Design Studies and Intelligence Engineering
L.C. Jain et al. (Eds.)

doi:10.3233/FAIA220707

Automatic Imagery Coloration and Regenerative Design of Ethnic Costume

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Abstract. The imagery colors of traditional ethnic costumes are unique and have great reference value for modern design. In this paper, 3 representative minority costume images of Miao, Tibetan, and Korean were respectively selected as imagery sources, and 20 different structure types of patterns were chosen as the object to be colored. Image pre-processing, adaptive color extraction, and multi-dimensional features extraction were executed to build a color nexus network model. Based on the color parsing results, an algorithm for color migration of clothing images was designed and developed, which could output multiple types of color schemes. The overall rating of each color scheme was compared to introduce the optimal scheme. Also, the experimental part tested the effect of the color schemes in various scenarios. The average pre-processing time cost of a single image is 0.05 seconds, the output time of the color network diagram is 0.38 seconds, and the output time of a single-color scheme is 1.44 seconds. The study can quickly provide an auxiliary decision for contemporary pattern color design.

Keywords. ethnic costume, color parsing, color nexus network model, automatic color matching

1. Introduction

Colour, pattern and structure are important visual expression features of ethnic costume. Imagery colors present strong visual conflict and differentiation, effectively representing the artistic characteristics of nation's costume. Color parsing and reuse of ethnic costumes can be an important solution in the excavation, transmission and promotion of traditional culture.

Current color researches on ethnic minority costumes mainly focuses on two aspects: artistic or aesthetic interpretation, and digital parsing. Gou et al. [1] analyzed the main colors composition of Huayao Dai costumes and the connection of cultural psychology; Chen [2] discussed the heritage and innovative design of Chinese ethnic costumes; Wang et al. [3] analyzed the color art of Korean costume from the perspective of art research;

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Yue et al. [4] tried to apply ethnic colors in product design. In recent years, the digital technology of image analysis has been gradually applied to the field of color analysis. Xu et al. [5] and Hagtvedt et al. [6] quantitatively analyzed the main colors extracted from ethnic costumes; Liu et al. [7-8] proposed an improved color network model to succinctly express the quantitative elements of color; Liu et al. [9] proposed a generative adversarial network-based automatic coloring model for ethnic costume sketching, which could obtain better coloring effects; Zhao [10], on the other hand, used an association rule algorithm to explore the color matching law in Miao costume color, which helps to explore and protect the color of Miao costumes. However, the current research on ethnic costume color still favors perceptual, and the scientific and innovative application of data samples on color characteristics is less.

This paper focuses on the objective quantitative analysis of the ethnic costume imagery colors and the format automatic coloration mechanism. Three representative chinese ethnic costumes were selected as case study. The color nexus network model was utilized to analyze the form of color composition and the inner correlation of each ethnic group. An automatic coloration of patterns based on the pattern modeling characteristics can be realized, and more user-oriented color schemes are recommended. It is vitally essential to improve the scientific and innovative application of ethnic costumes.

2. Imagery colors parsing

2.1. Imagery colors extraction

Certain pre-processing should be performed, which include illumination balance, costume area segmentation, and image denoising. In order to avoid the defects of excessive color equalization caused by fixed clustering centers, this study used an improved dichotomy K-means adaptive clustering (DKmeans) algorithm[11].

Imagery color extraction can be classified into two two stages: initial clustering and final clustering. The aim of initial clustering is to output the color fusion map of sequential scene images. Main colors of source scene image were extracted based on the DKmeans algorithm. Each image of an ethnic costume forms a row of colour bars, and, accordingly, the whole scene image forms a colour fusion map. On the basis of the color fusion images, the main color of each ethnic costume was extracted by final clustering. In order to facilitate designers to choose suitable imagery color number, the conventional K-means clustering algorithm was selected to realize the color clustering of custom cluster number. Overall schematic diagram was shown in Figure 1.

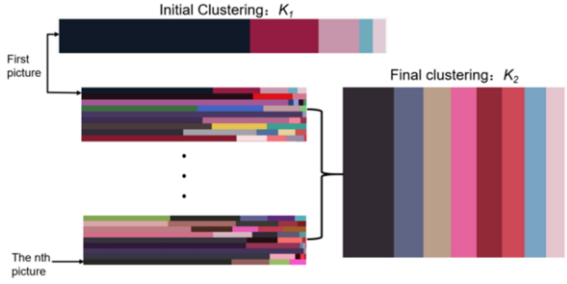


Figure 1. Extraction pipeline of comprehensive imagery colors.

2.2. Color nexus network model

Nexus network model[12] can visually express the interrelationship between costume imagery colors. The color matching of clothing not only contains color components, but also color features and coloration relationships. The color network model, which integrates several color characteristics, visualizes the color matching pattern of clothing. Moreover, color proportion, dual colors co-occurrence frequency, and color space distance form the core components of the color Nexus network model. The Creation process of color nexus network Model is shown in Figure 2.

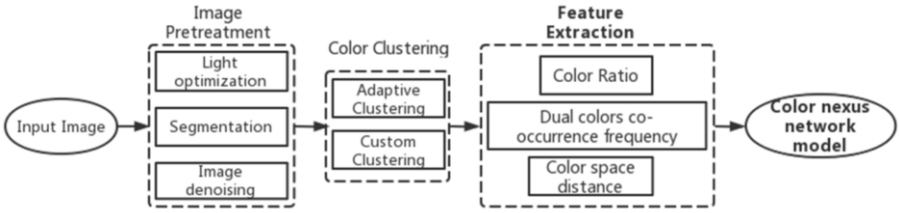


Figure 2. Creation Process of color nexus network Model.

Color nexus network model is organized in the form of a ring network. Final clustering clustering extraction colors are presented counterclockwise by ratio and each of them is a circle filled with the corresponding color; the bigger the circular patches are, the higher the color proportion. The line between the circular patches indicates the binary pair color co-occurrence relationship, and the thickness of the line reflects the size of the frequency. In addition, the increase of color difference values on the line is instrumental for users to obtain color relationships between binary color schemes such as contrasting or similar colors.

3. Automatic coloration scheme

Coloration mainly integrates harmonious theory[13-14] and scene colour relationships. Pattern independent units and their intrinsic structure similarities were analysed and correlated with the sequence of the imagery colour. The scheme consists of two parts: color matching, evaluation.

3.1. Color matching

In the color matching process, let input images number as P, and K_1 main colors were extract in the initial clustering stage, while K_2 was final clustering centers size. Therefore, source images output K_2 imagery colors to be matched. Let the independent area number as N, and the extraction of the main colors set as follows:

$$C = \{c_1, c_2, c_3, \ldots, c_{k2}\} \tag{1}$$

The set of pattern areas to be color-matched for the pattern artwork are:

$$A = \{a_1, a_2, a_3, \ldots, a_N\} \tag{2}$$

The color set elements are arranged in descending order by the percentage of the extracted colors, e.g., c_1 is the main color with the largest percentage of the extracted K_2 main colors. The elements in the region set are arranged in descending order according to the area of the region, e.g., a_1 is the region with the largest area to be matched.

Further, the color types are sorted according to user requirements, and different types of color matching effects can be formed, such as color matching based on extracted color proportion, color matching based on similarity, color matching based on contrast, integrated color matching, etc.

The automatic color matching mechanism currently only considers the number of main colors to be matched is greater than or equal to the number of color areas to be matched, that is, $K_2 \geq N$. After selecting N primary colors from K_2 extracted colors and filling in the area in the pattern, the number of extracted primary color groups is $C_{K_2}^N$; when filling in the color operation, the main colors in the color group are filled from the largest to the smallest corresponding to the area of the area to be matched, and finally a color scheme of $C_{K_2}^N$ can be obtained.

3.2. Evaluation criteria

Coloration evaluation combined harmonious theory and nexus relationship constructed above. Criteria formula is as follows:

$$H = \begin{cases} H_1, & H_1 \geq H_2 \\ H_2, & H_1 \leq H_2 \end{cases} \tag{3}$$

Where G indicates the harmonious part rating result; H_1 indicates the calculated rating result of similar color matching; H_2 indicates the calculated rating result of contrasting color matching. When the rating value of similar color matching is greater than or equal to the rating value of contrasting color matching, the rating result of harmonious rating is the rating value of similar color matching; otherwise, which is the rating value of contrasting color matching.

In the above formula, H_1 is the similar regular color matching evaluation factor, which contains three scores of color consistency, lightness consistency and purity consistency, which are expressed as h_1 , h_2 and h_3 respectively, and H_1 is calculated as follows:

$$H_1 = \alpha h_1 + \beta h_2 + \gamma h_3 \quad (4)$$

Where, α、β、γ is the allocation weight, can be set by the user according to the needs, the default is the average weight allocation, that is $\alpha = \beta = \gamma = 1/3$.

H_2 is the contrast color matching score, which includes hue contrast, lightness contrast, purity contrast and fill area contrast, respectively b_1, b_2, b_3 and b_4, and the H_2 calculation formula is:

$$H_2 = \chi b_1 + \delta b_2 + \eta b_3 + \lambda b_4 \quad (5)$$

Among them, χ、δ、η and λ are the assigned weights, which can be set by users according to their needs, and the default is the average weight assignment, that is $\chi = \delta = \eta = \lambda = 1/4$.

4. Empirical analysis of Color regeneration

In experiment, 200 source images of each ethnic costumes were chosen, including Miao, Tibetan and Korean for color paring and regeneration. These 600 costume samples were download from Chinese Ethnic Costume Museum (www.biftmuseum.com). The target objects to be color-matched were selected as samples of 20 patterns, include individual patterns, fit patterns and continuous patterns.

4.1. Color composition analysis

In the color parsing stage, DKmeans was utilized to extract main colors for each image from the three ethnic series sample images, to obtain its corresponding extracted color. Taking the Korean costumes (Figure 3) as an example, the value K_2 was set as 11 when final clustering was carried out, and the main colors extraction results are shown in Figure 4, including the distribution of the main colors in Lab space.

Figure 3. Part of the Korean costume samples.

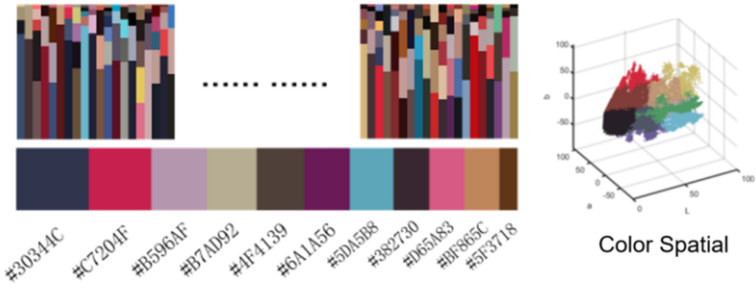
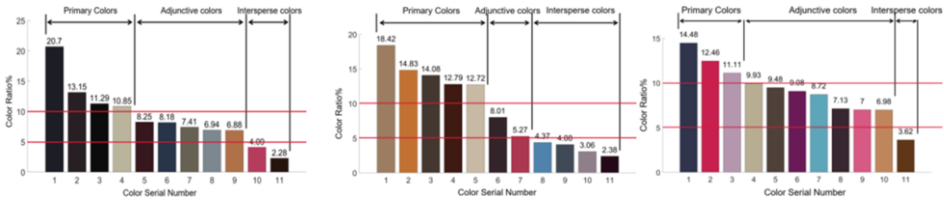


Figure 4. Color analysis of Korean costume.

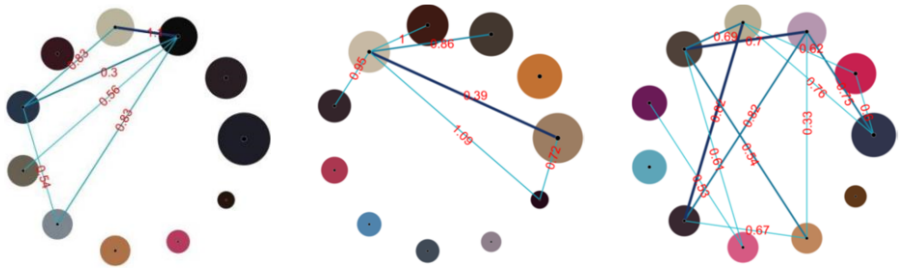
In the color extraction of the collected samples, according to the color proportion, the extracted color greater than or equal to 10% is the primary color, the extracted color greater than or equal to 5% but less than 10% is the adjunctive color, and the extracted color less than 5% is the intersperse color.The color histograms of 3 ethnic costumes are shown in Figure 5.



(a) Miao (b) Tibetan (c) Korean

Figure 5. Color histogram of 3 ethnic costume: (a) Miao; (b) Tibetan; (c) Korean.

The color nexus network model is based on the co-occurrence of paired colors to visualize the binary color matching situation of each ethnic costume. The results of color network linkage under different threshold values are different, and the linkage situation decreases as the threshold value increases. If the threshold value is too low, the link will be more complicated for designers to refer. To present the color relationship of each region more clearly, this paper sets the threshold value of 0.3 for the network model analysis linkage of each ethnic group, and the output results of each ethnic costume color model are as follows in Figure 6.



(a) Miao (b) Tibetan (c) Korean

Figure 6. Color nexus network model of various ethnic costumes: (a) Miao; (b) Tibetan; (c) Korean.

4.2. Automatic color matching

In order to achieve a better effect of color matching, the experiment considered a variety of color factors such as area, similar colors and contrasting colors to analyze the color scheme. The following is a comprehensive color scheme analysis of Korean costume imagery colors as an example. Sort the two groups of similar colors in the sample images, and sort the extracted colors that are in contrast with several colors by a certain position to get a new group of sorted colors. Table 1 shows the original order of color numbers and the integrated order.

Table 1. Color group comprehensive sort.

Color order	Color code										
Originally	1	2	3	4	5	6	7	8	9	10	11
Synthesis	3	9	6	8	2	1	10	4	11	5	7

A variety of sorting methods can be formed by arranging and combining the comprehensive color matching sort. In each sorting method, the 11 extracted colors of Korean costumes are filled into the area to be color-matched in turn by sorting (from largest to smallest in terms of area share), and the output of 11 color schemes can be generated automatically (Figure 7). Below each color scheme is its harmony score, which is indicated by the default weight of the harmony score formula of $\alpha = \beta = \gamma = 1/3$, $\chi = \delta = \eta = \lambda = 1/4$.

Figure 7. Automatic color matching effects of Korean Costume: (a) Scheme 1; (b) Scheme 2; (c) Scheme 3;(d) Scheme 4; (e) Scheme 5; (f) Scheme 6; (g) Scheme7; (h) Scheme 8; (i) Scheme 9;(j) Scheme 10; (k) Scheme 11.

Here the threshold value is set, and the output solutions are all qualified. Still, the top five scheme in order of rating from highest to lowest are scheme 4, scheme 1, scheme 2, scheme 3, and scheme 5. Users can select the solution application by reference or choose another preferred result from the output results. Figure 8 shows the highest scoring scheme output for each of the three ethnic groups.

(a) H = 0.656 (b) H = 0.659 (c) H = 0.659

Figure 8. Three ethnic groups with the highest rating color scheme: (a) Miao; (b) Tibetan; (c) Korean.

In order to test the intuitive effect of the color scheme in the design application, several cases of actual scenarios were experimentally tested, as shown in Figure 9 below.

(a) (b) (c)

(d) (e) (f)

Figure 9. Part of the scene application effects: (a) Sleeping pillow; (b) Cushion; (c) Sandals; (d) Vest; (e) hoodie; (f) Handbag.

In the experiment, the computer configuration for the algorithm test is a processor AMD3.59GHz, with 8.0G of RAM. The overall time-consuming depends on the number of samples in the series. The average pre-processing time cost of a single image is 0.05 seconds, the output time of the color network diagram is 0.38 seconds, and the output time of a single-color scheme is 1.44 seconds.

5. Conclusion

The paper proposed a new regeneration scheme, include pre-processing, color parsing, coloration modules, to analyze and regenerate national costume imagery colors. Taking the sample images of Miao, Tibetan and Korean ethnic costumes as an example, the designed algorithm was used to extract and analyze the color matching of each ethnic costume, construct the nexus network model and realize the automatic color matching of

the patterns. At the same time, the color schemes were put into multiple application scenarios for effect testing.

The experimental results show that the algorithm can quickly parsing and transfer the color scheme of ethnic costumes, generate multiple types of color matching effects and recommend the optimal color scheme. The sample images of ethnic costumes selected in this study can be changed by other imagery scene images, which expands the selection and color matching range of the designer's scene images and improves the color matching efficiency.

Acknowledgement

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by the National Natural Science Foundation of China(61702460), Key projects of National Social Science Foundation of China(19AMZ009), the Fundamental Research Funds of Zhejiang Sci-Tech University(2021Q057),foundation of National Virtual Simulation Experimental Teaching Center of Clothing Design(zx20212004),foundation of Zhejiang Provincial Research Center of Clothing Engineering Technology(2021FZKF05), Key project of education and teaching reform research of Zhejiang Sci-Tech University in 2022 (jgzd202202) and Scientific Research Fund of Zhejiang Provincial Education Department (Y202250618).

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