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Pattern Extraction of Ming and Qing Dynasty Furniture Based on Image Processing and Feature Extraction Algorithm with Application to New Chinese Furniture Designs

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SUMMARY: *Furniture industry is not only the engine of economic development, but also an important carrier of cultural expression and social influence. In order to adapt the Ming and Qing furniture to the development needs of modern society, this paper proposes an intelligent Ming and Qing furniture pattern color and texture extraction method. Firstly, the Ming and Qing furniture patterns are preprocessed to eliminate the complex color distribution, data noise and texture in the Ming and Qing furniture patterns, and then the K-means algorithm is used as the basis for obtaining the best initial clustering center of the Ming and Qing furniture pattern colors through the lion group optimization to realize the main color clustering of the furniture. Subsequently, the relative total variance model texture smoothing and interactive image segmentation are applied to realize the extraction of the target grain pattern of Ming and Qing dynasty furniture, and the image binarization processing technique is adopted to retain the complete grain feature information. Experimental results show that the main colors of Ming and Qing furniture extracted under this paper's method are black and navy blue, accounting for 37.6% and 18.2% respectively, and the difference of the same image feature values extracted by this paper's pattern extraction method in different noise environments is less than 0.002. Tip New Chinese furniture design retains the sense of serenity and elegance of Ming and Qing Dynasty furniture design, and completes the design work of antiquity-appreciating innovation of new Chinese furniture design from three aspects: direct application, content extraction, and disassembly and reorganization.*

KEYWORDS: *K-means lion group optimization; color extraction; pattern extraction; Ming and Qing furniture patterns; image binarization*

1 Introduction

In the development of traditional Chinese furniture, Ming and Qing furniture is the peak period of traditional furniture development, and it can be said that it occupies an important position in the history of furniture in the world [1]. Ming and Qing dynasty furniture created China's splendid furniture culture, but also traditional cultural thinking, philosophical beliefs, ethics, aesthetic consciousness and humanistic customs and other aspects of the physical product, many furniture has a variety of auspicious symbolism of the decoration [2-4]. Through these

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auspicious motifs to realize the picture must be intentional, meaning must be auspicious. For example, the dragon and phoenix, peony, cloud pattern, etc., through the decorative use of metaphors, harmonies and other symbolic means of art, reflecting the folk customs of various places, as well as people's aspirations for a better life, in accordance with China's traditional concept of auspiciousness by using the auspicious decorations, but also reflects the aesthetic interests of the ancients and the mode of thinking through the traditional culture of artifacts to achieve the effective fusion of realism and surrealism [5-8]. With the popularity of national trend brands, the demand for new Chinese style furniture rises. However, traditional new Chinese furniture design is mostly presented with simple traditional patterns, without thinking about the details of the patterns and their cultural connotations, resulting in a serious sense of severance between the finished new Chinese furniture and its and the environment, which is difficult to meet the modern aesthetic needs [9, 10].

At the same time, the introduction of digital tools in furniture design is only applied to improve the efficiency of the design, but in the integration of modern aesthetics and traditional patterns in the design of low adaptability [11]. The application of traditional patterns in furniture design is an important part of pattern extraction, and the traditional pattern extraction method is carried out by hand and two-dimensional topography, which leads to the distortion of the pattern three-dimensional surface, missing details and other problems, as well as low extraction efficiency. With the development of intelligent technology, image processing and feature extraction and other technologies make the pattern of three-dimensional scanning, detail extraction more and more accurate, and many of these technologies are applied to furniture design, which not only improves the visual effect of furniture design, but also improves the design efficiency [12-15]. Through the use of modern technology to extract traditional patterns, in-depth understanding of their connotations, and their integration into modern new Chinese furniture design, to improve the effect of furniture design, and promote the long-term development of new Chinese furniture.

In this paper, for the shortcomings of the traditional K-means algorithm with low extraction accuracy and uncertainty of the clustering center, an optimized K-means algorithm based on the lion group algorithm is proposed, which is applied to the color extraction of Ming and Qing dynasty furniture patterns. And before carrying out the color feature extraction of Ming and Qing furniture, the pre-processing work such as Resize processing and filtering processing is carried out on the Ming and Qing furniture images to eliminate the influence of noise in the furniture images. In addition, for the characteristics of Ming and Qing furniture that it is difficult to separate the target pattern from the background, RTV and Grabcut interactive image segmentation methods are used to achieve smooth extraction of the texture of the target pattern, and the Otsu algorithm in binarization processing is used to maximize the retention of the complete furniture pattern morphology. The application of specific example analysis verifies the usability of this paper's Ming and Qing furniture color features and texture features extraction method. On this basis, the application of traditional Ming and Qing furniture patterns in new Chinese furniture is proposed and evaluated for utility.

2 Pattern primary color extraction based on lion group optimization K-means algorithm

This chapter focuses on the color extraction of the acquired Ming and Qing dynasty furniture images. Most of the existing primary color extraction techniques are based on the traditional K-means algorithm, however, the algorithm has some problems, such as the uncertainty of the initial clustering center and low accuracy. Therefore, a furniture primary color extraction algorithm based on lion group optimization K-means is proposed, which is mainly based on K-means algorithm to solve the problem of color extraction of Ming and Qing dynasty furniture patterns. The lion king position is constantly updated by the lion group optimization algorithm to obtain the best initial clustering center to deal with the problem of uncertain initial clustering center in the traditional clustering algorithm to achieve color classification.

2.1 Image Preprocessing

Factors such as data size and noise that may be present in the image can affect the final result of color extraction and require preprocessing of the image.

2.1.1 Resize processing

Resize processing [16] is the technique of changing the size of an image dimension by scaling. It mainly adjusts the width and height of the image to make it enlarged or reduced. There are various methods for Resize processing, among them, bilinear interpolation helps to avoid the jagged edge effect when the image is enlarged or reduced, thus producing a relatively smooth image and improving the visual quality of the image, which is based on the following principles:

Suppose the original image has coordinates (x, y) and needs to be resized to the new size with coordinates $(x^{'}, y^{'})$. Find the four pixels in the original image that are closest to the coordinates $(x^{'}, y^{'})$ with coordinates $(x_1, y_1)(x_1, y_2)(x_2, y_1)(x_2, y_2)$. For each channel of the image, interpolation is computed using the bilinear interpolation formula:

$$f(x^{'}, y^{'}) = (1-\alpha)(1-\beta) f(x_1, y_1) + \alpha(1-\beta) \tag{1}$$

$$f(x_2, y_1) + (1-\alpha)\beta f(x_1, y_2) + \alpha\beta f(x_2, y_2) \tag{2}$$

where: α denotes the horizontal distance between the target pixel position and the neighboring pixel position, and β denotes the vertical distance.

The processing of bilinear interpolation makes it possible to maintain the details and smoothness of the image even during the process of resizing the image, thus obtaining a better visual effect and simplifying the subsequent processing.

2.1.2 Filtering

Common filtering processing methods include mean filtering, Gaussian filtering [17], median filtering and so on. Among them, Gaussian filter processing can effectively reduce the image texture details, and some minor color changes and structural details will be blurred, thus making the image smoother, reducing the interference and arithmetic for subsequent color extraction, and improving the efficiency and accuracy of image processing. The high period filtering method can be expressed as:

$$g(x, y) = \sum\sum f(i, j) w(i-j), (i, j) \in S \tag{3}$$

where: $g(x, y)$ is the output pixel value, $f(i, j)$ is the pixel value of the input image, $w(i-j)$ denotes the weights, and S denotes the range of the filtering window.

The weights of Gaussian filtering are calculated by Gaussian kernel function. The Gaussian kernel function can be expressed as:

$$w(i,j)=\frac{1}{2\pi\sigma^2}\exp(-\frac{(i-m)^2+(j-n)^2}{2\sigma^2}) \tag{4}$$

where: (i,j) is the position of the current pixel, σ denotes the standard deviation of the Gaussian kernel, and m and n denote the center position of the Gaussian kernel.

The filtering operation helps to reduce the effect of small noises, allowing the clustering algorithm to focus more on capturing the main color distributions, resulting in gains in efficiency and accuracy.

2.2 Main color extraction algorithm for Ming and Qing furniture patterns

K-means algorithm is a commonly used unsupervised learning algorithm, which belongs to one of the clustering algorithms. In furniture color extraction, data points are divided into different clusters through continuous iterative optimization, and the distance between the center of each data point and the cluster it belongs to is continuously optimized to be minimized. Each cluster represents a color group, and the smaller the distance between a data point and the center of the cluster, the higher its similarity. From this, it can be learned that the evaluation of whether the calculation results of the algorithm are accurate mainly lies in the selected initial clustering center, however, the determination of its initial clustering center is mainly through a random way, so this way will get different operation results, and it is also easy to be interfered by the image noise, which produces a local optimal solution.

2.2.1 K-means algorithm

K-means algorithm [18] is extremely actionable in color extraction, so K-means clustering algorithm is used to achieve color clustering and explore furniture color features, the steps of the algorithm are as follows.

(1) Initialization: set the size of sample data as N and the total number of clusters as K.

(2) Assign data points: calculate the Euclidean distance between each pixel and each cluster center, take the RGB image color display mode as an example, the Euclidean distance D is calculated as:

$$D=\sqrt{(X_i-x)^2+(Y_i-y)^2+(Z_i-z)^2} \tag{5}$$

(3) Update the clustering center: that is, calculate the RGB mean of all the samples in the category as the new clustering center until the maximum number of iterations is reached or the allocation of samples is no longer changed, in which each data object is classified into the class closest to it:

$$\sigma=\sqrt{\frac{1}{N}\sum_{i=1}^{V}(x_i-\mu)^2} \tag{6}$$

2.2.2 Adaptation function design

The design of the fitness function is an important task in optimization problems, mainly to assess the quality of the candidate solutions and provide guidance for the optimization algorithm, which can accurately reflect the objective of the problem, so that there is a clear relationship between the fitness of the candidate solutions and the optimization objective of the problem. In the task of color extraction in this paper, it is mainly designed based on the Davies-Bouldin index (DBI) [19] as a measure of the quality of the solutions produced by the algorithm in each iteration. This index not only reflects the intra-cluster closeness and inter-cluster separation of the samples, but also reflects the clustering results where the samples within the clusters are more similar but the samples between the clusters are more different. The lower the DBI index, the better the quality of the clustering solution, which has the functional form:

$$DBI = \frac{1}{N}\sum_{i=1}^{N} \max(\frac{R_i + R_j}{d(C_i + C_j)}) \tag{7}$$

2.2.3 Improved K-means algorithm for lion group optimization

This paper proposes an improved K-means algorithm based on lion group optimization algorithm, which first preprocesses the Ming and Qing dynasty furniture patterns, uses Resize processing to unify the size of the sample and removes the influence of image noise by Gaussian filtering, and then extracts the main color of the Ming and Qing dynasty furniture patterns and the corresponding occupancy through the lion group optimization of the K-means algorithm. The main process is shown below.

Steps:

Step1: Set the population parameters.

Step2: Initialize the position of the lion population and randomly generate the initial position of lion i within the parameter range.

Step3: Initialize clustering centers, use K-means algorithm to initialize K clustering centers, set the position of the lion king as the optimal position of the initial lion group.

Step4: Execute the optimization search strategy to update the position of the lion and calculate the fitness value of the lion.

Step5: Obtain the optimal solution to find the global optimal position of the lion king, i.e., the RGB value of the K clustering centers.

Step6: Execute clustering, calculate the Euclidean distance between the data objects and the cluster centers, assign the data objects to the cluster center with the smallest distance, and calculate the color percentage of the data objects contained in each cluster center.

3 Ming and Qing furniture pattern pattern extraction process

The Ming and Qing furniture pattern feature extraction process is shown in Fig. 1, in order to avoid the sample image blurring and complex texture interference and other reasons affecting the extraction effect during the pattern extraction process, the target pattern is completely extracted from the image by using Relative Total Variation Model (RTV) texture smoothing and Grabcut interactive image segmentation method.

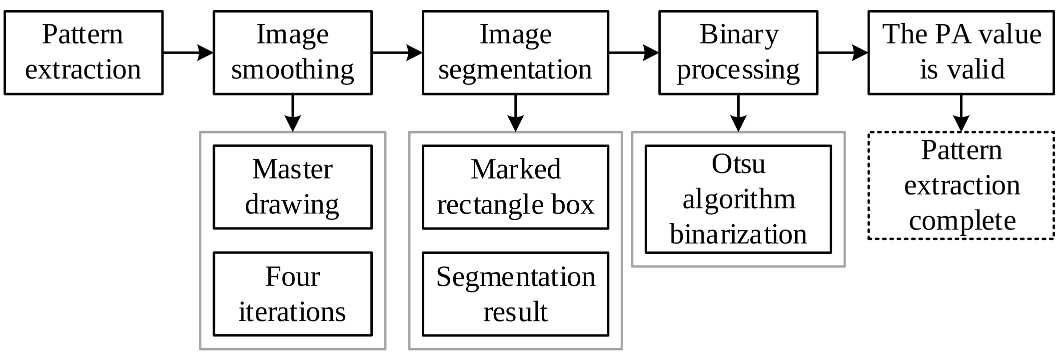

Figure 1: Feature extraction process

3.1 Image Smoothing

In order to reduce the interference of the textile's own organizational texture on the pattern information processing, the relative total variation (RTV) model algorithm is applied in order to achieve the purpose of extracting texture smoothing, which aims at smoothing the texture in the image while preserving the prominent structures. The relative total variation formula at any point p in the image is as follows:

$$\sum_p \frac{\Phi_x(p)}{\Psi_x(p)+\varepsilon} + \frac{\Phi_y(p)}{\Psi_y(p)+\varepsilon} \tag{8}$$

where ε is a fixed constant, $\varepsilon > 0$, the main function is to ensure that the denominator is not 0, to avoid calculation errors. The windowed full and intrinsic variants of any point p in the image in the x, y direction:

$$D_x(f_p) = \sum_{q \in R(p)} h_{p,q} \cdot |(\partial_x f)_q| \tag{9}$$

$$D_y(f_p) = \sum_{q \in R(p)} h_{p,q} \cdot |(\partial_y f)_q| \tag{10}$$

$$L_x(f_p) = \left| \sum_{q \in R(p)} h_{p,q} \cdot (\partial_x f)_q \right| \tag{11}$$

$$L_y(f_p) = \left| \sum_{q \in R(p)} h_{p,q} \cdot (\partial_y f)_q \right| \tag{12}$$

where R_p is a rectangular region centered on p, q is any point in the variational region R_p, x, y is the partial differential of the pixel point q in the direction of x and y, respectively, and $h_{p,q}$ is the weight function defined according to the space:

$$h_{p,q} \propto \frac{exp(-((x_p - x_q)^2 + (y_p - y_q)^2))}{2\sigma^2} \tag{13}$$

p_x and p_y denote the horizontal and vertical coordinates of the point p, respectively, and σ controls the window space scale.

The RTV algorithm is modeled as:

$$\arg\min \sum_f [(f_p - S_p)^2 + \lambda \cdot RTV(f_p)] \tag{14}$$

In the above equation: S denotes the input furniture pattern, f denotes the image after the structure is extracted, and λ is a fixed regularization parameter, i.e., the smoothing degree coefficient.

From the above model, it can be seen that the degree of smoothing of the image by the relative full-variate algorithm mainly depends on two parameters, the smoothing degree coefficient λ, and the spatial scale parameter σ.

The smoothing degree coefficient λ is generally taken between 0.005-0.03, adjusting λ alone will not make the texture and noise effectively separated, only increase into the image may cause blurring, will not need to retain the texture, so need to be adjusted at the same time with the spatial scale parameter σ. The spatial scale parameter σ usually takes a value between 0 and 6, σ mainly regulates the spatial scale of the window, and the value is determined by the size of the noise or blotchy spots in the image, and increasing the σ can be very good at removing the noise interference and the blotchy spots in the image.

3.2 Image Segmentation Processing

GrabCut is an interactive image segmentation algorithm based on the graph cut implementation that requires the user to manually label the region to be segmented with a rectangle. In the outer image of the rectangle, it is defined as the background, while inside the rectangle, pixels are considered as possible background and foreground. Furniture patterns are not well connected between patterns and patterns and between patterns and organizations, and selective local segmentation of Ming and Qing dynasty furniture patterns is performed by the GrabCut algorithm.

The steps of GrabCut algorithm are as follows:

(1) One or more rectangles T containing the target are defined in the image, with the outer region of the rectangle serving as the background region T_B, and the inner region of the rectangle serving as the foreground region $T_F = \varnothing, T_U = T_B$;

(2) For any pixel within T_B n initialize the label $\alpha_n = 0$ as the background pixel; for each pixel within T_U n initialize the label $\alpha_n = 1$ as the "likely target" pixel;

(3) Clustering the foreground region T_F and background region T_B into K classes by k-means clustering algorithm, respectively, to obtain K Gaussian models in the GMM.

(4) Model the background and foreground by Gaussian mixture model (GMM) to obtain the initial values (π, μ, σ]) of the two GMM parameters θ, where π is the weights, μ is the mean vector, and the covariance matrix σ;

(5) Calculate the GMM component of each pixel within the foreground T_U, i.e., the RGB value of the target pixel n is brought into each Gaussian component in the target GMM, and the one with the highest probability is the one that is most likely to generate n, i.e., the first k_n Gaussian component of the pixel n:

$$k_n := \arg\min_{k_n} D_n(\alpha_n, k_n, \theta, z_n) \tag{15}$$

(6) For a given image data Z, training learning of GMM parameters is performed.

$$\underline{\theta} := \arg\min_{\underline{\theta}} U(\underline{\alpha}, k, \underline{\theta}, z) \tag{16}$$

(7) Segmentation is performed by a maximum-minimum flow algorithm to obtain the minimum energy.

$$\min_{\{\alpha_n, n\in T_U\}} \min_k E(\underline{\alpha}, k, \underline{\theta}, z) \tag{17}$$

(8) Repeat (4) to (7) to optimize the GMM model and segmentation results until the energy E reaches a converged state, thus outputting a high-quality image.

After image preprocessing and segmentation, objective evaluation of pattern segmentation accuracy requires the calculation of pixel accuracy (PA for short), which is the ratio of the number of correctly classified pixels to the total number of pixels.

$$PA = \frac{\sum_{i=0}^{k} p_{ii}}{\sum_{i=0}^{k}\sum_{j=0}^{k} p_{ij}} \tag{18}$$

p_{ij} is the total number of pixels with true pixel category i that are predicted to be in category j, and p_{ii} is the total number of pixels with true pixel category i that are predicted to be in category i.

3.3 Image binarization

Image binarization is a basic technique of image processing, which can retain sufficient feature information. An algorithm for determining the image binarization segmentation threshold (OTSU), can effectively binarize the image for the furniture pattern in the pattern and the color gap between the tissue is obvious, the use of Otsu algorithm on the pattern of a single target for segmentation. The algorithm is mainly based on the grayscale characteristics of the image, which is segmented into background and foreground parts to achieve a more detailed image processing effect. The main core idea is to find the maximized gray level k which is the threshold value of Otsu, and then divide the image into two colors, black and white, which are larger than the threshold value and smaller than the threshold value. The principle of the specific algorithm is as follows:

For a grayscale image F, consider it as an M×N matrix, i.e., pixels in the image with pixel values of (0, 255), and let n_i be the number of pixels with gray level i, and p_i be the probability of a pixel's gray level being i, then:

$$p_i = \frac{n_i}{n_0 + n_1 + \cdots + n_{255}} \tag{19}$$

$$\sum_{i=0}^{255} p_i = 1 \tag{20}$$

The segmentation thresholds for the foreground and background are denoted as k, the image is classified into two classes C_A (less than k) and C_B (greater than k) according to the thresholds, the probability of a pixel being classified into the classes C_A and C_B is p_A, p_B, respectively, the two classes are denoted as m_A and m_B, respectively, the cumulative mean of gray level K is m, and the global mean of the image is m_G.

Then there are:

$$p_A(k) \times m_A(k) + p_B(k) \times m_B(k) = m_G \tag{21}$$

$$p_A(k) + p_B(k) = 1 \tag{22}$$

According to the concept of variance, the expression for variance is:

$$\sigma^2 = p_A(k)(m_A(k) - m_G)^2 + p_B(k)(m_B(k) - m_G)^2 \tag{23}$$

Substitution of values is calculated to obtain:

$$\sigma^2 = p_A(k)p_B(k)(m_A(k) - m_B(k))^2 \tag{24}$$

Among them:

$$p_A(k) = \sum_{i=0}^{k} p_i \tag{25}$$

$$p_B(k) = \sum_{i=k+1}^{255} p_i \tag{26}$$

$$m = \sum_{i=0}^{k} i p_i \tag{27}$$

$$m_G = \sum_{i=0}^{255} i p_i \tag{28}$$

$$m_A(k) = \frac{\sum_{i=0}^{k} i p_i}{p_A(k)} \tag{29}$$

$$m_B(k) = \frac{\sum_{i=k+1}^{255} i p_i}{p_B(k)} \tag{30}$$

The above equation can be deformed as:

$$\sigma^2 = \frac{(m_G * p_A(k) - m)^2}{p_A(k)(1 - p_A(k))} \tag{31}$$

The threshold k that maximizes the variance between classes is obtained by traversal. After obtaining the maximum threshold value the image is segmented by binarization:

$$img(i,j) = \begin{cases} \max val & if \quad img(i,j) > threshold \\ 0 & otherwise \end{cases} \tag{32}$$

After Otsu algorithm to get the binarized image, the target image is separated from the background color, and the final binarized result is presented in black and white to retain the foreground target image to the maximum extent.

4 Experimental results of Ming and Qing furniture pattern extraction

4.1 Ming and Qing furniture image database construction

The extraction and quantification of Ming and Qing furniture color features and pattern features require a large amount of image materials, so it is necessary to collect and organize images in an all-round way, and obtain a large number of Ming and Qing furniture image materials through literature review, field visits, network query and other means. And then screening and adjustment, delete the color distortion, unclear, obvious color difference and other images that will have a greater impact on the study, remove the background, clutter, etc. on the image, so that the image is clear, perfect, and reduce the impact on the subsequent clustering results. Finally, a total of 200 Ming and Qing dynasty furniture picture materials were obtained.

4.2 Ming and Qing furniture pattern main color extraction results

4.2.1 Single Image Color Extraction

Taking a single Ming and Qing dynasty furniture pattern as an example, the color results obtained from the extraction are shown in Table 1, the pixel area of all 12 color blocks are recorded, the color block percentage is calculated and plotted in a table, which results in the RGB values of the furniture extracted colors and their color percentage. Among them, the proportion of navy blue, dark blue and black is large, accounting for more than 10%, and the proportion of navy blue in the single Ming and Qing dynasty furniture pattern reaches 32.9%, and the Ming and Qing dynasty furniture dominated by the navy blue pattern gives people a sense of serenity and elegance, and the rustic sense of the era is expressed in the best way.

Table 1: individual furniture image color extraction results

Color serial number	Color	R	G	B	Pixel area	Proportion
1	Navy blue	36	33	55	8320	32.9%
2	Dark blue	46	47	77	3322	13.1%
3	Black	41	32	44	2929	11.0%
4	Light blue	94	128	199	1922	7.2%
5	Cowboy blue	61	102	175	1531	6.3%
6	Sapphire	43	70	125	1520	5.8%
7	Milky white	232	218	201	1500	5.6%
8	Lake blue	125	156	203	1313	5.5%
9	Red	172	48	74	1105	3.8%
10	Gray	92	74	94	838	3.4%
11	Bright pink	222	32	118	728	3.2%
12	Purple pink	165	75	160	632	2.1%

4.2.2 Multi-image color extraction

Multi-image color extraction uses the single image color clustering results as the source map, i.e., the extracted color of each image is used to construct a fusion map, the fusion map is clustered and analyzed to extract the main colors, the extraction mode is set to be the main color priority mode, and when extracting the fusion colors, the percentage of the extracted colors is emphasized. Since the extraction results will be used for subsequent color relationship network establishment, the number of Ming and Qing furniture extracted is set to 15 with reference to the conclusions of related studies.The color extraction results of multiple images are shown in Table 2.

The color of Ming and Qing dynasty furniture patterns is relatively single, mainly black and navy blue, mostly as the base color, accounting for 37.6% and 18.2% respectively. In addition, dark blue is also often used as the base color of Ming and Qing furniture, and the two shades of dark blue account for 10.4% and 7.1% respectively. In addition, there are white, red, dark green, etc., which account for a relatively low percentage, and are often used in the furniture pattern of the pattern, decoration and other parts. The study found that the traditional base color of Ming and Qing dynasty furniture, mostly black, mainly black or green-black, due to subtle differences in materials, techniques, etc., the base color of the furniture will have small differences.

Table 2: Multiple image color extraction results

Color serial number	Color	R	G	B	Proportion
1	Black	40	38	41	37.6%
2	Navy blue	43	51	62	18.2%
3	Deep blue	46	65	89	10.4%
4	Sapphire	39	98	172	7.1%
5	Navy blue	44	70	129	5.8%
6	White	240	236	234	3.9%
7	Red	180	54	54	3.0%
8	Dark green	26	69	46	2.4%
9	Azure	90	176	210	2.3%
10	Gray	133	131	135	2.1%
11	Pale red	229	53	38	1.9%
12	Pink	196	97	116	1.8%
13	Earth yellow	233	180	72	1.6%
14	Light yellow	242	246	117	1.4%
15	Pale green	45	189	107	0.5%

The color extraction results of 100 randomly selected single images of Ming and Qing dynasty furniture, the RGB values extracted from each image were recorded in an Excel table, which was imported into the data analysis software Matlab, and a three-dimensional scatter plot was drawn, and the drawing results were shown in Fig. 2, which can clearly and intuitively reflect the color characteristics of Ming and Qing dynasty furniture. The pattern colors of Ming and Qing dynasty furniture are more often used in blue, green and other cold tones. Image extraction of the main color has a more obvious distribution characteristics, that is, similar color points are more obvious cluster distribution. Specifically, the black squares appear frequently and densely formed a group, which says that the people of the Ming and Qing dynasties on the preference for black and the frequent use of black, black is the most commonly used colors, fully expresses the Ming and Qing furniture conveyed in the “black” culture, but also explains the importance of the black in the furniture of the Ming and Qing dynasties. In addition to black, blue and red also show more obvious characteristics of the group.

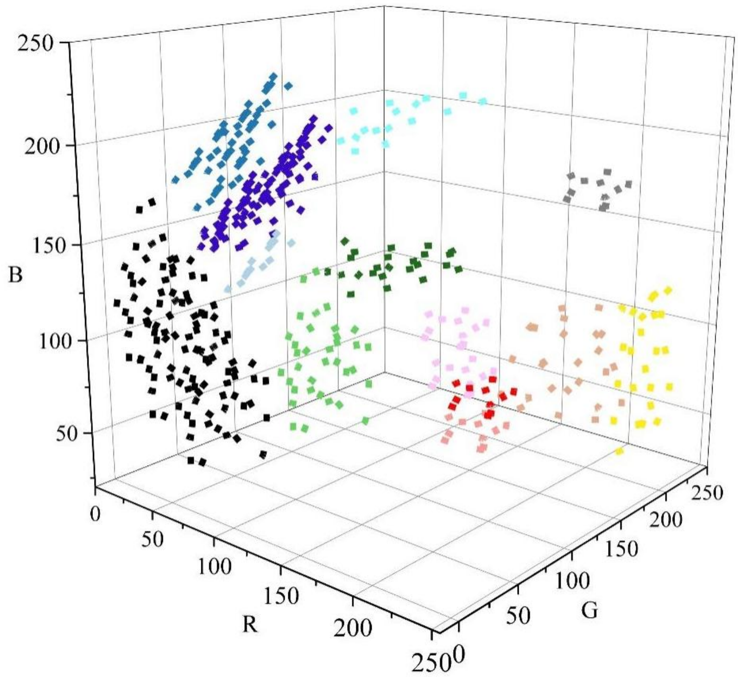

Figure 2: Color distribution three-dimensional scatter diagram

By extracting the characteristic colors of Ming and Qing dynasty furniture, the frequency and proportion of the appearance of characteristic colors can be obtained, but it is not possible to form the connection between the characteristic colors, so the concept of complex network is introduced in order to form the color relationship, and the network model of color relationship of Ming and Qing dynasty furniture is shown in Fig. 3. The purpose of constructing the color relationship network model is to clearly express the collocation relationship and frequency between the characteristic colors through its network structure, and to study and obtain the way of using color combinations. At the same time, the complex and diversified color composition elements are condensed into a relationship network, which helps to interpret the color usage paradigm in the furniture culture of the Ming and Qing Dynasties, which in turn is conducive to the innovative application of the new Chinese furniture design.

The construction of the color relationship network is mainly divided into two steps: (1) primary color selection, i.e., to find out the multiple colors with the highest proportion in the image of the research object. (2) Secondary color selection, that is, to find out the colors that form a co-occurrence relationship with the selected primary color. In order to better represent the relationship between the colors, the color relationship network is constructed by drawing lines according to the frequency of color co-occurrence. The size of the circle reflects the proportion of a certain color, while the line represents the co-occurrence of the corresponding color in the source atlas, avoiding the arbitrariness and accidental nature of relying solely on subjective perception and judgment for color matching, and converting abstract color imagery into intuitive visual expression. In order to indicate the frequency of color co-occurrence more clearly, the higher the frequency of the two colors between the thicker line, the lower the frequency of the line is more thin.

The most frequent color co-occurrence of Ming and Qing furniture is black, blue, white, red and magenta, white, red and magenta, which account for a small proportion of the three colors, the reason why there are more lines is that these three colors are mostly used as decorative colors for patterns, accessories, etc., which have a high frequency of occurrence but a very low proportion. Tibetan blue, dark blue such a proportion of more, but fewer lines of color, mostly as a base color used in large areas, but also due to the Ming and Qing dynasty furniture of a variety of base colors, the base color will make the frequency of the appearance of a slight decline, so compared to the frequent appearance of other colors as a decorative color, the frequency of its appearance is low, ultimately leading to its co-occurrence with other colors of low frequency.

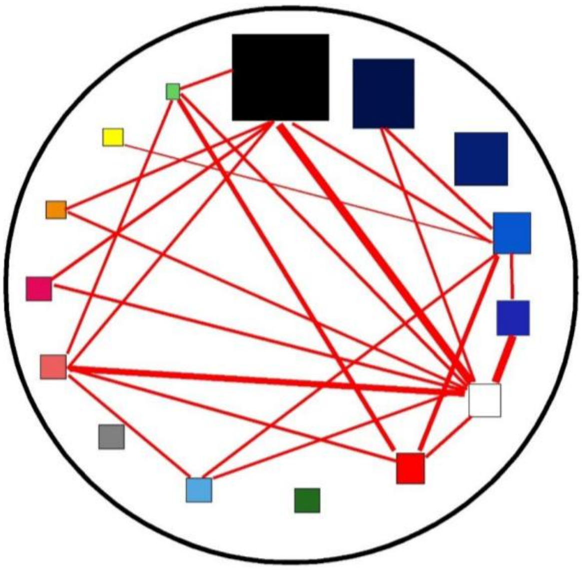

Figure 3: The color network of the characteristics of the qing and qing dynasties

4.3 Ming and Qing furniture pattern feature extraction results

In this section, the features of Ming and Qing furniture patterns are extracted. Firstly, FM transform is performed on the image. The result obtained after FM transform is decomposed using wavelet transform to obtain subbands of different frequencies. According to the mean μi and variance σ formulas, the energy of each layer is calculated to compose the feature vector. In order to test the effectiveness of this paper's algorithm with geometric invariance, a large number of experiments are carried out, all of which have achieved good results. The following is an example for illustration. Effective extraction of Ming and Qing dynasty furniture pattern of deformed exaggerated image is verified, and the experimental image is shown in Figure 4, in which Figure 4(a) is the original image of single tooth pattern, and the deformed image is from Figure 4(b) to Figure 4(i). Where Fig. 4(b) to Fig. 4(d) are the general geometric transformations of Fig. 4(a), Fig. 4(e) to Fig. 4(i) are the non-strict mathematical transformations of Fig. 4(a), and Fig. 4(j) is the different categories of tattoos, which are used to validate the difference of features. Using the method of this paper for feature extraction, the feature vectors are listed in Table 3.

From these seven feature vectors, it can be seen that the difference in the approximation from Fig. 4(a) to Fig. 4(i) is not too big, which indicates that it belongs to the same category, but there is a difference, which indicates that there is a deformation. The difference between the features of Fig. 4(j) and Fig. 4(a) is large, especially the e_6 feature values are 17.4976 and 20.3176, which is a difference of 2.82, indicating that it is two kinds of patterns of different classes. That is, the features of the tattoos extracted to the same class are similar, while the features of the tattoos of different classes are more different.

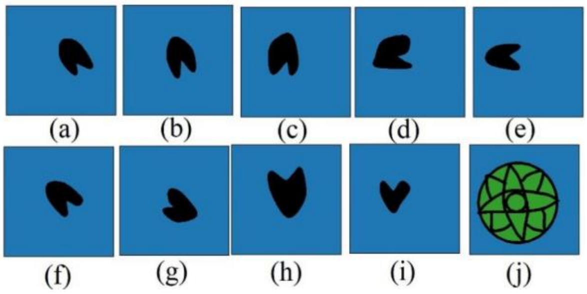

Figure 4: The image of the picture of Ming and qing furniture

Table 3: Multi-scale characteristics of deformed images

Image	Eigenvalue						
	e_1	e_2	e_3	e_4	e_5	e_6	e_7
a	0.10986	3.0629	4.7340	2.7241	1.4754	17.3756	1.4095
b	0.10962	3.2096	4.718	2.9354	1.7347	17.4095	1.6479
c	0.10936	3.3421	4.7247	3.1307	1.8577	17.4418	1.9063
d	0.10953	3.4745	4.6901	3.1116	1.8994	17.2139	1.8343
e	0.10924	3.2025	4.6673	2.8908	1.7195	17.5569	1.5783
f	0.10929	3.1723	4.6904	2.8067	1.5740	17.2910	1.4336
g	0.10966	3.3388	4.7517	3.0486	1.8078	17.1972	1.7574
h	0.10875	3.2725	4.5930	2.8868	1.7016	17.5564	1.7269
i	0.10983	3.1864	4.5561	2.7598	1.5744	17.4976	1.4310
j	0.11667	4.4353	5.7549	4.2754	3.1183	20.3176	3.0806

The pattern is illustrated as an example, and 256-color images are still used here for the experiment. Fig. 5(a) is the original image, and Fig. 5(b)~(d) are all noise-added images of Fig. 5(a). Figure 5(b) is pretzel noise with variance of 0.05 added. Figure 5(c) has Gaussian noise with a variance of 0.05, while Figure 5(d) has random noise added. The experimental results are listed in Table 4. For the same image under different noises, e_1 in the table shows that the features extracted by this paper's algorithm are more similar, with a difference of no more than 0.002, which has good robustness.

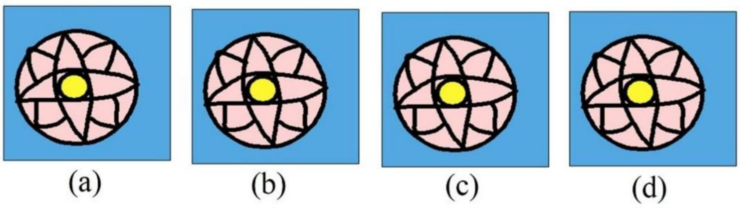

Figure 5: Noise image

Table 4: Noise effect

Image	Eigenvalue						
	e_1	e_2	e_3	e_4	e_5	e_6	e_7
a	0.15142	9.7553	11.2901	9.6503	8.4437	39.9937	8.3319
b	0.15294	10.3385	11.7358	10.3021	9.1384	41.5957	8.9614
c	0.15251	10.1661	11.5813	10.0829	8.9382	41.1515	8.9051
d	0.15288	10.102	11.4545	9.9426	8.8304	40.6157	8.8016

5 Application of traditional Ming and Qing furniture patterns in new Chinese furniture

5.1 Direct application method

Direct application method is through the traditional carving process will be the traditional carving pattern of Ming and Qing dynasty furniture directly applied to modern humanized furniture products. Ming and qing dynasty furniture traditional carving pattern has its own unique meaning, the application of appropriate can make the new chinese furniture both novel and rich cultural flavor. But the direct application does not mean that the traditional pattern is rigidly copied, in order to retro and retro, resulting in the lack of traditional cultural connotations. Ming and Qing dynasty furniture traditional carving patterns and the integration of new Chinese furniture is a gradual process, the need for traditional carving patterns of Ming and Qing dynasty furniture behind the meaning of in-depth understanding of the combination of modern aesthetic, the appropriate carving patterns applied to the appropriate furniture, in order not to appear out of the blue in the case of the combination of traditional and modern in the new Chinese furniture seems more natural.

5.2 Content distillation method

Although the traditional carving pattern of Ming and Qing dynasty furniture has a profound meaning, it is dull and cumbersome for modern young people, and is not accepted by most contemporary young people. In the design of new Chinese furniture need to refine the traditional carving pattern of Ming and Qing dynasty furniture, simplify and innovate. This innovation is manifested in two aspects, one is to refine the content of the pattern after streamlining as a local decoration. The second is through the modern level of science and technology and the designer's brain to refine the content of the two-dimensional to three-dimensional modeling of the abstract transformation of the traditional cultural meaning of inheritance and carry forward.

5.3 Disassembly and reorganization method

Combination of traditional culture and modern design ideas, not only to take into account the connotation of traditional culture, but also to reflect the “new” furniture products. The process of combining the two needs to be the deep meaning behind the traditional carving patterns of Ming and Qing dynasty furniture to be excavated, on the basis of which the pattern is disassembled and reorganized, the modern elements into it, to achieve the traditional pattern and modern thought collision, this collision has two forms, one is the ancient and modern, the old and the new form of close combination of traditional carvings of Ming and Qing dynasty furniture patterns in the application of the new Chinese furniture through the new color, new materials, new colors, new materials, new techniques and new decorative language for new elaboration. The other is to reorganize the traditional carving patterns of Ming and Qing dynasty furniture with relatively stable connotation into symbols acceptable to contemporary young people, so that the traditional carving patterns of Ming and Qing dynasty furniture have the characteristics of today's era.

5.4 Application of Evaluation Methods for Imitation Ming and Qing Style Furniture

According to the results of the study, the process of the evaluation method was sorted out, and when the evaluation of the imitation Ming and Qing-style furniture was carried out, the physical quantities of its material color were firstly measured and calculated. Then the imitation Ming and Qing style furniture is subjected to target user eye tracking experiments, hot spot image feature extraction is performed, and the values are counted and brought into the equation. Then evaluation is carried out according to the results. The evaluation corresponding indexes are shown in Table 5.

Table 5: Evaluation index

Color characteristics	Texture characteristics	Test result	Evaluation result
Not in the traditional color range	/	d(t)>0	The definition of the furniture of the new Chinese style chair is not in conformity with
		d(t)<0	New Chinese style chair furniture
Brightness range 21.61-37.83	/	d(t)>0	The definition of the furniture of the new Chinese style chair is not in conformity with
		d(t)<0	There are new Chinese style chairs with traditional, noble, rigid and heavy feeling
Brightness range 21.61-31.79	The texture is not clear	d(t)<0	A new style chair furniture with a sense of simplicity
Brightness range 31.00-37.83	Clear texture	d(t)<0	A new style chair furniture with gorgeous sense
Brightness range 42.52-59.28	/	d(t)>0	The definition of the furniture of the new Chinese style chair is not in conformity with
		d(t)<0	There is a new style chair furniture with light, concise and warm sense
	Clear texture	d(t)<0	A new style chair furniture with natural, elegant and concise sense

6 Conclusion

In this study, a main color extraction method of Ming and Qing dynasty furniture patterns based on lion group optimization K-means algorithm and a pattern extraction method based on relative total variation model texture smoothing and Grabcut interactive image segmentation are designed to provide a new method for the design of new Chinese furniture.

The results of the main color extraction of the pattern of Ming and Qing dynasty furniture show that the pattern color of Ming and Qing dynasty furniture is relatively homogeneous, with black and navy blue accounting for 37.6% and 18.2%, respectively, as the main design colors of Ming and Qing dynasty furniture. White, red, dark green and other colors are often used in the pattern of Ming and Qing furniture patterns, decorative design part, so it accounts for less than 5%. In this paper, the method effectively extracts the color characteristics of the Ming and Qing furniture patterns, and visually presents the relationship between the colors of the Ming and Qing furniture patterns by means of network co-occurrence diagrams, so as to better promote the technological innovation of the new Chinese furniture design.

The seven eigenvectors of the Ming and Qing furniture pattern features show that the approximate values of the same kind of deformation patterns do not differ much, but there are some differences, and the eigenvalues of the different classes of patterns differ greatly, and the e_6 eigenvalues of some of the graphs differ by 2.82. The feature values of the same image extracted by this paper's method under different noises are also relatively similar, with a difference of no more than 0.002, which shows that this paper's pattern extraction method based on the relative total variation model texture smoothing and Grabcut interactive image segmentation has good robustness and has a good application prospect in the field of new Chinese-style furniture design.

In summary, this paper designs the specific application methods of traditional Ming and Qing furniture patterns in new Chinese furniture from three aspects: direct application, content extraction, disassembly and reorganization, and describes the evaluation methods of imitation Ming and Qing furniture.

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