Research Article

Innovative Design of Artificial Intelligence in Intangible Cultural Heritage

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Driven by artificial intelligence technology, the research of intangible cultural heritage innovative design is carried out. Firstly, the appearance modeling characteristics, decorative element characteristics, and composition form characteristics of typical intangible cultural heritage products are analyzed. According to the collected relevant data of intangible cultural heritage products and existing products, combined with the regional cultural characteristics of intangible cultural heritage products and other factors, the analysis Atlas of intangible cultural heritage product innovation design is constructed. Based on perceptual engineering, the elements of intangible cultural heritage product innovation design for user participation are determined according to the needs and perceptual images of users. The shape grammar is used to extract the elements of intangible cultural heritage products, deduce and deform them, and finally generate the preliminary design scheme.

1. Introduction

Intangible cultural heritage refers to various traditional cultural expressions handed down from generation to generation by people of all ethnic groups and regarded as an integral part of their cultural heritage, as well as physical objects and places related to traditional cultural expressions. Intangible cultural heritage is an important symbol of the historical and cultural achievements of a country and nation and an important part of Chinese excellent traditional culture. “Intangible cultural heritage” is opposite to “material cultural heritage,” which is collectively referred to as “cultural heritage.” To some extent, intangible culture is a nation’s unique cultural memory, and its inheritance value and application value are worthy of in-depth exploration. There are many kinds of intangible cultural heritage in China [1–6]. With the progress of domestic economic development and social development, many intangible cultural heritages began to appear in people’s vision, but there are still a large number of intangible cultural heritage facing the dilemma of no inheritance [7–10]. Intangible cultural heritage may integrate with other industries, explore its market value with the help of the people, and regard it as an unattractive cultural element in the innovative design system, so as to lay a more solid foundation of traditional culture while promoting the progress of cultural design level. It is worth noting that the national cultural spirit behind the intangible cultural heritage can also become the power source to promote the progress of cultural and creative industries [11–14]. Modern innovative design can be based on material cultural heritage and traditional cultural spirit, fully reflect the important value of innovative thinking, and create cultural products that can better meet people’s diversified needs with the help of more diversified forms of expression.

Intangible cultural heritage is different from static cultural relics displayed in museums [13, 14]. It is the inheritance and accumulation of culture and the continuation of living civilization with vitality. However, the current situation of China’s intangible cultural heritage is not optimistic, as shown below.

(1) Insufficient attention to intangible cultural heritage: at present, for many people, intangible cultural heritage is a vague concept. The first reason is the
lack of regulations and measures and rescue and protection funds; second, the inheritance and dating of some intangible cultural heritage. Due to the impact of industrialized mass production, most of the intangible cultural heritages of technology type have complex production processes. Young people's unintentional learning leads to no successors and abandoned technology, which directly leads to the loss of many materials; third, the concept of intangible cultural heritage protection is backward, the technology and means are single, and there is no connection with new technologies and methods.

(2) A large number of intangible cultural heritage are disappearing. Intangible cultural heritage is a valuable spiritual wealth. It carries the cultural memory of national generations and is a cultural symbol of national diversity. However, these memories and symbols are easy to be ignored and forgotten over time, especially some oral cultural heritage. They will be trapped in remote and underdeveloped areas, which will make them more vulnerable and underdeveloped.

From the conceptual conception in the 1960s to the practical application today, artificial intelligence [15–19] has triggered three upsurges of development and application. Different from previous academic research, business demand is the primary factor leading this upsurge. The continuous expansion of application scope not only improves its application value and influence, but also realizes the organic integration of artificial intelligence technology and industrial chain. As the combination of human knowledge, skills, and aesthetic taste, traditional handicraft intangible cultural heritage belongs to an important part of the cultural industry. Artificial intelligence also brings new technical means and development space for its dissemination. As the continuation of human cognitive ability and emotional talent, the deep learning rate of artificial intelligence in the field of cognitive understanding is much higher than that of human beings. In the field of communication, artificial intelligence has strong practicability, such as natural language technology, real-time learning technology, cross screen recognition technology, and intelligent interaction technology. The embedding of digital technology makes virtual information coexist with tangible forms, and the accessibility and experience of intangible cultural heritage resources have been enhanced. Through technological empowerment, we can integrate the traditional intangible cultural form into the contemporary cultural ecology, make it survive and develop healthily, and continue to grow new cultural forms adapted to the times.

2. User Participatory Innovative Design

Under the development trend of experience economy, users are no longer satisfied with the ownership of a single commodity [20, 21]. On the basis of meeting the basic material needs, they begin to seek the creation of their own lifestyle and pursue their own products or services. User participatory design is to integrate users into the design, in which the status and power of all participants are equal. The concept of participatory design originated from Nordic countries. Its original intention is to add the “voice” of the public to the decision-making of public affairs. At this time, the Nordic trade union movement made the new law give new rights to enterprise employees, and employees have the right to decide and speak to change their working environment. User participatory design mainly emphasizes the participation of users, which is less related to design. Later, it was developed into a design method by American enterprises.

User participatory design method is a modern design method that takes the user as the center, integrates the user into the design process, and cooperates with each other on the premise of respecting the user's background, ability, and ideas. It is also a modern design method to meet the diversified needs of users and ensure the equality of design. Compared with the traditional design method (the difference between them is shown in Table 1), user participatory design method is more flexible and open, allowing users to participate in the design process to the greatest extent and enable users to get the best interactive experience. At present, participatory design has been applied to many research fields.

With the rapid development of social and economic level, users' demand for products is not only satisfied with functionality and practicability, but also the pursuit of spiritual enjoyment. This study proposes the design concept of “user participation.” Its purpose is to open some design rights and production rights to users, so that non relic lovers, designers, and the general public can give full play to their advantages and characteristics and carry out independent innovation with the assistance of relevant personnel, truly participate in the design and production process of intangible cultural heritage innovative products, and improve users' participation and sense of experience, so as to better carry forward and inherit traditional culture.

User participation in design starts from user analysis and establishes user needs, such as interaction needs, self-realization needs, use needs, and cultural needs, by analyzing users' physiology, behavior, and psychology. Then, it analyzes user demand data, designs and develops product forms and decorative elements that meet users’ needs, and allows users to give full play to their creativity through user participation in design. Finally, complete the product design and production. The user participation design process is shown in Figure 1.

The specific steps are as follows:

(1) User analysis: it mainly analyzes the physiological, behavioral, and psychological needs of target users, which helps designers better understand users and obtain characteristic needs. Products can only be accepted by users on the premise of truly grasping the needs of users. In the whole design process, the user is the main body to help designers more accurately obtain the real needs of users, so as to find a solution satisfactory to users. User analysis is the first step of user participatory design. The commonly
used methods include interview, accompanying observation and cultural analysis.

(2) Requirements acquisition: through field research, user interview, accompanying observation and cultural analysis, we can understand the user’s life situation, behavior habits, cultural concepts, and expectations, so as to further improve the information needed for the research and prepare for relevant data analysis. We gradually insight and analyze the role of stakeholders in nonlegacy cultural and creative products and explore the service experience of users in the process of using products from multiple angles.

(3) User demand analysis: we obtain the relevant data information of users through questionnaires and other methods and finally establish the user needs according to the distribution characteristics of the data.

(4) Design element development and user participation: according to the needs of users, determine the shape,
3. Extraction and Reconstruction of Innovative Design Elements of Intangible Cultural Heritage Driven by Artificial Intelligence

3.1. Design Element Extraction. The innovative design elements of intangible cultural heritage are mainly extracted from intangible cultural heritage products, including ancient products and existing products, from which the characteristic factors such as appearance modeling, decorative elements, composition form, and color application are extracted, respectively. The feature factor extraction model of intangible cultural heritage innovative design is shown in Figure 2.

Through consulting relevant documents, visiting museums, and field investigation of intangible cultural heritage product factories, we collected a large number of cultural relics, pictures, documents, and other materials containing intangible cultural heritage innovative design factors, screened and sorted out the collected materials, mainly divided into ancient products and existing products, formed the characteristic analysis table of intangible cultural heritage products, and constructed the analysis Atlas of design elements.

3.2. Selection and Reconstruction of Design Elements. The intangible cultural heritage innovative design for user participation is mainly divided into five parts: selection of design elements, reconstruction of design elements, generation of design scheme, evaluation of design scheme, and participation in the production experience. The specific process is shown in Figure 3.

1. Identify design elements. Based on perceptual engineering, collect relevant perceptual words according to the user’s perceptual image, let the user score the sample, and determine the elements of intangible cultural heritage innovative design through the user’s perceptual semantic word evaluation results and the target user’s perceptual image words for intangible cultural heritage innovative design products.

2. Design element refactoring. The shape grammar is used to deduce and deform the design elements selected by the user, generate new design elements, and reconstruct the design elements.

3. Generate design scheme. According to the needs of users and the regenerated design elements, finally generate multiple sets of initial design schemes for users to choose and evaluate.

4. Design scheme evaluation. The fuzzy comprehensive evaluation method is used to evaluate and score the generated multiple sets of design schemes and finally select several groups of schemes with high scores for refinement.

5. Participate in the production experience. Users first choose their favorite product components through app, including the shape, decoration, style, and carcass of intangible cultural heritage innovative design products, and then participate in the post-production of products offline, under the guidance of relevant professionals, including carcass production, decoration, and polishing.

Perceptual engineering is guided by the needs of users and expresses perceptual problems qualitatively or quantitatively through mathematical analysis, so as to achieve the goal of guiding product design. We use perceptual engineering and shape grammar to guide the design of many similar modeling elements and decorative elements of intangible cultural heritage innovative products for users to choose independently. Firstly, through the comparative analysis of the characteristics of the collected intangible cultural heritage ancient products and existing products, such as appearance modeling, decorative elements, and composition forms, we can get the common design factors and select 10 typical samples from the collected samples of intangible cultural heritage products. We collect relevant perceptual words according to users’ perceptual images, classify and sort out the collected semantic words, and finally get 63 semantic words. Then, we invite 30 typical users to rate the 63 perceptual semantic words collected, select words with similar semantics according to the score, and select “sharp-mellow,” “complex-concise,” “gorgeous-plain,” “exaggerated-elegant,” “simple-exquisite,” “rough-smooth,” “gorgeous-plain,” and “dim-bright” 8 pairs of adjectives.

In order to further obtain the user’s perception preference of intangible cultural heritage innovative design products, 10 samples were selected from the design element Atlas of intangible cultural heritage innovative products, and the perception survey was carried out by using the 7-order scale method. According to the semantic vocabulary correlation, they were divided into 7 levels: 3 points, −2 points, −1 point, 0 point, 1 point, 2 points, and 3 points, where “0” means consistent, “−2” and “2” mean average, and “−3” and “3” mean very high.

Finally, the distribution of users’ perceptual semantic vocabulary evaluation results is obtained. By constructing a five-point psychological evaluation table and connecting the semantic vocabulary of each group of samples with broken lines, the semantic vocabulary description diagram of intangible cultural heritage innovation style features is obtained. According to the evaluation results and results of users’ perceptual semantic words, the perceptual image words of target users for intangible cultural heritage innovative products are smooth, exquisite, mellow, elegant, bright, simple, and elegant.
According to the extraction method of design elements of intangible cultural heritage innovative products and based on the positioning needs of intangible cultural heritage innovative products, modeling elements, decorative elements, and color elements are selected, respectively. Based on the perceived image of the target user, determine the parent elements, and then determine the appearance modeling elements and color elements, so as to provide design element support for subsequent practice.

Based on the selected design elements of intangible cultural heritage innovative products, the shape grammar [22] is used to deduce and deform them, and finally new design elements are obtained. Shape grammar (SG) can be represented by

$$SG = (S, L, R, I),$$

where “SG” is the shape set derived from “s” through translation, scaling, deformation, and mirroring, “L” represents the marker set, “R” is the reasoning rule set, and “I” is the original shape. According to the morphological deduction rules in the shape grammar theory, the seven rules of shape grammar are used to properly deform the original intangible cultural heritage innovative product design elements and then form new intangible cultural heritage innovative product design elements that meet the aesthetic needs of users by means of random arrangement and combination, replacement, addition and deletion, scaling, and staggered cutting. In the choice of color, black is generally selected as the main color, and red and yellow are the auxiliary colors.

3.3. Design Scheme Generation. Through the shape grammar deduction rules, the elements are deformed and redesigned to obtain new design elements. According to the needs of users, 6 sets of initial design schemes are finally generated. The preliminary design schemes can meet the basic needs of users. In order to further meet the diversified needs of users, this study selects the fuzzy comprehensive evaluation method [23–26] to evaluate the scheme generated by reasoning. With reference to the design elements of intangible cultural heritage innovative products, the evaluation index is set as

$$E = \{e_1, e_2, \ldots, e_n\},$$

where $n = 5$.

According to the needs and satisfaction of users, the evaluation weight of each evaluation index of intangible cultural heritage innovative product design is determined by scoring method.

$$W = \{0.3, 0.3, 0.2, 0.1, 0.1\},$$

where the highest weight given is 0.3 and the lowest is 0.1. $e_5$ is regarded as the basic demand in the evaluation index. We invite 100 users to evaluate the scheme. The evaluation and test criteria are shown in Table 2.

Finally, three schemes with high scores are selected for design optimization. Taking scheme 1 as an example, the evaluation and test results are shown in Table 3.

Then, the comprehensive evaluation model $B$ is

$$B = W \times D.$$ 

That is, $B = \{0.224, 0.139, 0.185, 0.191, 0.261\}$.

The comprehensive evaluation results of the final 100 users on the six initial design schemes are shown in Table 5. According to the evaluation results, it can be seen that 22.4% think scheme 1 is very good, 8.8% think scheme 2 is very good, 31.8% think scheme 3 is very good, 24.6% think scheme 4 is very good, 27.4% think scheme 5 is very good, and 21.8% think scheme 6 is very good. The top schemes are scheme 3, scheme 5, and scheme 4 in turn. Therefore, this

![Feature factor extraction model of intangible cultural heritage innovative design.](image)

Figure 2: The feature factor extraction model of intangible cultural heritage innovative design.
Figure 3: The intangible cultural heritage innovative design for user participation.

Table 2: The evaluation and test criteria.

<table>
<thead>
<tr>
<th>Evaluation criterion</th>
<th>Gradation</th>
<th>Evaluation weight</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e_1$</td>
<td>Extremely consistent ($G_1$)</td>
<td>0.3</td>
<td>Users can have space to give full play to their creativity.</td>
</tr>
<tr>
<td>$e_2$</td>
<td>Very consistent ($G_2$)</td>
<td>0.3</td>
<td>The product composition form can fully express the ideas of users.</td>
</tr>
<tr>
<td>$e_3$</td>
<td>Generally consistent ($G_3$)</td>
<td>0.2</td>
<td>The design style is fashionable, modern, and simple.</td>
</tr>
<tr>
<td>$e_4$</td>
<td>Basically consistent ($G_4$)</td>
<td>0.1</td>
<td>The overall design of the product is novel and unique.</td>
</tr>
<tr>
<td>$e_5$</td>
<td>Consistent ($G_5$)</td>
<td>0.1</td>
<td>The product has certain value and function.</td>
</tr>
</tbody>
</table>
study takes these three sets of schemes as the schemes for end users to participate in practice and carries out iterative optimization to get the final design scheme.

4. Conclusions

With the acceleration of market evolution, people’s material life is becoming richer and richer, and their needs are becoming more and more diversified. The demand for products is no longer just functional, but also pays more attention to the feeling of spiritual level, and has higher requirements for the aesthetic value and cultural value of products themselves. This study comprehensively uses questionnaire survey, user interview, and user perception preference analysis to analyze and study the personal needs of users and the methods and processes of user participation in design. Finally, the theory is applied to practice to complete the research on the innovative design of artificial intelligence in intangible cultural heritage.

This study uses the Atlas analysis method to analyze and summarize the characteristics of intangible cultural heritage products, constructs the analysis Atlas of intangible cultural heritage products, determines the design elements of intangible cultural heritage innovative products according to the needs of users, deforms and reconstructs the design elements of intangible cultural heritage innovative products based on the shape grammar, deduces the deformation, obtains new design elements that meet the aesthetic needs of users, and generates the initial design scheme. The fuzzy comprehensive evaluation method is used to score and evaluate the generated design scheme, and the scheme with the highest user satisfaction is selected for iterative optimization to obtain the final design scheme. Secondly, through a series of design practices, it provides users with independent creative space and platform to meet the diversified needs of users. Finally, the design of intangible cultural heritage is verified by user-oriented design.

The main innovations of this study are as follows: (1) by combining traditional handicrafts with modern design ideas, the market transformation channels of intangible cultural heritage innovative design products are increased, and a user-oriented intangible cultural heritage innovative design model is established. (2) In view of the difficulties faced by intangible cultural heritage art, explore the needs of different users for intangible cultural heritage innovative products, let users participate in the design process of intangible cultural heritage innovative products, enable users to obtain the creative dominance of products, and improve users’ consumption experience. (3) According to the needs of users, this paper puts forward the design scheme of intangible cultural heritage innovative products to meet the needs of user groups and promote the wide dissemination of intangible cultural heritage culture.

Data Availability

The dataset can be accessed upon request.

Conflicts of Interest

The author declares no conflicts of interest.

References


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**Table 3:** The evaluation and test results of scheme 1.

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>35</td>
<td>12</td>
<td>16</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>e2</td>
<td>17</td>
<td>15</td>
<td>20</td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>e3</td>
<td>23</td>
<td>12</td>
<td>6</td>
<td>20</td>
<td>39</td>
</tr>
<tr>
<td>e4</td>
<td>16</td>
<td>5</td>
<td>30</td>
<td>32</td>
<td>17</td>
</tr>
<tr>
<td>e5</td>
<td>6</td>
<td>29</td>
<td>35</td>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

**Table 4:** The fuzzy judgment matrix D.

<table>
<thead>
<tr>
<th></th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
</tr>
</thead>
<tbody>
<tr>
<td>e1</td>
<td>0.35</td>
<td>0.12</td>
<td>0.16</td>
<td>0.17</td>
<td>0.2</td>
</tr>
<tr>
<td>e2</td>
<td>0.17</td>
<td>0.15</td>
<td>0.2</td>
<td>0.21</td>
<td>0.27</td>
</tr>
<tr>
<td>e3</td>
<td>0.23</td>
<td>0.12</td>
<td>0.06</td>
<td>0.2</td>
<td>0.39</td>
</tr>
<tr>
<td>e4</td>
<td>0.16</td>
<td>0.05</td>
<td>0.3</td>
<td>0.32</td>
<td>0.17</td>
</tr>
<tr>
<td>e5</td>
<td>0.06</td>
<td>0.29</td>
<td>0.35</td>
<td>0.05</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Table 5:** The comprehensive evaluation results of the final 100 users.

<table>
<thead>
<tr>
<th>Initial design scheme</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.224</td>
<td>0.139</td>
<td>0.185</td>
<td>0.191</td>
<td>0.261</td>
</tr>
<tr>
<td>2</td>
<td>0.088</td>
<td>0.117</td>
<td>0.383</td>
<td>0.251</td>
<td>0.161</td>
</tr>
<tr>
<td>3</td>
<td>0.318</td>
<td>0.114</td>
<td>0.083</td>
<td>0.182</td>
<td>0.303</td>
</tr>
<tr>
<td>4</td>
<td>0.246</td>
<td>0.211</td>
<td>0.131</td>
<td>0.127</td>
<td>0.285</td>
</tr>
<tr>
<td>5</td>
<td>0.274</td>
<td>0.273</td>
<td>0.157</td>
<td>0.073</td>
<td>0.223</td>
</tr>
<tr>
<td>6</td>
<td>0.218</td>
<td>0.057</td>
<td>0.123</td>
<td>0.380</td>
<td>0.222</td>
</tr>
</tbody>
</table>


