Research on Innovative Design Method and Evaluation of Jewelry Based on CiteSpace&Playgound AI

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Abstract. This study aims to propose an innovative jewelry design method that combines knowledge graph with artificial intelligence to solve the problem of relying on the experience of designers in the traditional jewelry design field, resulting in unstable design quality, difficulty in inheriting experience, and inability to evaluate innovation. The specific method is to extract research hotspots in jewelry design from the knowledge graph, and construct artificial intelligence recognizable prompt words based on the rules of prompt word formation. Use prompt words in artificial intelligence tools to generate ideas, then use AHP Analytic Hierarchy Process to screen the best ideas, and finally combine the designer's ability to output design solutions. The combination of knowledge graph and artificial intelligence can affect the working methods and efficiency in the field of jewelry design, improve design quality and innovation, and solve the problem of inheriting design experience, which is of great significance for modern jewelry design.

Keywords. Citespace, Playground Ai, Jewelry design, Knowledge map

1. Introduction and summary of jewelry design research problems

Jewelry design was developed on the basis of craftsmen in the early days. Traditional design and production are based on the experience of experienced craftsmen, which is inefficient, outdated in design form and unable to pass on design experience. Even in industrialized jewelry factories, there are a large number of design innovations that rely on designers' experience and aesthetics, and then engineers evaluate the design feasibility. This form not only can't break through the traditional innovation, but also has a bad influence on the development of jewelry industry, the introduction of new technologies and new ideas. However, with the development of new technology and new ideas, people put forward new requirements for jewelry innovation, and personalization, customization and stylization have become urgent problems for the jewelry industry. Starting from these problems, this paper uses knowledge map and artificial intelligence to innovate the innovative design method of jewelry, thus solving the above problems in jewelry industry.

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1.1. A survey of generative artificial intelligence

The new era of artificial intelligence started in Turing Machine. At the end of 2022, with chatgpt and midjourey entering into a wide range of social applications, generative artificial intelligence rose again in society, which had a far-reaching impact on industrial design and jewelry design.

In 2014, Canadian Dr. Goodfellow proposed a generative model based on game theory - generative adversarial network.[1] So that artificial intelligence can automatically generate image classification, image synthesis, image translation, style conversion, image restoration and video prediction.[2] In June 2017, a research paper from Rutgers University introduced the Creative Adversarial Network (CAN), which enhances its style ambiguity on the basis of GAN and makes the generation effect more "creative"[3] In 2017, Google Research published an article about transformer, the attention mechanism, which brought the generative artificial intelligence into a new era.[4] In 2020, JonathanHo proposed the DDPM (Denoising Diffusivity Probabilistic Model) generation model. It can achieve sampling in complex image distribution through multi-step denoising of the denoising network during the image generation stage.[5]

Starting from 2022, generative artificial intelligence has entered an explosive era. Various AI image generation tools such as OpenAI's DALL·E2, Google's Imagen, Midjouney, Playround Ai, Stable Diffusion, DALL-E2, and Stableboost Ai provide industrial designers with textual, graphic, post-processing, and Model training and other functions.These tools have directly changed traditional innovative design methods, and jewelry design thinking and working methods must also adapt to the development of the times. Research based on this aspect is of great significance for improving jewelry design efficiency and design productivity.

1.2. Advantages of Generative Artificial Intelligence Tools in Jewelry Design

With the popularity of generative artificial intelligence, a large number of visual designs have been replaced by artificial intelligence, and the jewelry design industry has also been greatly impacted. Compared to traditional design, generative artificial intelligence tools have significant advantages in short-term creative generation, stylization, and combination of ideas. In terms of short-term creative generation, AI jewelry design can generate 4-10 sets of effect plans in 1 minute, while traditional design takes 3-7 days. Meanwhile, AI painting tools are very user-friendly, which can reduce the time cost for humans to learn jewelry design.[6]In terms of creative stylization, AI jewelry design can customize various styles such as digital, entertainment, metal, and so on through cultural and graphic forms. In terms of creative combination, AI jewelry design can generate scheme diagrams through the AI Text To Image generator. The experiments of German researchers such as STEVE GÖRING have shown that some generators can produce realistic and highly attractive images.[7]

Although AI has significant advantages in intelligent generation, how to ensure the quality of innovative jewelry design for generative AI is still a problem that most designers face. This article plans to study the literature knowledge graph of jewelry design, establish hot keywords to define product attributes, and then use artificial intelligence image generation tools to visualize rational data and keywords, generate independent creativity, and establish new jewelry design methods and processes that conform to the era of artificial intelligence, better serve society, and have pioneering significance for enhancing the depth and breadth of jewelry design.

2. Creative jewelry design method based on knowledge map and generative artificial intelligence

2.1. Jewelry design method model combined with artificial intelligence

In order to better study the influence of artificial intelligence in jewelry design and the design method of combining the two, this paper sets up the research flow, as shown in Figure 1, which can be divided into four steps.

1.Acquisition of frontier hotspots: use the data visualization software Citespace to study the literature knowledge map of domestic jewelry design direction, confirm the current hotspots of jewelry design through the literature knowledge map, take the research hotspots as the main design objects and creative points, analyze the hot keywords, and initially define the product theme.

2.Prompt word transformation: using the existing AI-generated jewelry picture prompt words and general prompt words as materials, the natural language processing model ChatGPT is trained to be a prompt word generator. Input the preliminarily defined product theme into chatGPT, and ask chatGPT to output preliminary prompts. Input the prompt words into AI image generation tool to check the effect of drawing, and manually adjust the prompt words until they are satisfied.

3.Scheme evaluation and screening: use AHP to screen the generated creative schemes and determine the final scheme by scientific methods.

4.Final scheme presentation: designers combine design tools to output excellent design schemes.
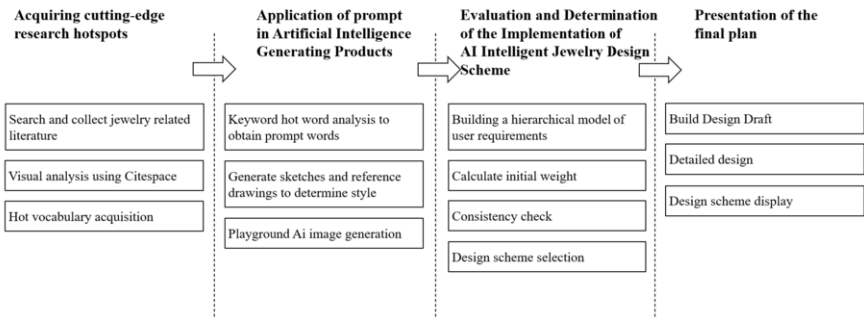

Figure 1. jewelry design method model combined with artificial intelligence

2.2. Key words construction and transformation of knowledge map

The data of this study were collected from CNKI (China National Knowledge Internet) platform, and 1671 valid literature articles were obtained from 2018.1.1 to 20123.6.30.

The specific operation method of literature analysis method is using the information visualization software named Citespace developed by Professor Chen Chaomei and other researchers[8] draws a knowledge map for keywords, research institutions and authors in the literature of jewelry design. Refworks format document data is exported on CNKI platform, and the data is preprocessed and format converted by CiteSpace, then the data analysis conditions are set. The time slice is set to 1, and the literature is studied at multiple levels through keyword co-occurrence and keyword time zone map. Then, according to the set output visual data map, manually adjust the chart

to ensure its readability. Finally, the research hotspots and trends in the field of jewelry design are summarized, so as to get hot words.
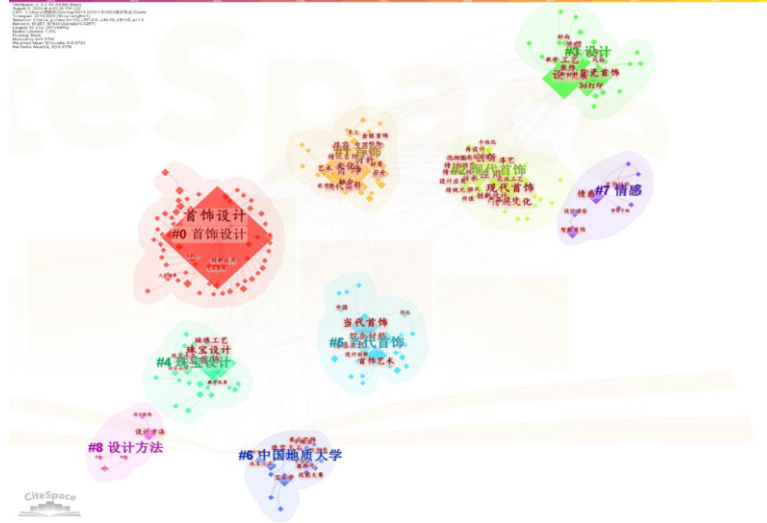
(1) Keyword clustering vocabulary extraction

Figure 2. Keyword cluster diagram of jewelry design research field from 2018 to First half of 2023

Through cluster analysis, we can see that the field of jewelry design also pays more attention to the following aspects.

1．The hot field of jewelry design is jewelry field. The scope of jewelry design is limited to precious metals and precious stones, and it emphasizes traditional fine craftsmanship, excellent quality and elegant style, while jewelry design is not limited by materials and styles.

2．In recent years, jewelry design has mostly used "ceramic jewelry", "comprehensive materials", "jewelry and jade", "jewelry" and "new materials" as materials. While maintaining the development and application of traditional materials such as jewelry, jade, gold, platinum, silver, diamonds and rubies, this research direction is also actively exploring new materials such as plastics, wood, crystals, bones and ceramics.

3．The key aspects in the field of jewelry design are innovation, application, craft, culture, material, emotion, modeling, development, inheritance, integration, nature, tradition, art and style.

4．Jewelry field pays special attention to technology, and there are two main research directions. The traditional directions are: enamel craft, lacquer art, filigree craft and mosaic craft, which is one of the representatives of China traditional culture and an important craft of traditional luxury goods production. Emerging directions are: "3D printing", which is based on rapid prototyping and additive manufacturing technology and is a brand-new digital forming manufacturing process.

5.Cross-field: "Mineralogy" and "Gemmology" became high-intensity words in 2022. Hao Liang and other researchers used glass sponge structure, 3D printing and digital monitoring technology to design hard, lightweight, high strength and high toughness smart wearable jewelry.[9]

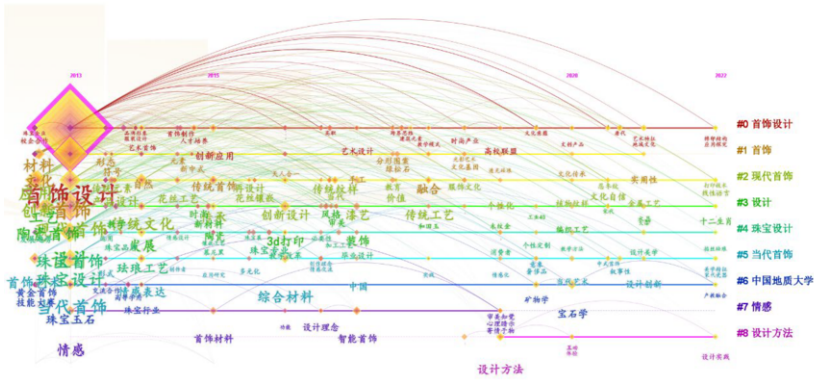(2) Keyword extraction of timeline graph

Figure 3. Timeline diagram of jewelry design and research in early 2018-2023

Based on Citespace's time-zone mapping (Figure 3) and analysis, eight cluster groups marked with "#" are extracted, which reflects the phased keywords and development direction of this research field. In order to keep up with the direction of scientific research and the development of the times, this study extracts the hot words of the main clustering groups in 2020 and beyond as the creative points and product themes of AI-generated jewelry. Artificial intelligence prompt word transformation method for creative keywords of jewelry design.

2.3. Artificial intelligence prompt word transformation method for creative keywords of jewelry design

2.3.1. Citespace vocabulary arrangement and induction

Because some words in the knowledge map are not suitable as reference hints for AI image generation tools. Therefore, it is necessary to delete words that have no reference meaning or are counterproductive when they are generated, expand and refine words that contain a wide range, and describe words that are difficult to distinguish correctly in natural language, and finally sort out and summarize them. In this study, the hot words of style from 2020 to 2022 are refined and summarized, which are mainly divided into categories, appearance attributes, culture and theme, technology, materials, scientific research and market demand, individualism and style, and interdisciplinary subjects. Finally, a small vocabulary with timeliness is obtained, which provides inspiration and direction for designers when it is generated.

2.3.2. Refer to the usage rules of artificial intelligence prompts to add commonly used prompts in jewelry field.

At present, AI drawing tools such as Midjouney use large-scale pre-training language model, also known as large language model. (LLMs), which has brought new opportunities and challenges to the field of natural language processing since 2018. Using the learning paradigm of "pre-training large model+fine-tuning large model" can achieve a leading effect in almost all natural language processing tasks, Researchers only need to fine-tune the downstream task annotation data set with pre-trained large-scale language models to obtain better task performance[10], which provides a technical basis for the transformation of hot words into hints.

Based on this, the hot vocabulary of citespace knowledge map mostly overlaps with the natural language model vocabulary except some proper nouns and professional vocabulary. The schematic diagram of the intersection between the natural language model vocabulary and Citespace hot vocabulary in jewelry field is as follows. That is, in most cases, artificial intelligence can correctly identify the user's requirements, so the application of hot thesaurus is feasible.
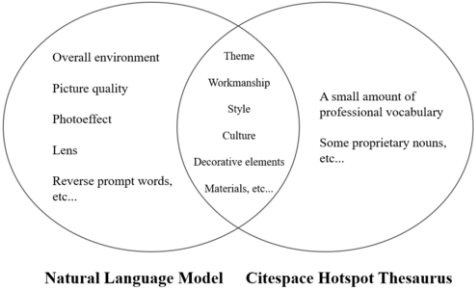

Figure 4. schematic diagram of the intersection of natural language model vocabulary and citespace hot vocabulary in jewelry field.

2.3.3. General rules for AI to generate tooltips

In order to get more accurate results and good visual effects, there are many AI drawing tool users who summarize and prompt vocabulary from a human perspective.

Prompt words are generally divided into positive words and negative words. The general order formula of positive words is: prefix+subject+subject descriptor+other descriptions. In the first part, prefixes are mostly for the requirements of image quality to ensure the generated quality. The second part puts forward subjects. This study will use the hot word brooch as the subject. The third part, describing the subject or imposing requirements on the subject, this study will put forward requirements in terms of technology, theme, material and style. The fourth part, supplementary expansion, to determine the background, environment, lens and filter. Reverse words are also called negative prompts, such as: low quality, malformed hands, etc., to avoid unsuitable elements and low-quality generation.

The specific application steps are as follows:

Step 1: Preliminary generation. According to the above formula and citespace hot words, we can get the preliminary artificial intelligence tips: Masterpiece, High-quality, A Butterfly Brooch, Enamel, Gold and Silver, Chinese Style, White Background and Front View. This tip can get the works that meet the requirements in most AI drawing tools.

Step 2, expand the generation. ChatGPT can be trained by using the above prompt word method and prompt word cases, and then hot words are used as the theme to ask chatGPT to draw inferences to obtain a large number of available vocabularies, or you can query the prompt word website to supplement the vocabulary yourself.

Step 3, because the effects of different tool platforms are different, users need to fine-tune them repeatedly to get satisfactory results.

2.4. Comparison of creative graphic schemes of extracted keywords in various artificial intelligence drawing tools

2.4.1. Comprehensive comparison of artificial intelligence image generation tools

In this study, the mainstream artificial intelligence image generation tools, such as Midjourney, Stable Diffusion and Playground AI, are selected to analyze the tools themselves, the media used, the features and the generation examples. At the same time, according to the above application methods, various tools are used to generate relevant jewelry design schemes. Here, the butterfly element is taken as an example for further study, as shown in Table 1. Three preliminary tools of butterfly-shaped jewelry are generated, and then the tools are selected for in-depth design.

Table 1. Comprehensive comparison chart of artificial intelligence image generation tools

	Midjourney	Stable Diffusion	Playground AI
summarized account	Midjourney is an artificial intelligence program and service developed by Midjourney, an independent research lab based in San Francisco. Midjourney offers a service based on the Discord platform, which can generate images based on natural language descriptions (called "Prompt"), and supports picture-generated graphics.	Stable Diffusion, a deep learning text-to-image generation model released in 2022, is a potential diffusion model developed by startup Stability AI in collaboration with several academic researchers and non-profit organizations. Its source code and models are open source and are being maintained by developers around the world.	Playground AI is an online AI painting tool that generates 1,000 free images per day and is the leading platform for text-to-image generation, offering image generation, automatic art style tips, free image magnification, image saving in the cloud, and social media for AI-generated images.
Image resolution	Can only control the image aspect ratio, high resolution need to enter HD, 8K and other prompt words	self-configurable	Available in a variety of sizes
Use media	Installed on the discord website, you can get AI images directly online after sending a command from the chat interface.	It can be downloaded to the local computer. You need to select various model plug-ins and adjust various parameters before using them.	Use on an independent web platform that integrates communication and generation.
Features/ advantages and disadvantages	1, no hardware requirements, can run on almost all devices. 2, simple deployment, no threshold for use. 3, low difficulty to use, easy to master. 4, the upper/lower limit difference is very small. 5, weak controllability, no plug-in, the output of the screen style is fixed. 6, run the whole network, the data exists on the server, it is difficult to save locally. 7. Only use officially defined models.	1, high hardware requirements, the need for local independent graphics card, high hardware requirements. 2. Deployment is relatively difficult. 3, it is difficult to use, there are a lot of content in the interface, such as sampling methods, model training, etc., which requires a more complex learning process. 4, the upper/lower limit gap is very large: no special operation in the case of poor visual effect, after a certain amount of learning to generate a very high upper limit. 5, highly controllable, many plug-ins, LORA, can almost change style and form at will, the number of drawings is large. 6, can be completely local operation, data only exists locally, with hardware can be unlimited use. 7, can train the model, get a personal database, let the AI completely according to their own ideas to shape the content of the target style.	1, no hardware requirements, can run on almost all devices. 2, simple deployment, no threshold for use. 3, the use of low difficulty, but still need to learn. 4, the upper/lower limit has a certain gap. 5, strong controllability, more models and styles, there are various parameter options. 6. Untrainable model. 7. Playground combines the advantages of the first two, which is easy to use and controllable. 8. Close communication between users.
Example: Preliminary prompt word: Masterpiece, high-quality, a butterfly brooch, enamel, gold and silver, Chinese style, white background, front view			

2.4.2. Playground AI & Midjourney in-depth design

In order to obtain the preliminary design concept, this study used the prompt phrases obtained above in playground Ai and Midjourney to generate butterfly brooches, which provided inspiration and materials for designers. Examples of specific effects are shown in the figure 5. Figure 6.
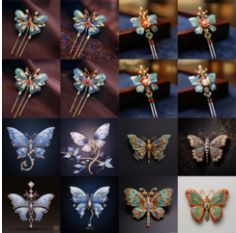

Figure 5. Playground AI Generation Diagram.

Figure 6. Midjourney Generation Diagram.

2.4.3. Refinement of Jewelry Design for Single Element

Because the effect of artificial intelligence is uneven, this study based on visual effect, feasibility, cost and style, screened out feasible and beautiful schemes and expanded

them into group-based scheme styles. The following style pictures are based on the butterfly brooch, which are generated by changing the description and order of the prompt words. After manual screening, they basically meet the requirements and meet the standards in vision and structure. See Figure 7, Figure 8, Figure 9 and Figure 10 for specific examples.
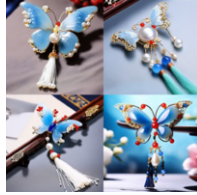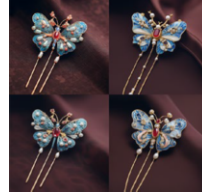

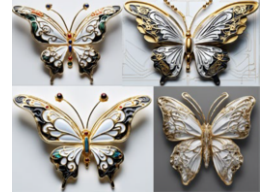**Figure 7.** style I.   **Figure 8.** Style II.   **Figure 9.** Style III.   **Figure 10.** Style IV.

3. Determination and evaluation method of innovative jewelry design scheme

3.1. Construction of hierarchical model of users' jewelry innovation demand

In order to obtain the demand of Chinese jewelry design scheme based on preliminary keywords and from the designer's perspective, this study uses questionnaire and interview. Based on the comprehensive results, 7 key evaluation criteria were determined to construct a hierarchical model for jewelry design scheme evaluation, as shown in Figure 11.
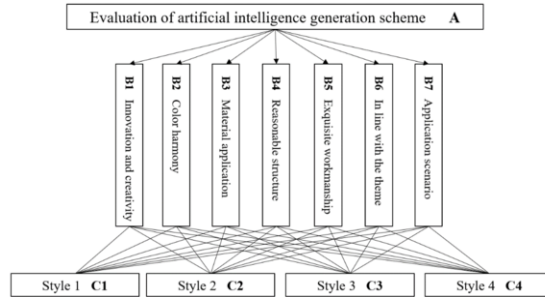

Figure 11. Requirements of Chinese Jewelry Design Scheme.

3.2. Weight calculation of criterion layer

Accord to that established evaluation hierarchy model of artificial intelligence generation scheme, 8 expert user and ordinary users are invited to compare each factor with 1-9 scale method, and an initial judgment matrix Z is established as follow:
Accord to that established evaluation hierarchy model of artificial intelligence generation scheme, 8 expert user and ordinary users are invited to compare each factor with 1-9 scale method, and an initial judgment matrix Z is established as follow:

$$\boldsymbol{Z} = \left(z_{ij}\right)_{m \times n} = \begin{bmatrix} z_{11} & z_{12} & ... & z_{1n} \\ z_{21} & z_{22} & ... & z_{2n} \\ ... & ... & ... & ... \\ z_{m1} & z_{m2} & ... & z_{mn} \end{bmatrix} \tag{1}$$

Among them, z_{ij} represents the relative importance value of factor i to factor j, satisfying $z_{ij} = \dfrac{1}{z_{ji}}$. Using the above judgment matrix and based on the basic principles of Analytic Hierarchy Process, the square root method is used to calculate the weight values of the evaluation criteria layer for the artificial intelligence generation scheme in this study, as shown in Table 2.

Table 2. Weight of criteria layer of jewelry design scheme generated by artificial intelligence

	Innovation and creativity	Harmonious color matching	Material application	rational construction	exquisite workmanship	Meet the theme	Application scenario	proper vector	Weight value (%)
Innovation and creativity	1	3	2	3	4	0.5	5	2.1	23.478
Harmonious color matching	0.333	1	0.5	1	2	0.25	3	0.82	9.172
Material application	0.5	2	1	2	3	0.25	4	1.292	14.442
Rational construction	0.333	1	0.5	1	2	0.333	3	0.855	9.557
Exquisite workmanship	0.25	0.5	0.333	0.5	1	0.25	2	0.521	5.825
Meet the theme	2	4	3	3	4	1	6	3.022	33.793
Application scenario	0.2	0.333	0.25	0.333	0.5	0.167	1	0.334	3.734

The weight calculation results of analytic hierarchy process show that the weight of theme is 33.793%, the weight of innovation is 23.478%, the weight of material application is 14.442%, the weight of reasonable structure is 9.557%, the weight of harmonious color matching is 9.172%, the weight of exquisite craftsmanship is 5.825%, and the weight of application scene is 3.734%.

3.3. consistency check

In order to ensure the rationality of AHP, it is necessary to check the consistency of the initial judgment matrix. The consistency ratio CR is used to measure the degree of consistency, and the formula is:

$$CR = \frac{CI}{RI} \tag{2}$$

In the formula, if CR is less than 0.1, it means that the initial judgment matrix is consistent, otherwise, the test fails and the matrix needs to be readjusted. RI is a random consistency index, and its value can be found in the average random consistency index table. CI is a consistency test index, which can be calculated by Formula (3) and Formula (4).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3}$$

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(ZW)_i}{nW_i} \tag{4}$$

The calculation result based on the above formula shows that the maximum feature root is 7.188, and the corresponding RI value is 1.341 according to the RI table, so CR=CI/RI=0.023<0.1. The weight calculation result is valid through one-time testing.

3.4. Scheme selection and determination

According to the summary results of the scheme level judgment matrix (Figure 12, Table 3), the overall ranking of the scheme level is obtained. Based on the single ranking of index level and the total ranking of scheme level, the best scheme in the evaluation and analysis of artificial intelligence generation scheme is Style III, and its quantitative score

is 1.447, so this study will choose Style III for further design. Table 3 shows the calculation results of scheme layer weight, and the CR values of seven key evaluation criteria are all less than 0.1, which passes the consistency test.
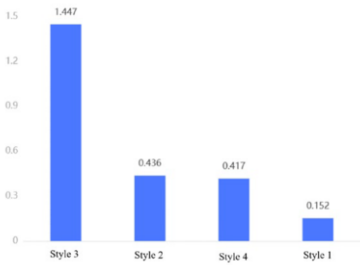

Figure 12. Quantitative score histogram of Chinese jewelry design scheme

Table 3. Weight Values and One-time Inspection Results Table

Node term	Style 1	Style 2	Style 3	Style 4	CR value	Consistency check
Innovation and creativity	0.249	0.096	0.558	0.096	0.016	Pass
Harmonious color matching	0.07	0.193	0.368	0.368	0.002	Pass
Material application	0.073	0.17	0.472	0.285	0.019	Pass
Rational construction	0.084	0.113	0.479	0.324	0.035	Pass
Exquisite workmanship	0.246	0.069	0.438	0.246	0.01	Pass
Meet the theme	0.088	0.496	0.332	0.083	0.018	Pass
Application scenario	0.061	0.311	0.495	0.133	0.03	Pass

4. Digital deepening and establishment of jewelry design scheme

In addition to drawing pictures by artificial intelligence to get inspiration quickly, designers should also give full play to their subjective initiative to avoid the problems of logic and structural details and provide a solid foundation for the landing of products. Synthesizing the ranking of key evaluation criteria, style selection, Citespace prompt thesaurus, artificial intelligence generation chart and multiple references of personal ability obtained by AHP, the final design case is as follows (Figure13). The scheme takes butterflies as the main elements, disassembling and reorganizing many elements in the pictures generated by artificial intelligence, with elegant style and compact and harmonious decoration, which meets the requirements of prompt phrases.
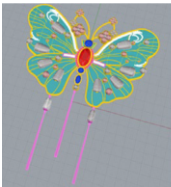

Figure 13. Rhino modeling.   **Figure 14.** Final Scheme Presentation.

5. Summary

In this paper, the initial jewelry scheme is designed by the innovative design method combining knowledge map with AI, and then the generated creative scheme is screened by AHP. Finally, the designer combines design tools to output excellent design schemes. The above practical operation verifies a new jewelry design method combining knowledge map with artificial intelligence, directionality and randomness, which solves the problem that the traditional jewelry design field relies on the designer's experience to design, which leads to the problem that the design experience cannot be passed down, the design level is unstable, and the design innovation cannot be evaluated. At the same time, it can effectively improve the designer's design quality and innovation. The method obtained in this study is of great significance to modern jewelry design, and can also provide some reference for other artificial intelligence drawing research.

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