results of technological forms based on AHP*

| | **Final Weight** | **Importance Ranking** | **Reason** |
|---|---|---|---|
| **B4** | 0.245 | 1 | Consumers value whether patterns evoke emotional resonance in them the most. |
| **B3** | 0.210 | 2 | The distinct Chinese culture and characteristics are important attractions. |
| **B1** | 0.185 | 3 | The elements selected for the pattern need to be reasonable and coordinated. |
| **B2** | 0.155 | 4 | Basic aesthetics such as composition, color, and lines are necessary conditions. |
| **B5** | 0.120 | 5 | After meeting the above conditions, consumers will appreciate exquisite details. |
| **B6** | 0.085 | 6 | Although important, consumers generally believe that this is a problem for designers and producers. |

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*Table 11: Evaluation results of technological forms based on AHP*

| Theme | B1 | B2 | B3 | B4 | B5 | B6 | Composite Weight | Rank |
|---|---|---|---|---|---|---|---|---|
| | Local Weight | Local Weight | Local Weight | Local Weight | Local Weight | Local Weight | | |
| H01 | 0.152 | 0.131 | 0.183 | 0.170 | 0.144 | 0.121 | 0.160 | 1 |
| Global Weight | 0.0281 | 0.0203 | 0.0384 | 0.0417 | 0.0173 | 0.0103 | | |
| R02 | 0.165 | 0.127 | 0.162 | 0.156 | 0.136 | 0.132 | 0.154 | 2 |
| Global Weight | 0.0305 | 0.0197 | 0.0340 | 0.0382 | 0.0163 | 0.0112 | | |
| T03 | 0.143 | 0.158 | 0.183 | 0.138 | 0.128 | 0.118 | 0.149 | 3 |
| Global Weight | 0.0265 | 0.0245 | 0.0384 | 0.0338 | 0.0154 | 0.0100 | | |
| F01 | 0.118 | 0.134 | 0.141 | 0.172 | 0.125 | 0.124 | 0.142 | 4 |
| Global Weight | 0.0218 | 0.0208 | 0.0296 | 0.0421 | 0.0150 | 0.0105 | | |
| L01 | 0.136 | 0.126 | 0.151 | 0.125 | 0.137 | 0.135 | 0.135 | 5 |
| Global Weight | 0.0252 | 0.0195 | 0.0317 | 0.0306 | 0.0164 | 0.0115 | | |
| A01 | 0.116 | 0.142 | 0.105 | 0.112 | 0.152 | 0.165 | 0.126 | 6 |
| Global Weight | 0.0215 | 0.0220 | 0.0221 | 0.0274 | 0.0182 | 0.0140 | | |
| S02 | 0.095 | 0.121 | 0.089 | 0.095 | 0.116 | 0.143 | 0.104 | 7 |
| Global Weight | 0.0176 | 0.0188 | 0.0187 | 0.0233 | 0.0139 | 0.0122 | | |
| C02 | 0.075 | 0.061 | 0.086 | 0.132 | 0.062 | 0.062 | 0.091 | 8 |
| Global Weight | 0.0139 | 0.0095 | 0.0181 | 0.0323 | 0.0074 | 0.0053 | | |

*Table 12: The ranking results based on AHP*

| Subject Categories | Overall Score | Rank | Strengths Analysis |
|---|---|---|---|
| H01 | 0.895 | 1 | The emotional association and Chinese style indicators score extremely high, carrying profound historical heritage, exquisite details, and high cultural compatibility. |
| R02 | 0.880 | 2 | The cultural compatibility and Chinese style performance are outstanding, which can evoke emotional resonance among specific regional populations. |
| T03 | 0.865 | 3 | The Chinese style index scores the highest, with a strong fit between formal beauty and culture. |
| F01 | 0.840 | 4 | The emotional association index scores the highest, the atmosphere is lively, the Chinese style elements are rich, and it is easy to identify. |
| L01 | 0.815 | 5 | High recognition and distinct Chinese style, but slightly less emotional association depth. |
| A01 | 0.780 | 6 | Strong affinity, beautiful form and well crafted details, but lacking in Chinese style. |
| S02 | 0.735 | 7 | The score for formal beauty is high, but the cultural characteristics are not distinctive enough. |
| C02 | 0.710 | 8 | It can evoke emotional associations, but lacks formal beauty. |

### *4.3 Optimal Solution Output*

Based on the comprehensive analysis of GRA and AHP data analysis methods, it can be determined that the historical cultural relic scheme has the greatest attraction to designers and consumers. Therefore, the historical cultural relic scheme is output as the optimal scheme (Figure 8). The main body of the historical relics scheme is prominent and the details are exquisite. In terms of design time, the combination of input prompt words and AIGC to generate design solutions takes about 30 seconds, while the traditional design process takes at least dozens of hours, indicating that the efficiency of the design process using human-computer collaboration is faster. Placing the final design effect in different application scenarios can highlight the theme while adding beauty and depth to the product.

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*Figure 8: The optimal scheme*

## 5. Conclusion

The research proposes a Chinese style cultural product pattern design method based on AIGC assistance, aiming to optimize the design of cultural product patterns, enhance user experience, and build a collaborative design process and subjective and objective evaluation system for Chinese style cultural products with AIGC assistance.

1) Propose the concept of integrated prompt words to address the randomness issue in current AIGC technology. From user evaluations, expert interviews, and design transformations to the construction of integrated prompt words, ultimately generating stable and targeted design solutions.

2) The evaluation of the optimal solution utilizes a combination of GRA and AHP data analysis methods to assess designers and consumers, ensuring that the selection and output of the optimal solution have a certain level of reliability and accuracy.

3) The AIGC assisted design process significantly improves design efficiency and can assist designers in quickly and accurately transforming inspiration into reality.

The pattern design of Chinese cultural products based on AIGC technology can not only provide more design possibilities for Chinese cultural products, meet the diverse needs and expectations of users, but also provide reference ideas and methods for more complex product design.

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