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Research on the Construction and Application of Color Model of Huizhou Architectural Painted Murals

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Abstract:

When designers conduct design research on the Huizhou architectural painted murals as a subject, they often only use their personal senses to extract and match colors, therefore, it is inevitable that there will be deviations in the restoration of color matching. In this paper, an extraction method of color model for Huizhou painted murals was proposed, and based on the principles of graph theory and by using the co-occurrence relationship between characteristic colors, a color network model and primary and secondary color network models were established. By establishing a big data image database of Huizhou murals, the characteristic colors of image colors of K-means cluster were extracted, and using VBA language based on Illustrator platform, a color extraction system and automatic color matching population generation engine were developed, which can assist designers in batch generation of plane design schemes and product development that embody color imagery in combination with color network model. Conclusion Taking the color of Huizhou architectural painted murals as an example, the innovative color matching of Huizhou murals and their application in product design were tested. The results show that this method can highly restore the color expression in Huizhou architectural painted murals, which provides a new idea for innovative application of Huizhou painted murals.

Keywords:

Huizhou Painted Murals, Color Model, Pattern Design

1. Introduction

The decorative art of Huizhou architectural painted murals has been recreated through a long history. It reflects the strong local characteristics and deposits the rich spiritual feelings of the people of Huizhou. It appears as color paintings in various architectural forms such as houses, ancestral halls, temples, lounge bridges, theatre pavilions, and pavilions in Huizhou, and they are widely distributed in different forms and in different regions. The color paintings in Huizhou area are divided into Jiangnan bundle brocade paintings and the paintings of natural conditions and social customs of

a place. Official color paintings are mainly applied to architectural components such as ancestral halls and academies of classical learning. They emphasize the order of colors and forms, and expresses the Huizhou people's idea of respecting the ancestors and respecting Confucianism. At present, the domestic research on the colors of Huizhou murals focuses on the discussion of painting, artistic style and decorative language. Most of the unique style and color harmony of Huizhou painted murals are generalized text outlines. Usually, the methods of "formal aesthetic rules" and "decorative color structure" [1] are used to subjectively describe the law of color distribution, and to perceptually combine and match the colors according to the order of decorative colors. They are mainly based on empirical cognition, lack systematic research on "colorology" and "iconography", and mostly are simple imitation and repetition. The construction of the color network model can help designers clearly extract and define color characteristics, rationally mine the color characteristics and connections of Huizhou painted murals, and provide a reference basis for product innovation expression design with Chinese excellent traditional culture content.

2. Overview of Complex Networks and Color Networks

The complex network theory and complex network model based on the complex system and its network structure are inspiring for the design of product culture expression. By studying various topological structures and properties of complex networks, the operation mode based on complex networks can be understood and explained, and then the behavior of the networks [2] can be predicted and controlled to provide designers with the required services.

2.1. Complex Network Model

Through research, it is found that there are a large number of complex systems in nature described by networks, and the corresponding complex networks are also very similar in structure. The current complex networks are mainly divided into random networks, small-world networks and scale-free networks according to their structural characteristics. Structure determines functions. Research reveals the internal connection between complex network functions and structure. It has important application value in assisting designers to precisely control perceptual imagery in the design field. At present, the network cluster structure [3] is one of the important attributes applied to describe the complex network structure.

As one of the most common and important topological attributes of complex networks, the network cluster structure is defined as the densely connected branches of the network. It has the characteristics of dense connections within the clusters and relatively sparse connections between clusters. The complex network clustering method that reveals the network cluster structure is very instructive for understanding and explaining the hidden laws and operation modes based on the complex networks, and then inferring and controlling the behavior of the networks.

2.2. Color Network

Color is one of the main features of an image, and the extraction method is relatively mature, which can accurately extract the number of characteristic colors, color values and the proportion of each color from the image. The application goal of the color network model is to seek to extract the matching relationship between colors through its network structure, and to study the combined use of extracted colors to assist designers in interpreting the complexity and diversity of color components [4],

and then to innovate application of traditional culture. The basic idea is as follows: first abstract the topological structure of the color network starting from the complex network theory, and then use the color network to express the product of color extraction, that is, the extracted characteristic colors are represented by nodes, and the connecting lines between the characteristic color nodes represent a collocation relationship in which the frequency of co-occurrence exceeds a certain threshold between two characteristic colors. This is of great reference value for designers to carry out creative activities.

3. Color Extraction of Huizhou Painted Murals and Network Construction and Application Process

When constructing and applying the color network of painted murals, clustering provides the main technical support for color extraction. When applied to color, the multiple characteristic color areas generated by clustering are a collection of color objects with similar color information. Then extract the most representative colors in the color areas for application, calculate the weights of the extracted colors to find the key nodes, determine the main color, and use the principles of graph theory and complex network theory to determine the strong relationship group so as to establish the relationship network between main and auxiliary colors. Understand the internal logic of the color composition of Huizhou painted murals, deeply interpret the form composition factors of Huizhou painted murals so as to provide designers with color library and color relationship references, generate plug-ins in combination with intelligent color matching, and generate color matching population schemes so as to assist designers in creative activities. The color extraction, network construction and application process of Huizhou painted murals are shown in Figure 1.

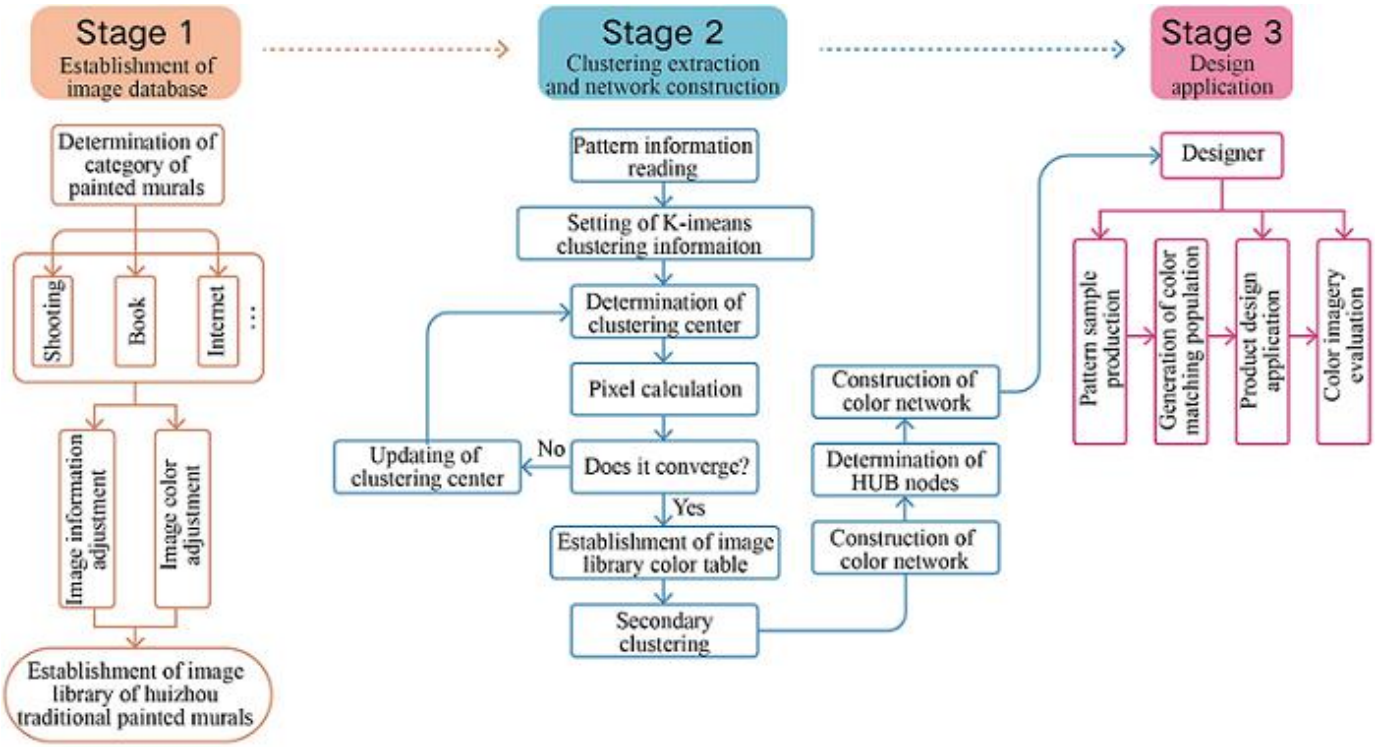

Figure 1. *The color network construction and design application process of Huizhou painted murals.*

4. Color Extraction of Huizhou Painted Murals and Construction of Color Network Model

4.1. Establishment of Image Library of Huizhou Painted Murals

There are a large number of Huizhou painted murals, they are scattered in the ancient buildings in various regions of Huizhou. The colors are complex and the relationships are subtle. They are suitable for analysis by cluster extraction and color networks. The author understands Huizhou painted murals through reading literature and books, and based on this, has obtained more than 100 representative Huizhou murals by downloading network images, scanning pictures in books, field shooting, etc. During the screening process, images with large changes in light brightness, presence of perspective (color changes in brightness), and obvious adjustments in the later period will not be included in the image library; Make adjustments to the images in the library similarly, remove the watermarks from some images with watermarks to ensure the accuracy of color extraction; Adjust the brightness of some images, and restore them to the original colors of the murals to ensure the authenticity and accuracy of the data. (Part) of the images in the image library of Huizhou painted murals are shown in Figure 2.

Figure 2. *(Part) of image library of Huizhou painted murals.*

4.2. Color Cluster Extraction of Huizhou Painted Murals

4.2.1. Color extraction Technology of Single Images

For the color extraction of single images, the K-means clustering method is used to extract a set number of colors from all the pixel color information in any image in the image library as the source data. K-means clustering is a relatively simple clustering method. K represents the number of objects in the cluster. After determining the appropriate K value and initial clustering center, the data is classified, and then the characteristics of different data clusters are studied separately. The clustering process based on the K-means method is shown in Figure 3. Because the color composition of Huizhou painted murals is relatively rich, the theme colors of the images are clear, but the color elements are not single, so in the color extraction of Huizhou painted murals, the RGB color grayscale mode is selected for extraction, and the extraction color is set to 12 colors. K=12; Select characteristic colors at equidistant and equal angles along the hue circle in the hue mode as the initial clustering centers. Computer technology is used to calculate the distance between any pixel color and the clustering center, and

include it in the category of the nearest clustering centers to form 12 characteristic color clusters.

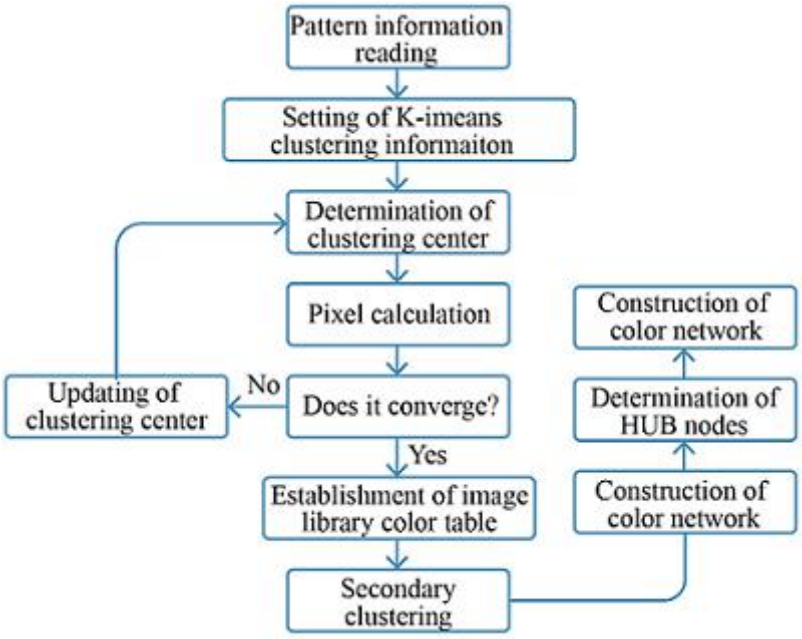

Figure 3. *Color clustering extraction process.*

In the extraction process, process the pixels in the image as coordinates in the RGB color space, and define the mean square error as a measurement function for the 12 color clusters, and calculate the measure function value in each cluster. If it does not converge, calculate the color mean value of the color cluster, replace the clustering center with this value and re-cluster until the measure function converges. Re-clustering is an iterative process. When the calculated maximum distance between the clustering center and the last clustering center is less than a fixed threshold, terminate the iteration. The judgment formula is:

$$D_{max} = \sqrt{([C_r]' - [C_r])^2 + ([C_g]' - [C_g])^2 + ([C_r]') - [C_b]^2}/\sqrt{3 \times 255^2}$$

(1) D_{max} is the maximum distance between each clustering center this time and the last clustering center, that is, calculate the distance between each type of center and the last time, respectively, and take the maximum value;

(2) $[C_r]'$ $[C_g]'$ $[C_b]'$ are the RGB values of clustering center this time; and $[C_r]$, $[C_g]$, $[C_b]$ are the RGB values of the last clustering center;

(3) $\sqrt{3 \times 255^2}$ is the length of the diagonal line of the three-dimensional color space, that is, the maximum possible distance value. Dividing the absolute distance by the maximum distance is to convert the distance into a relative index between 0→1 for easy evaluation;

(4) $[D]$ is the judgment threshold, the selection of judgment threshold $[D]$ is based on the smallest difference that can be recognized by the human eyes, which is an empirical value, and the value is taken as 0.05 in this paper. The clustering form of a single image is shown in Figure 4.

Figure 4. *Characteristic color extraction of a single image.*

4.2.2. Color Extraction Technology for Multiple Images

The extraction of multiple images is based on the secondary K-means clustering of the color extraction result set of a single image. Based on a large number of samples from a certain type of image library (image library of Huizhou painted murals), a series of characteristic colors of color imagery representative of this type of image set is extracted. The output result of a single image extraction is a rectangle composed of 12 characteristic colors of different proportions, which can be regarded as a new image. More than a hundred extracted color images are combined to form an extracted fusion color library as shown in Figure 5.

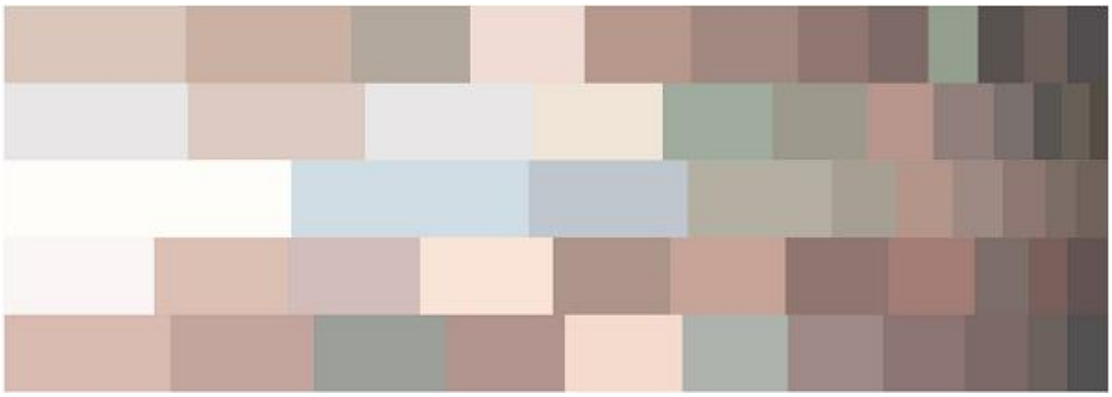

Figure 5. *(Part of) color library of mural images extracted by color clustering.*

Secondary K-means clustering is performed on the fusion color library, the mode is the primary color priority mode, and when extracting the fusion color library colors, consideration is focused on the proportion of the final extracted color in the fusion map. When performing the second K-means clustering, K is set to be 20, and the final 20 characteristic colors are extracted. See Table 1 for the color information of 20 representative clusters. Through investigation, it is preliminarily verified that the series of characteristic colors output can basically express the color characteristics of Huizhou painted murals.

Infomation of 20 representative cluster colors						
Color block	RGB values	proportion %	Color block	RGB values	proportion %	Pie chart
	255.253.251	12.6		161.137.129	3.8	 Pie chart for proportions of extrated colors of secondary cluster
	208.221.228	10.7		127.107.102	2.7	
	233.230.231	9.1		157.153.139	3.3	
	219.198.187	7.8		144.117.112	2.7	
	217.187.179	7.2		120.96.90	3.4	
	196.165.157	5.3		89.81.78	2.5	
	158.159.155	6.8		143.120.115	2.8	
	181.148.143	4.6		96.83.82	2.5	
	192.198.207	5		83.81.81	2.4	
	161.172.159	4		114.98.93	0.8	

Table 1. *Color information of 20 representative clusters.*

4.3. Construction of Color Network Model

Extracting the characteristic colors of murals by establishing a color library can provide designers with color choices and obtain the frequency and proportion of the occurrence of characteristic colors, but it is impossible for designers to understand the relationship between characteristic colors; Color matching is not just a mix and match following the color rules. In order to restore the imagery beauty of Huizhou painted murals, it is necessary to find the relationship between characteristic colors. Therefore, the complex network concept is introduced to express the relationship between the extracted colors, and provide assistance for the designer to carry out color creative activities. In the color matching process, it is necessary to determine the theme color of the design scheme, that is, the main color lays the foundation for the overall style imagery of the scheme, and then match with several or more auxiliary colors, which are simple but not monotonous, to show the uniqueness of Huizhou colors. Therefore, when constructing the color network, it is first necessary to construct a complex network of relationships between characteristic colors; Based on the relationship network, through the determination of the main color, the main and auxiliary color relationship network between the main color and its auxiliary colors is constructed. The color relationship network diagram is shown in Figure 6.

In the constructed color relationship network in Figure 6, 20 nodes represent the 20 characteristic colors extracted by clustering, and the size of the node, that is, the size of the circular color block, represents the weight of each characteristic color (that is, the color weight in the main color mode); The connecting line between the nodes indicates that the two characteristic colors co-occur at a certain frequency in the color library map. The co-occurrence frequency threshold is set in advance, and the co-occurrence is achieved when the threshold is exceeded. After many tests, the author

found that the threshold 0.4 network constructed is the most stable, so the threshold is set to 0.4. The determination of the main color needs to consider the color relationship and the weight of the characteristic color. Therefore, an expert team was formed to screen the four characteristic colors of 01, 02, 03, 04 with the largest weight. After discussion, because the lightness of the 01 characteristic color is higher than the other three characteristics The color is higher, which can highlight the design, and at the same time, the weight is the largest, which is most in line with the image of the mural. Therefore, the 01 characteristic color is determined as the main color and the auxiliary color is selected.

After the main color is determined, the selected auxiliary color node should have a strong co-occurrence connection relationship with the main color node. Set the threshold of the relationship. According to the definition of the strong and weak relationship group in the closure principle of graph theory, if among the nodes, they are connected in pair, a strong relationship group will be formed. The stronger the embeddedness, the greater the trust relationship, that is, the closer the color relationship; Therefore, the multiple characteristic color nodes of the main color and the auxiliary color need to achieve connection in pairs. If the requirement is not met, the threshold of the node connection relationship needs to be lowered and the network needs to be rebuilt; According to the final design requirements, determine the number of auxiliary colors, which is generally not less than 2 auxiliary colors, in this paper 3 auxiliary colors are chosen; Use 01 characteristic color as the main color to choose three auxiliary colors, there are two schemes (05,13,14) and (06,17,18), and use the black and red connecting lines to distinguish and represent the main and auxiliary color. The selection networks are shown as in Figure 7.

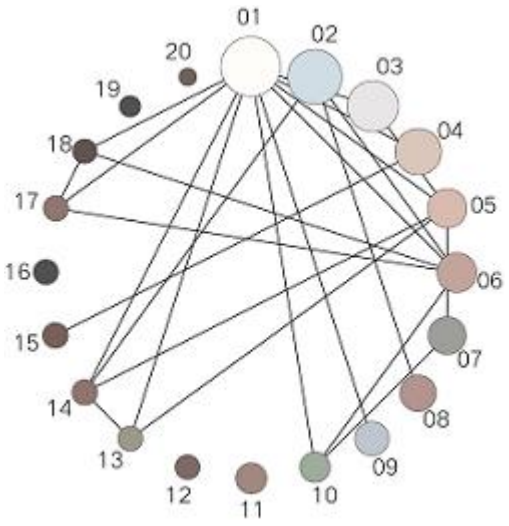

Figure 6. *Color relationship network construction diagram.*

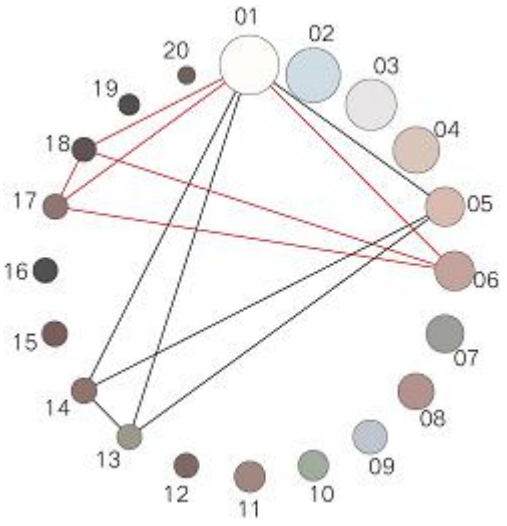

Figure 7. *Primary and secondary characteristic color selection network.*

5. Network Model Assisted Color Matching Design

The patterns and decorations of Huizhou murals are rich but not chaotic, and orderly, and contain unique modeling rules [5], with distinct levels and unified forms. Design line drafts based on Huizhou painted mural patterns and mural modeling [6], and select the first scheme in the color selection network of the main and auxiliary characteristic colors for preliminary color matching and pattern color scheme; The

color matching in the color matching scheme is constructed based on the main and auxiliary color selection network, and eight pictures with rich colors are selected from the remaining characteristic colors, and are filled with colors using the Illustrator software, and the same color area patterns are grouped to form object groups. The generated color combinations are applied to the patterns, as shown in Figure 8. The generated color matching basically conforms to the color imagery of Huizhou painted murals, and plays an auxiliary role in the designer's creative activities.

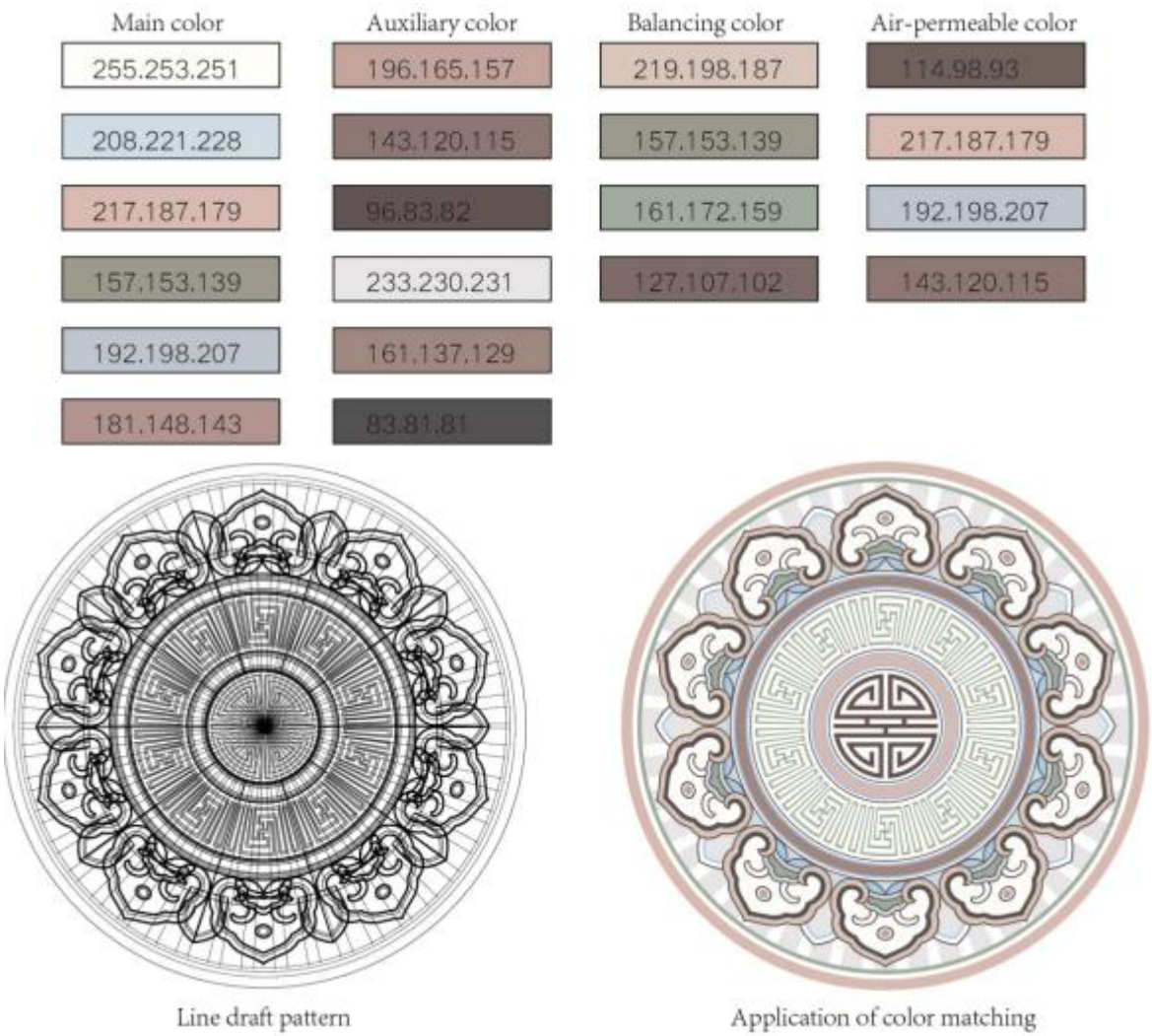

Figure 8. *Pattern color matching scheme and application.*

6. Conclusions

The colors of Huizhou painted murals have a unique charm of geographical features, which have great research and redesign value. Through the establishment of the image library of Huizhou painted murals, the characteristic colors are extracted and color network is constructed, the color matching relationship is found by the scientific method, and the unique color features of the Huizhou painted murals are presented through a rational way of thinking, thereby assisting the designer to conduct design. Experience has proven that they can effectively improve the designer's color matching efficiency and accurately reflect the cultural imagery of Huizhou painted murals; Applying the redesigned patterns to product design is the inheritance and development of traditional mural culture, so that the beauty of Huizhou painted mural

colors can be effectively active in modern life, and can effectively promote the harmonious co-prosperity of traditional mural culture and modern civilization. It provides a new idea for the development of Huizhou traditional mural culture.

There are still some shortcomings in the research model of this paper. First, the author's team has limited understanding of Huizhou painted murals and lacks experts in Huizhou painted murals, which may cause the problem of insufficient representativeness of samples in the murals library; In addition, when the clustering threshold $[D]$ is set for expert evaluation, there is a certain error, which will have a certain impact on the stability and authenticity of the color network construction. Therefore, in the next step of the research process, it is necessary to add research experts of Huizhou color painted murals, and at the same time test the threshold setting so as to experimentally get a threshold setting method with a universal applicability, so that the construction of the mural color network model is more scientific.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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References

[1] Huang, C. Analysis of the image connotation and space environment of the architectural color painting of Chengzhitang in Huizhou. Decoration, 2015,04: 121-123.

[2] Yang, B.; Liu, D.Y.; Jin, D. et al. Complex Network Clustering Algorithms. *Journal of Software,* 2009, 20(1), 54-66.

[3] Liu, X.J.; Cao, Y.J.; Zhao, L.X. Color network models of traditional cultural patterns and color design aiding technology. *Computer Integrated Manufacturing System,* 2016, 22(4), 899-907.

[4] Liu, X.J.; Cao, Y.J. Interactive Instant Extraction Technology of Color Information Based on Mobile Terminal. *Packaging Engineering,* 2015, 36(12), 33-36.

[5] Huang, C.; Chen, J. Analysis of the Color Painting Art of Ancient Folk Houses in Yixian County, Huizhou. *Journal of Anhui Jianzhu University,* 2015, 03, 124.

[6] Ding, Q. An Analysis of the Creative Features of Huizhou Murals — Taking Folk Painted Murals in Guanlu Village, Yixian County as an Example. *Journal of Huangshan University,* 2014,16(2), 81-83.

[7] Zhang Y. Application of Chinese Traditional Patterns in Modern Design. *Packaging Engineering,* 2009, 30(4), 179-180+192.

[8] He, W.J. Research on the Traditional Production Technology of Colored Paintings of Ancient Buildings In The Ming Dynasty In Huizhou Area. *Journal of Nanjing University of the Arts,* 2014, 4, 117-120.

[9] Yue, J.F.; Jiang, W.W. The Artistic Comparison between the Color Paintings of Beijing Palace Architecture and the Local Architectural Paintings in Huizhou. *Beauty and Times (Chinese),* 2016, 2, 130.