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Jewellery Shape Optimization Based on Genetic Algorithm Integration of Traditional Cultural Elements and Design Uniqueness

Abstract: - This study deeply discusses the application of the genetic algorithm in jewellery design and how traditional cultural elements are organically integrated into jewellery design. Firstly, the basic principle of the genetic algorithm is described in detail, including critical steps such as gene coding, fitness function, selection, crossover and variation. Using genetic algorithms to optimize jewellery shape design is further discussed to achieve higher design efficiency and better design effects. Analyze the extraction and analysis methods of traditional cultural elements, including the definition, classification and characteristic analysis of traditional cultural factors. Through these methods, we can accurately identify the traditional cultural elements that are representative and full of artistic value. When these elements are organically integrated into jewellery design, we pay attention to maintaining modern aesthetic taste while showing profound cultural heritage. Through the clever use of genetic algorithms for shape optimization, combined with material selection, technology and other aspects of consideration, the jewellery successfully reflects the traditional cultural elements with a unique style. The advantages and limitations of applying genetic algorithms in jewellery design are pointed out. Although this method can improve design efficiency and create better results, there are still some problems, such as relying on manual intervention and difficulty in fully meeting the needs of personality.

Keywords: genetic algorithm, jewellery design, shape optimization, traditional cultural elements, design integration method

INTRODUCTION

The jewellery design industry is a dynamic and innovative field. It is a perfect combination of art and craft, but it also has a deep integration of business and culture. However, with the increasingly fierce market competition and the diversification of consumer demand, the jewellery design industry is facing unprecedented challenges [1]. How to stand out in many designs and create jewellery that has both artistic beauty and market demand is a problem that every designer needs to face and solve [2]. Genetic algorithm (GA) is a search algorithm that simulates natural selection and genetic mechanisms, and it is widely used in many fields, including jewellery design. Genetic algorithms can help designers find the optimal solution in many design schemes and improve design efficiency and quality [3]. However, the application of the genetic algorithm in jewellery design is still in the initial stage and needs further research and exploration. Traditional cultural elements are essential resources for jewellery design, which are rich in profound historical and cultural connotations and can endow jewellery with unique artistic charm and cultural value [4]. However, properly integrating traditional cultural elements

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into jewellery design, not only to maintain its original cultural characteristics but also to meet modern aesthetic needs, is the challenge that designers need to face. Design uniqueness is a key factor in jewellery market competition, and it can not only attract the attention of consumers but also be an important embodiment of brand image and market positioning. However, how to meet the actual needs of the market and the individual needs of consumers while maintaining the uniqueness of the design is a problem that the jewellery design industry needs to solve [5]. This study will discuss how to use genetic algorithms to optimize jewellery shape design, integrate traditional cultural elements, and improve design uniqueness to provide theoretical support and practical guidance for the development of the jewellery design industry. The main goal is to explore how to use genetic algorithms to optimize jewellery shape design, integrate traditional cultural elements, and improve design uniqueness [6]. To achieve this goal, this study will include the following main contents. Research on the application of the genetic algorithm in jewellery design The principle and characteristics of the genetic algorithm are studied in detail, and its application methods and steps in jewellery design are discussed, including how to use the genetic algorithm for shape optimization, how to set fitness function, and how to select and vary [7]. Study how to properly integrate traditional cultural elements into jewelry design, including how to select and extract traditional cultural elements, transform them into design language, and combine them with modern aesthetic needs [8]. Research on how to improve the uniqueness of jewellery design, including how to improve the uniqueness of design through shape optimization and the integration of cultural elements, how to balance uniqueness and market demand, and how to enhance brand image and market positioning through uniqueness [9]. It is expected to provide theoretical support and practical guidance for the development of the jewelry design industry and promote the innovation and development of jewellery design [10].

2. LITERATURE REVIEW

A genetic algorithm is an optimization algorithm based on the principle of natural selection and genetic evolution, which finds the optimal solution by simulating the process of biological evolution. In jewellery design, genetic algorithm is mainly used in shape optimization and parameter optimization. By coding the shape and parameters of the jewellery and then applying a genetic algorithm to optimize it, a more beautiful jewellery design that is more in line with human aesthetics can be obtained [11]. For example, some studies use genetic algorithms to optimize the shape of jewellery and obtain jewellery designs that are more in line with human aesthetics by adjusting the shape, size, texture and other parameters of jewellery [12]. In addition, there are some studies using genetic algorithms to optimize the material and colour of jewellery so as to obtain more attractive jewellery designs. Research on the application of the genetic algorithm in jewellery design mainly focuses on shape optimization and parameter optimization and finds the optimal solution by simulating the process of biological evolution so as to obtain jewellery design that is more beautiful and more in line with human aesthetics [13]. The application of traditional cultural elements in jewellery design can not only give jewellery unique cultural connotations and historical deposits but also enhance the artistic value and market appeal of jewellery [14]. In China, traditional cultural elements include the Chinese knot, auspicious cloud, dragon, phoenix and other patterns, which have rich cultural and historical connotations and can give jewellery a unique charm. For example, the Chinese knot symbolizes unity, happiness and auspiciousness; auspicious clouds symbolize auspiciousness, ruyi and beauty, and the dragon and phoenix symbolize honour, authority and power. Traditional cultural elements can also include some traditional crafts and techniques, such as cloisonne, wire enamel, etc., which can give jewellery a unique texture and beauty. Cloisonne is a traditional enamel process characterized by bright colours, fine texture and bright lustre, while wire enamel is a traditional metal process characterized by smooth lines, rich colours and unique texture. In jewellery design, the application of traditional cultural elements can not only enhance the artistic value and market appeal of jewellery but also promote the inheritance and development of culture. For example, some designers combine traditional Chinese cultural elements with modern design to create jewellery works with both traditional cultural characteristics and modern aesthetic concepts. These works not only have high artistic value but also have high market appeal, which can attract more consumers' attention and purchase. The application of traditional cultural elements also needs to pay attention to some problems. First of all, the application of traditional cultural elements needs to respect and protect traditional culture and can not be arbitrarily tampered with and abused. Secondly, the application of traditional cultural elements needs to be combined with modern design, which cannot be too old and conservative.

3. THE PRINCIPLE OF GENETIC ALGORITHM AND ITS APPLICATION IN JEWELLERY SHAPE OPTIMIZATION

3.1 Basic principles of genetic algorithm

The genetic algorithm is an optimization algorithm based on the theory of biological evolution, which simulates the process of selection, crossover and variation in biological evolution. The basic principle of the genetic algorithm is as follows: First, the solution to the problem is represented as a chromosome; each chromosome is a possible solution. Then, through operations such as selection, crossover and mutation, a new chromosome is generated, that is, a new solution. Finally, the optimal solution to the problem is found by iterating this process continuously. In jewellery shape optimization, a genetic algorithm can be used to optimize the shape of jewellery. First, the form of the jewellery is represented as a chromosome, each of which is a possible shape. Then, through operations such as selection, crossover and mutation, a new form is generated, which is a new solution. Finally, by constantly iterating this process, the optimal jewellery shape is found. The application of the genetic algorithm in jewellery shape optimization can provide more possibilities for jewellery design and make jewellery design more diversified and innovative. At the same time, genetic algorithms can also improve the efficiency and accuracy of jewellery design, making jewellery design more efficient and accurate.

3.2. Online Algorithm for Color Equal Element Clustering Based on K-Means Multi-images

Since the main research object of this paper is the elements of Chinese traditional cultural phenomena, the distribution of traditional elements is basically presented in the form of block surface filling. The image types with relatively concentrated pixel distribution are clustered in the traditional element space. Do not consider the position of pixels in the image. Therefore, the K-Means clustering method is chosen to extract traditional elements. Traditional element extraction represents element values as coordinate points in three- or four-dimensional space. Specify the number of element types to be obtained and get the central coordinate of each point set through iteration, that is, the number of extracted elements. Two kinds of element clustering need to be carried out on the image, that is, cluster the elements of a single image and multiple images, respectively, which will be described in detail below. Single image element extraction processes all pixels of an image into a data set in the element space. In the process of element extraction, three types of data need to be input: the path of the image sample library of the extracted element, the number of elements to be extracted, and the number of iterations of the extracted element. The algorithm, in turn, calculates the distance between the colour value of each pixel in the image and each cluster centre and classifies it into the category represented by the nearest cluster centre. After all pixels are classified, the average of all pixels in each category is calculated as the new clustering centre for that class. When the algorithm is finished, the final cluster centre value is output, which is the element of the extracted single image. Element extraction data is saved as an Excel spreadsheet. The algorithm flow is shown in Figure 1 below:

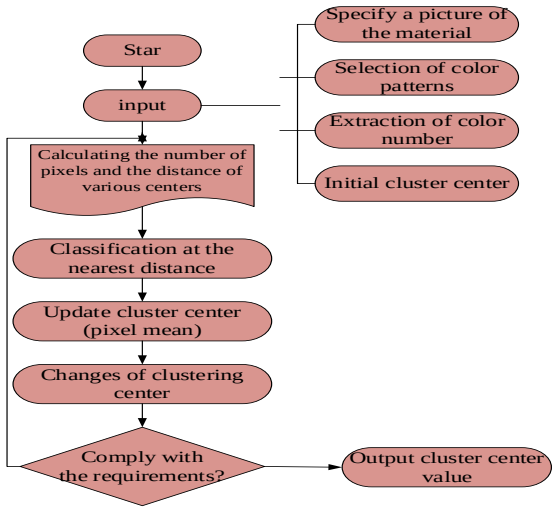

Figure 1 K-Means clustering process of colour extraction

What needs special note is that the selection of traditional element application modes is divided into two types. First, when the RGB mode is used, the initial cluster centre is evenly distributed along the diagonal of the RGB three-dimensional space, which is a series of grey values from pure black to pure white. Second, when the HSB mode is used, the initial cluster centre is uniformly distributed along the circumference of the hue circle. That is, the H value varies from 0 to 360, and both the S and B values take 100. The clustering result in RGB mode has a certain number of pixel members under each class, and there is no zero-member class. That is, the number of elements the user specifies to get is the same as the number of factors that are ultimately obtained. The clustering of elements in the HSB schema is more general in terms of features.

Classes with zero members often occur; that is, the final number of elements obtained is less than the number of element classes specified by the user. It depends on the image. Two modes can be selected according to the specific situation. If the object is a photo, you can use the HSB pattern if you need to extract a series of elements with reference values from the photo because the photo is rich in colour, and it is difficult to judge the number of elements included. You can specify more colours. The algorithm determines how many elements are ultimately extracted. If the object is a graphic design work, if you need to extract the colour pattern of the original author, you need to extract the smaller series of colours separately. RGB mode can be used to extract a specified number of elements. Since the number of elements used in design work is usually limited, it is up to the user to determine the number of elements extracted.

The research content of this paper is mainly the phenomenon of Chinese traditional culture. The data sources are mainly flat pictures. Therefore, RGB mode is selected for element research. Using the above method, 480 pieces of Mogao Grottoes in Dunhuang were selected for single-image element extraction. The number of elements extracted in the figure is 8. The partial extraction results after 20 iterations are shown in the figure below. You can see eight colours extracted for each image. At the same time, the specific RGB value and pixel ratio of each extracted element are calculated.

3.2 Online color clustering algorithm based on K-Means multi-image traditional elements

The image library of the research object is updated at any time, and the colour extraction results need to be recalculated. If all the pictures are recalculated, some of the work will be repeated, and the efficiency will be reduced. A multi-image colour clustering algorithm is proposed, which computes colour clustering for newly added images and corrects the original cluster centre data. The online colour clustering algorithm for multiple images has two key steps. The first is to judge the clustering centre of the colour extracted from the newly added image material. The second is to update the cluster centre of the newly added image material. The specific online clustering algorithm calculation process is shown in the figure below:

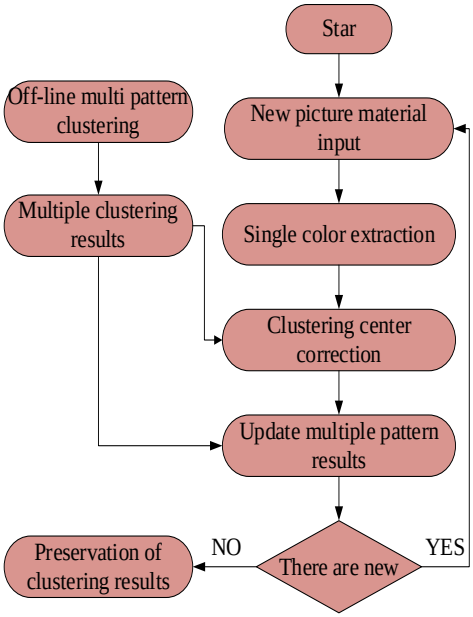

Figure 2 Multi-image color clustering online algorithm

The RGB mode is used as an example. Suppose that the number of members of a category colour is n, according to the K-Means clustering algorithm, C is a specific category, r, g, and b are three colours, j is a number, and its clustering centre is

$$C = (Cr, Cg, Cb) \quad (1)$$

$$Cr = \frac{\sum_{j=1}^{n} Cr_j}{n}, Cg = \frac{\sum_{j=1}^{n} Cg_j}{n}, Cb = \frac{\sum_{j=1}^{n} Cb_j}{n} \quad (2)$$

If the extracted colour $(Cr_{n+1}, Cg_{n+1}, Cb_{n+1})$ of the new image material is classified in this category, the iteration formula for the new cluster centre is as follows:

$$C' = (Cr', Cg', Cb') \quad (3)$$

$$Cr' = \frac{\sum_{j=1}^{N} Cr_j + Cr_{N+1}}{n+1} = \frac{n}{n+1} Cr + \frac{1}{n+1} Cr_{N+1} \quad (4)$$

$$Cg' = \frac{\sum_{j=1}^{N} Cg_j + Cg_{N+1}}{n+1} = \frac{n}{n+1} Cg + \frac{1}{n+1} Cg_{N+1} \quad (5)$$

$$Cb' = \frac{\sum_{j=1}^{N} Cb_j + Cb_{N+1}}{n+1} = \frac{n}{n+1} Cb + \frac{1}{n+1} Cb_{N+1} \quad (6)$$

The above formula expresses the updated cluster centre as a linear combination of the old cluster centre and the extracted colour of the newly added image material.

3.3 Colour Characteristics of the Discrete Method

Take the Mogao Grottoes in Dunhuang as an example. The specific colour extraction method is described by calculating the standard deviation between the extracted RGB value and the extracted colour of the murals in the Mogao Grottoes of Dunhuang. Standard deviation, also known as mean square error, is a measure of the dispersion of the mean of a set of data. It is important to note that the difference between standard deviation and mean is different. When the mean values of a collection of data are the same, the standard deviation does not necessarily have the same value. A relatively large standard deviation indicates a significant difference between most of the values in a set of data and their mean. A relatively small standard deviation indicates that this set of values is closer to its average. Colour feature extraction is studied by using the K-means clustering method. There are many similar colours within each extracted colour. The extracted colours are the average of these colours. How do you judge the meaning of colour features? Here, you need to calculate the standard deviation between colours to see the dispersion of that colour. The smaller the standard deviation value is, the smaller the dispersion between the extracted colour and the similar colour contained in the extracted colour is, and the more obvious the characteristics of the sample colour are. On the contrary, the larger the standard deviation value, the greater the dispersion of the extracted colour and the similar colour contained in the extracted colour, and the less distinct the colour characteristics of the sample. The standard deviation formula is as follows:

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (X_i - \mu)} \quad (7)$$

In the formula, σ it stands for standard deviation. The radical sign is the average value. XI, X2, X3, X4...Xi is real numbers. N is the number of real numbers. The calculated standard deviation value is actually equivalent to

the distance from the colour value of one pixel to the extracted colour (i.e., the cluster centre). It should be noted here that the formula for calculating the distance between the colour value of the pixel and the extracted colour is as follows:

$$d = \sqrt{(Cr-[Cr])^2+(Cg-[Cg])^2+(Cb-[Cb])^2} / \sqrt{3\times 255^2} \quad (8)$$

In the formula, Cr, Cg, and Cb are the RGB colour values of a particular pixel. [Cr], [Cg], [Cb] are the RGB colour values of a cluster centre. $\sqrt{3\times 255^2} \approx 441.67$ It is the length of the diagonal of the three-dimensional colour space, that is, the maximum possible distance value. The distance is converted to a relative indicator to facilitate evaluating whether the standard deviation values calculated in this paper are within the normal range. It can be seen that the maximum standard deviation is calculated to be 27.42514, and the smallest standard deviation is 13.94225, which is far less than the maximum possible distance value of 441.67. This result further shows that the colour extracted by the K-Means clustering method is a more scientific result. It can be inferred that the colour of the murals in Dunhuang Mogao Grottoes is distinctive. The next task is to determine how large the value of the colour standard deviation is and whether the colour features are obvious. In the process of designing and implementing a multi-sensor fusion system, we should not only consider the performance of the fusion system but also adopt a good algorithm and consider various factors such as calculation amount and system communication ability. Therefore, sometimes simple fusion algorithms are used, and sometimes complex fusion algorithms are used. The variability of fusion accuracy based on system and system is obtained through the study of simple fusion algorithm and covariance weighted fusion algorithm. An adaptive track fusion algorithm is proposed in the literature to enhance the system's adaptability. The algorithm mainly uses statistical distance and threshold judgment and adaptively selects a fusion algorithm to solve global state fusion estimation. In the algorithm, the statistical distance D and Dz are defined as the distance estimated by the fusion of the local state of a sensor with the SF algorithm and WCF algorithm of multiple transmitters, then:

$$D_1 = (\hat{x}_i - \hat{x}_{SF})^T (p_i + p_{SF})^{-1} (\hat{x}_i - \hat{x}_{SF}) \quad (9)$$

$$D_2 = (\hat{x}_i - \hat{x}_{WCF})^T (p_i + p_{WCF})^{-1} (\hat{x}_i - \hat{x}_{WCF}) \quad (10)$$

In the formula, $\hat{x}_i$ and p_i are the local state estimation of a certain sensor and the corresponding error covariance matrix, and $i \in (1,2,...,N)$ (N is the number of sensors). The specific implementation of this algorithm is as follows. First, the thresholds G1 and G2 may be set by the impact of system resources on the system's quality requirements and fusion algorithms for the fused track. As can be seen from equations (1) and (2), the statistical distance D1 is only related to the local state estimation of each sensor and their error covariance. The D2 is related not only to the local state estimation and error covariance of each sensor but also to the mutual covariance between sensors.

4. RESULT ANALYSIS AND DISCUSSION

4.1 Feature extraction of Chinese traditional cultural elements

Based on the algorithm and model proposed above, Su Embroidery is taken as an example to illustrate the function and application of the algorithm. The style of Su's embroidery is perfect, with even stitches and harmonious colours. It is loved by the royal family. At that time, a lot of embroidery was made by artists who worked in the art of embroidery. A large number of embroidery pictures have been censored. The colour feature dispersion method described above will be used below. By analyzing the standard deviation of colour extraction, the colour features and the significance of colour features of Suzhou embroidery are analyzed. Calculate the extracted colour as IZ colour, and calculate the standard deviation value of Suzhou embroidery as shown in Figure 3 :

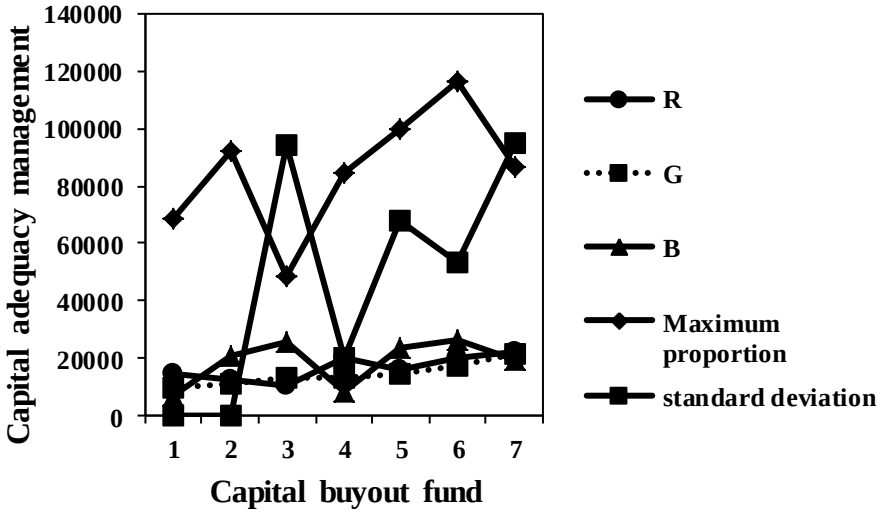

Figure. Three standard deviations of Suzhou

By calculation, the mean, standard deviation of the 12-colour extraction colour of Suzhou embroidery is 29.45104, and the colour rendering is 15.95,070. Judging from this, the colour characteristics of Su embroidery are the more apparent characteristics of Su embroidery culture. From the 12 colours extracted from many embroidery images, it can also be seen that the colour characteristics of Suzhou embroidery are high colour purity, brightness, and richness. At the same time, the colour extraction results of Suxi embroidery are consistent with the colour characteristics of many embroidery literature studies. This also shows that the results of this study are more accurate and have certain practical significance. The next step is to use the method of colour relationship network introduced above to draw the colour relationship network diagram of Suzhou embroidery. Frequency is about the further study of the colour-matching law of Suzhou embroidery. As shown in the figure below, when the total colour is 40%, the calculation results of the 12-color Suzhou embroidery color relationship network diagram are as follows:

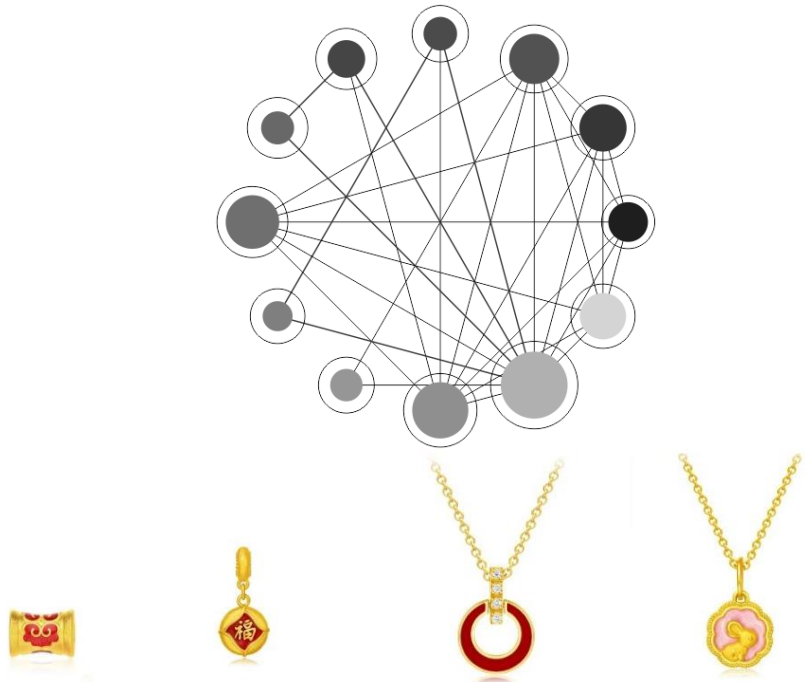

Figure 4. Integrating traditional culture into jewellery shape

To verify the accuracy of the colour network diagram, select some pictures in the embroidery photo library, as shown in Figure 4. Through comparison, it can be seen that the network diagram of the colour relationship is relatively accurate, and the colour matching is basically manifested in the image. A random Su embroidery picture was selected to compare the colour relation network in detail. The embroidery is dominated by red, and the clothing colours vary from dark red to light red. The colour of the dragon ranges from dark blue to light blue, with dark blue, black, white and other colours for tone harmony. The result is that the red line of the connected icon between the image and the colour network icon is basically the same.

4.2 Analysis of the Characteristics of Chinese Traditional Cultural Phenomena

Figure 5 shows the colour extraction results of traditional Chinese cultural phenomena studied in this paper. According to the extracted colours, it can be clearly seen that the biggest difference between the folk tapestry and the colour of the four famous embroideries is that the colour between the folk is simple, the colour is grey, and the contrast colour is used well. The bright colours of the four famous embroideries are vivid and bright, rich in colour and natural in colour transition. At the same time, the different colour phenomena in Chinese traditional culture are mostly influenced by the "five colours" culture, namely red, yellow, black and white. Different colour phenomena are affected by many factors, such as geographical environment, cultural origin and customs.

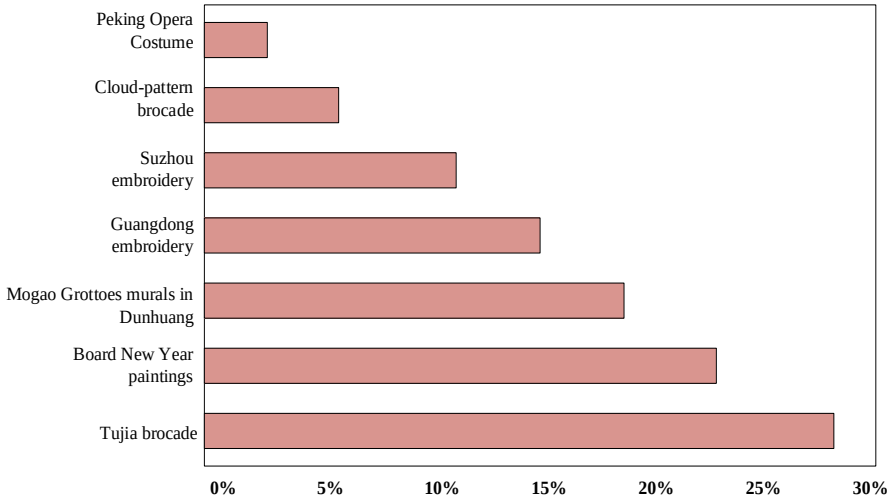

Figure 5 Color feature salience list

This paper summarizes the colour relationship network of traditional Chinese cultural phenomena studied in this paper. Through the study of colour relationship network diagrams, it is helpful to check the colour-matching law of various cultural phenomena and also can improve the efficiency of designers. In short, colour in traditional Chinese culture is one of the essential references in history and design. Extracting traditional colours and using innovative cultural heritage can not only promote traditional culture but also enhance the artistic value and cultural quality of China's modern industrial design.

4.3 Extraction and analysis of traditional cultural elements

Jewellery shape optimization is a complicated problem that needs to consider many factors, such as aesthetics, comfort,t and practicality of shape. The genetic algorithm can provide an effective solution for jewellery shape optimization. Specifically, the jewellery shape can be represented as a chromosome, with each gene corresponding to a design parameter, such as shape, size, colour, etc. Then, a genetic algorithm is used to optimize the chromosome to find the best design parameters to obtain the best jewellery shape. When applying the genetic algorithm in jewellery shape optimization, the following points need to be paid attention to Fitness function design: Fitness function needs to be able to accurately evaluate the advantages and disadvantages of jewellery shape. This can be achieved by combining a variety of factors, such as expert opinion, user feedback, market data, etc. Design of crossover and mutation operations: Crossover and mutation operations need to ensure the diversity of the population and avoid the algorithm falling into the local optimal solution. This can be achieved by designing suitable crossover and mutation probabilities. Setting of the stop condition: The stop condition needs to be able to ensure that the algorithm can find a satisfactory solution in a finite time. This can be achieved by setting a maximum number of iterations, fitness thresholds, and so on. Through a genetic algorithm, the optimal jewellery shape can be found while maintaining the diversity of jewellery shapes so as to improve the design level and market competitiveness of jewellery.

4.4. Methods of integrating traditional cultural elements into jewellery design

There are several ways to integrate traditional cultural elements into jewellery design: Direct reference: This is the most direct way to incorporate traditional cultural factors, such as patterns, symbols, colors, etc., directly into jewelry design. For example, the Chinese dragon, phoenix, lotus and other patterns are designed directly on the jewelry, as shown in Figure 8.

Figure 6. Pattern direct design

Abstract processing: Abstract the traditional cultural elements, extract their core features, and then integrate them into the jewelry design. For example, Chinese moire is abstracted and designed into the shape or texture of jewelry as shown in Figure 9.

Figure 7. Abstract treatment of traditional culture

Process integration: The traditional process technology such as cloisonne, wire enamel and other applications in jewelry production, so that the jewelry has a traditional texture and beauty. Cultural connotation expression: express the connotation and spirit of traditional culture through jewelry design. For example, to design a jewelry series with Confucius' "benevolence, righteousness, etiquette, wisdom and faith" as the theme, through the design of jewelry to express these traditional cultural values. Innovative integration: On the basis of respecting and inheriting traditional culture, innovative design is carried out, combining traditional cultural elements with modern design language to create jewelry with both traditional charm and modern sense. The above is the method of integrating traditional cultural elements in jewelry design. Through these methods, designers can

skillfully integrate traditional cultural elements into jewelry design, so that jewelry has both cultural heritage and artistic beauty.

CONCLUSION

Jewelry design is a combination of art and craft, which requires designers to have unique innovative thinking and exquisite technical skills. In this process, the integration of traditional cultural elements undoubtedly adds deeper cultural heritage and artistic value to jewelry design. In this paper, the application of traditional cultural elements in jewelry design is deeply studied and discussed. First, traditional cultural elements are important resources for jewelry design. They have rich cultural and historical connotations, which can give jewelry unique charm and artistic value. Through the extraction and analysis of traditional cultural elements, designers can get inspiration from them and create jewelry designs with unique styles and characteristics. The integration of traditional cultural elements requires designers to have profound cultural literacy and artistic accomplishment. Designers need to deeply understand and master the cultural connotation and historical heritage of traditional cultural elements, in order to properly integrate these elements in jewelry design, so that it can not only reflect the charm of traditional culture, but also meet the needs of modern aesthetic. There are many ways to integrate traditional cultural elements, including direct reference, transformation and innovation, abstract extraction and so on. Designers can flexibly use these methods according to the needs of design and their own innovative thinking, to create a unique style and characteristics of jewelry design. To sum up, the application of traditional cultural elements in jewelry design is an important design strategy, which can help designers create jewelry design with profound cultural heritage and artistic value. In the future jewelry design practice, designers should pay more attention to the research and application of traditional cultural elements, so as to enhance the artistry and culture of jewelry design and meet people's aesthetic and cultural needs for jewelry.

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