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Article

Exploring the optimization method of color matching in visual communication design based on graphical algorithm

Dan Xu *

Wuhan City College, Wuhan, Hubei, 430205, China; m18008656408@163.com

Abstract: Color can not only have an impact on the user's mood, but also affect the user's browsing time. Therefore, color matching in visual communication is of great significance. In this paper, following the basic principle of color matching, we propose to use improved clustering algorithm to obtain image color features, and then use association rule mining algorithm to construct color matching rules. Considering that the essence of the color matching problem is combination optimization, genetic algorithm can be used to achieve color matching optimization, and finally design a color matching model based on color matching rules, and explore and analyze the model in this paper. The improved clustering algorithm obtains 2216 colors and 24 optimal color numbers, while the association rule mining algorithm constructs 4 two-color and 3 three-color matching rules. In addition, with the genetic algorithm, 20 optimal color matchings of the living room are obtained, which comprehensively confirms the application value of the research in this paper in color matching.

Keywords: clustering algorithm; association rule algorithm; genetic algorithm; color matching; visual communication design

1. Introduction

Visual communication design is a kind of sensory visual enjoyment and experience. Color, on the other hand, is one of the indispensable and important elements in visual communication design, and color is not only an invisible art, but also a changeable art [1]. Visual communication design can accurately convey information through color matching, achieve emotional fluctuation through sensory stimulation, and show the overall atmosphere effect of visual communication design [2-4]. Through color matching to create the desired sense of atmosphere, so that people from the psychological and physiological impact on the viewer [5-6]. The use of reasonable color matching, grasp the emotional value that color brings to people, enhance the overall design sense at the same time is also an indispensable part of the visual communication design [7-9].

In visual communication design, traditional color matching is highly dependent on the experience and sensitivity of designers, which requires designers to have a high level of color perception and color culture knowledge, leading to the limitations of the existing color matching strategy. On the one hand, it is the designer's understanding of the cultural symbolism of color presents differences, resulting in the same color matching strategy presenting different understandings in different audiences' sensory stimulation, which is easy to produce cultural conflicts [10-12]. On the other hand, different display ends can lead to differences in color presentation, resulting in the distortion of the fixed color matching scheme color, and the lack of different color matching evaluation system, resulting in backward feedback of matching design effects [13-15]. Therefore, there is an urgent need to optimize the color matching of visual communication design and promote the development of chromatic communication design.

The development of intelligent algorithms provides new ideas for the optimization of visual color matching strategies. Literature [16] used genetic algorithms to generate a harmonious visual communication color matching scheme for brand design that is more in line with brand objectives and user preferences, and combined with psychological laws, companies can personalize their color formulas.

Literature [17] calculated the chromaticity moments of the color scheme through Legendre polynomials, combined with the key features of the color of the landscape decoration, extracted the different color distances, and proposed a simulation method to optimize the color matching of the decorative patterns of the marine landscape. Literature [18] used reinforcement learning to optimize the color matching scheme of interactive graphic design, thanks to the advantage of reinforcement learning in the representation of global information in the image pixels, which makes the style of the color to be recognized effectively. Literature [19] proposed a meta-heuristic color harmony algorithm to explore and develop harmonious colors and harmony templates for art by creating hue groups to optimize the global color matching situation. Literature [20] proposed a color matching assessment method by combining visual perception techniques and similarity measurements, and created an intelligent color matching algorithm, which became an important supporting technology in the field of graphic design. Literature [21] studied users' semantic preferences for multiple colors and explored color genes by combining factor analysis, color images and color visual aesthetics, and optimized the color matching of cultural and creative products using an interactive genetic algorithm. Literature [22] combined the contour coefficient method and eye tracking technology to extract image colors in computer vision, and performed color clustering and matching evaluation to construct a color extraction and art matching model, and the model can generate higher quality color matching schemes.

This paper proposes to use an improved clustering algorithm to construct an image color extraction model. After that, the association rule algorithm is used to mine the association relationship of the color data, and the abstract color matching features are converted into concrete color matching rules. Next, the color block mapping is used to realize automatic coloring, and the color harmony calculation formula is determined and then set as the objective function, and the genetic optimization algorithm solves the objective function calculation, and ultimately generates multiple optimal color matching design schemes in accordance with the color matching rules. With the help of the model in this paper, the color matching problem in visual communication design is explored in depth, aiming to promote the development of visual communication design field.

2. Exploration of Color Matching in Visual Communication Design

In visual communication design, the products designed only through the mechanical combination of words and patterns are not qualified, but must be matched by the reasonable use of color, so that the works have a strong visual impact, thus attracting the attention of customers [23]. As an important factor of visual symbols, color is also the language of visual communication, which has a dominant role in visual communication design, and designers need to master a wealth of color theory knowledge in order to be able to use color freely in actual visual communication design. In general, the basic principles of color in visual communication design are as follows.

2.1. Basic principles of color application

2.1.1. Focus on local customs

Before designers carry out visual communication design, they should have an in-depth investigation on the customs and consumer preferences of the regions involved in designing products, so as to avoid the phenomenon of violating the local customs and beliefs in terms of color in the process of carrying out visual communication design, which may cause resentment of the locals and the phenomenon of boycotting the visual communication design products.

2.1.2. Harmonization of primary and secondary color structures

In the color elements of visual communication design, the primary and secondary structure of which should also be coordinated, so that a good product can be designed, by highlighting the contrast between the bright main color and the low-profile, dark background color, so that the consumer will bring a strong visual impact at the first sight, thus leaving a deep impression.

2.1.3. Clearly defined priorities

In the use of color in visual communication design, it is necessary to constantly deploy the color variety between the whole and the part in order to form a colorful color effect. Adopting contrasting colors to match and combine can effectively enhance the visual impact of visual communication design products and catch consumers' eyes in a short time. If the overall color of the product is too uniform, it will give people a flat impression with no distinctive features. Therefore, when carrying out visual communication design, it is necessary to highlight a certain local hue by using the overall color, so that it can form a huge color difference with the color of other parts, which will bring a strong visual effect and at the same time, make the products of visual communication design energetic.

2.1.4. Enhancing the relationship between color and psychology

When people see a certain color, they can't help associating it with something close to them, accompanied by emotional and sensory changes. Color matching in visual communication design should be different from person to person, different countries and regions, work occupation, age and gender of the people, after seeing the color caused by the psychological associations are also very different, so the designers in the visual communication design, we should take into full consideration of the product for the consumer groups in the economic conditions, cultural level, personal preferences, psychological conditions and other factors, so as to do a good job in the color aspect of the reasonable matching. Matching.

2.2. Color Extraction Model Design

2.2.1. Image collection

The images are mainly derived from the series of writings, and the images in the writings with complete flat form and large color differences between the background color and the physical object itself are scanned under the same light conditions using the Zhongjing v700Plus scanner, and the electronic images are normalized and loaded to form the experimental sample set. In order to verify the color accuracy of the electronic images, 10 images were randomly selected from the sample set, 5 volunteers were invited to identify the color closest to the main color of the images in the writings with the help of a color card, and record the rgb value of the color, followed by an algorithm that extracts the main color rgb value of the corresponding image, and finally, the above color values were transformed into lab values and the CIELAB color difference formula was used. The calculation formula is:

$$\Delta E_{ab}^{*} = \sqrt{\left(l_1^{*} - l_2^{2}\right) + \left(a_1^{*} - a_2^{*}\right) + \left(b_1^{*} - b_2^{*}\right)^2} \tag{1}$$

Calculate the color difference between the color card control value for the primary color of each image and the color value obtained by the algorithm.

2.2.2. Image Preprocessing

It is easy to wear out or leave stains over time, so the median filter is utilized to pre-process the image in the preparation stage of the experiment, and is output through the R, G, and B channels respectively. Median filtering is a nonlinear signal processing technique that can effectively suppress noise, and the basic principle is to replace the value of a pixel point in the image with the median of the values of the points in a neighborhood of the point, so that the surrounding pixel values are close to the true value, in order to eliminate isolated noise points.

2.2.3. Color Conversion

The color spaces commonly used in image processing are RGB, CMYK, CIE-Lab and HSV color spaces, and different color spaces can be converted by formulas. In order to allow users to more intuitively perceive the visual effect of color, and to facilitate the calculation of color, the subject of the RGB color space of the image is converted to HSV color space for subsequent color value analysis. General image in the computer in the form of RGB storage, with the help of computer c language for image processing, will involve opencv computer vision library, in the library, the image format default RGB mode, so the first image RGB mode into HSV mode which, RGB to HSV involved in the formula is shown below. Let $\max$ and $\min$ be the largest and the smallest in r, g, b respectively, i.e., (h, s, v) in HSV color space is:

$$h=\begin{cases} 0 & \text{if } \max=\min, \\ 60\times\dfrac{g-b}{\max-\min}+0 & \text{if } \max = r \text{ and } g, \\ 60\times\dfrac{g-b}{\max-\min}+360 & \text{if } \max = r \text{ and } g< b, \\ 60\times\dfrac{b-r}{\max-\min}+120 & \text{if } \max = g, \\ 60\times\dfrac{r-g}{\max-\min}+240 & \text{if } \max = b, \end{cases}$$

$$s=\begin{cases} 0 & \text{if } \max=0, \\ \dfrac{\max-\min}{\max}=1-\dfrac{\min}{\max} & \text{Other;} \end{cases} \tag{2}$$

$$v=\max.$$

2.2.4. Improved clustering algorithm

In the field of image color extraction, in order to use quantitative data information to reflect the color, many scholars have introduced computer image processing techniques based on clustering algorithms in their research. K-means is widely used in clustering algorithms because of its simple principle and operability. However, both algorithms have the defects that the initial clustering center is difficult to choose and the number of class clusters k value is difficult to determine, so they are optimized first.

(1) Optimization of selecting the initial clustering center

Traditional clustering algorithms for color clustering of images have two forms for the selection of the initial clustering center: hue mode and grayscale mode. Hue mode refers to the initial clustering center selected by hue, along the hue h^* from 0 to 360 according to the number of k values required and the average distribution. Grayscale mode means that the initial clustering centers are selected in terms of grayscale values, which are evenly distributed from 0 to 255 according to the number of k-values required. Both of these forms have a drawback that the initial clustering centers cannot be reasonably changed according to the differences in the composition of image pixels, so this topic uses the max-min criterion method to optimize the selection of the initial clustering centers. The first step is to randomly select a point in the data set as the initial clustering center v_1, calculate the point furthest from the first clustering center as the second clustering center v_2, calculate the point with smaller Euclidean distance to the first two clustering center points from the remaining points and put it in the set V, and put the point with the largest distance in the set as the third clustering center, and repeat the calculations by using the formula, until the maximum and minimum distances are not greater than $\theta \cdot dist_{1,2}$ ($dist_{1,2}$ is the distance between the distance between the first and second clustering centers). For:

$$dist_l=\max\left\{\min\left(dist_{i1},dist_{i2},\cdots\cdots\right)\right\} \\ (l,i=1,2,\cdots\cdots,n) \tag{3}$$

where: $dist_{i1},dist_{i2}$ are the Euclidean distances from the sample i to v_1 and v_2 respectively.

The color matching styles will be different in different era backgrounds and geographical environments, and the optimized way of selecting initial cluster centers can better select different initial cluster centers according to the pixel distributions of different images to improve the accuracy of color extraction.

(2) Determination of the number of class clusters K value

Traditional clustering algorithms generally need to rely on personal experience to input the estimated value of the number of human clusters k, compare the segmentation effect of images under different number of clusters and then adjust the value of k, which is only applicable to experiments with a small sample size. In order to obtain the optimal number of clusters for experimental objects, reduce manual input and improve the efficiency of experiments, the elbow method is introduced to estimate the number of clusters. The elbow method uses a formula to calculate the sum of squared errors (SSE) from the sample points of each class cluster to the respective center of mass where they are located and is used as a performance metric, with smaller values indicating greater convergence of the individual class clusters. In this process, a maximum possible number of class clusters i is first randomly specified. The number of class clusters is incremented from 1 to i and i SSEs are computed. When the set number of class clusters keeps approaching the true number of class clusters, SSE will show a rapid downward trend. The value of k can be better determined by drawing the k-SSE curve and finding the inflection point on the way down. For:

$$SSE = \sum_{i=1}^{k} \sum_{p \in L_i} \left\| p - q_i \right\|^2 \tag{4}$$

where: p denotes the data objects in the i th class group L_i, q_i denotes the mean value of all data objects in a given class group, and k denotes the number of classification groups.

This subsection focuses on color matching based on color matching rules and recommends color design results to users based on color harmony scores. Designer in the completion of the sample design, and select the color needed for color matching, the general idea of color matching design. In which the coloring result evaluation and adjustment will consume a lot of manual effort, this section uses color block mapping, color harmony evaluation model and genetic optimization algorithm to replace this work.

2.3. Color matching model based on color matching rules

2.3.1. Color matching rules

After extracting the color values after the common colors are extracted using the improved clustering algorithm, it is also necessary to know the combinatorial relationship between colors, i.e., which colors often appear together. In order to get this collocation relationship between colors, this section uses association rule mining algorithm (Apriori) to get the co-occurrence relationship between different colors. The extracted set of common colors is the set of items, and each color value is an item. After replacing the color values within the image with the corresponding cluster center color, the color value attribute of the graph is i.e. an item. The color clustering results output in the previous section are stored into the Tran_database.xlsx table, i.e., the color transaction database is obtained, and then the association rule mining program based on the Apriori algorithm is written using Matlab to obtain the frequent item sets of often the same color and the strong color association rules within the color transaction database and stored in Fre_sets.txt and Ass_ rules.txt respectively.

2.3.2. Color Block Mapping

Applying the color matching rules to the design drawing and assigning different colors to different areas of the design drawing is the final step in the color matching design process. In this section, the sample drawing will be colored and the coloring results will be evaluated based on the input sample drawing to be colored and the color matching rules. The template image is represented as $A = \{a_1, a_2, \cdots a_n\}$, and the color matching rule can be represented as $C = \{c_1, c_2, \cdots c_n\}$, applying the color scheme C to the template image A is a color mapping process, and there are countless ways to combine different areas and colors.

2.3.3. Color Harmony Calculation

2 or 2 or more colors through the combination to achieve a harmonious matching effect, known as color harmony, color harmony, the degree of direct impact on the aesthetics of the color design. Figure 1 for the CIELab color space a-b plan, the model through the calculation of color in the CIELab color space color, brightness and hue differences to comprehensively assess the degree of harmony of the two colors adjacent to the match. These three factors are independent of each other, so the final model calculation formula is the sum of the three factors. As shown in equation (5):

$$CH(c_1, c_2) = H_C(c_1, c_2) + H_L(c_1, c_2) + H_H(c_1, c_2) \tag{5}$$

c_1, c_2 represents the two colors that need to calculate the harmony, and the value of CH is in the interval $[-1.24, 1.39]$, the larger the value is, the higher the harmony of the two color combinations. When calculating the color difference influence factor H_C and the hue difference influence factor H_H, in addition to the color's L, a, b value in the CIELab color space, we also need to know the color's hue angle value h, and color saturation value $C*$.

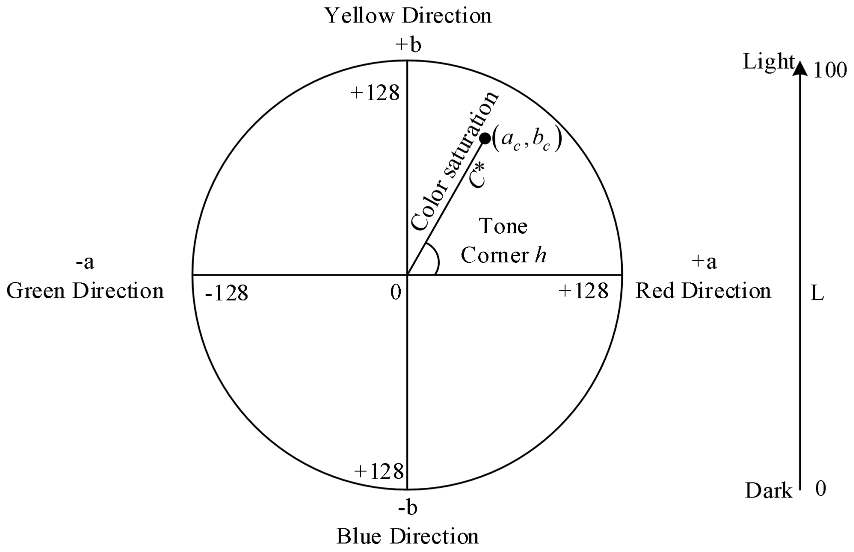

Figure 1. CIELab Color Space a-b floor Plan.

The hue angle h is the value of the angle at which the color turns counterclockwise on the $a-b$ cross-section of the CIELab color model with the $+a$ axis as the baseline, and is the angle of the color on the hue ring, where a_c, b_c are the a, b values of the color, respectively. For:

$$h = \tan^{-1}\left(a_c / b_c\right) \tag{6}$$

The color saturation C^* is the distance of the color from the origin in the $a-b$ cross-section, and represents the vividness of that color, the larger the value the more vivid the color. For:

$$C^* = \sqrt{a_c^2 + b_c^2} \tag{7}$$

where the color difference influence factor H_C is calculated as shown in Eqs. (8)-(9), where ΔH_{12}^* is the difference between the hue angles of the two colors, and ΔC_{12}^* is the difference between the color saturation of the two colors. For:

$$H_C\left(c_1, c_2\right) = 0.04 + 0.53\tanh(0.8 - 0.045\Delta C) \tag{8}$$

$$\Delta C = \left[\left(\Delta H_{12}^*\right)^2 + \left(\Delta C_{12}^* / 1.46\right)^2\right]^{\frac{1}{2}} \tag{9}$$

The luminance difference influence factor H_L is calculated as shown in Eqs. (10)-(12), where L_I, L_2 are the luminance components of the two colors, respectively. For the

$$H_L\left(c_1, c_2\right) = H_{Lsum}\left(c_1, c_2\right) + H_{\Delta L}\left(c_1, c_2\right) \tag{10}$$

$$H_{Lsum}\left(c_1, c_2\right) = 0.28 + 0.54\tanh\left(-3.88 + 0.029\left(L_1 + L_2\right)\right) \tag{11}$$

$$H_{\Delta L}\left(c_1, c_2\right) = 0.14 + 0.15\tanh\left(-2 + 0.2\left|L_1 - L_2\right|\right) \tag{12}$$

The hue difference impact factor H_H is calculated as shown in Equation (13), where $H_{SY}\left(c_1\right), H_{SY}\left(c_2\right)$ is the hue difference between the color c_1 and the color c_2 values. For:

$$H_H\left(c_1, c_2\right) = H_{SY}\left(c_1\right) + H_{SY}\left(c_2\right) \tag{13}$$

The formula for calculating the hue difference value of each color is then shown in Eqs. (14)-(17), where L is the luminance component of the color, h is the value of the hue angle of the color, and $C*$ is the value of the color color saturation. For:

$$H_{SY} = E_C * \left(H_S + E_Y\right) \tag{14}$$

$$E_C = 0.5 + 0.5\tanh\left(-2 + 0.5C^*\right) \tag{15}$$

$$H_S = -0.08 - 0.14\sin\left(h + 50°\right) - 0.07\sin\left(2h + 90°\right) \tag{16}$$

$$E_Y = [(0.22L - 12.8)/10]\exp\left\{\left(90° - h\right)/10 - \exp\left[\left(90° - h\right)/10\right]\right\} \tag{17}$$

For the template map, $f\left(a_i\right) = c_j, i \in [1,n], j \in [1,n]$, it means that the mapping f assigns the color c_j to the region a_i, and the degree of the color harmony of the whole pattern after the coloring is computed by Equation (18). Where w is the region association matrix, if region a_i is adjacent to a_j then $w_{ij} = 1$, otherwise $w_{ij} = 0$. For:

$$Harm(f) = \sum_{a_i, a_j \in A} w_{ij} CH\left(f\left(a_i\right), f\left(a_j\right)\right) \tag{18}$$

2.3.4. Color combination optimization based on genetic algorithm

Among all the ways of combining colors and regions, it is necessary to find several kinds of the highest color harmony rating values as the output of the color matching results. The arrangement of all the color regions is the solution space, and the color harmony evaluation is the objective function. There are many algorithms for solving combinatorial optimization problems, but for specific problems often require specific solution methods, and it is difficult to find an exact solution. For most intelligent algorithms, such as genetic algorithms, ant colony algorithms, etc., their algorithmic framework does not depend on the specific problem, although it is not possible to find the exact solution but can get the near optimal solution of the problem in the case of high efficiency and low cost, therefore, genetic algorithms are used to get the final results of the color matching [24].

The specific optimization process is shown in Figure 2, firstly, the initial population is generated according to the template and color matching rules, then the color harmony value of each individual is calculated and judged, if the maximum number of genetic generations is reached, all individuals in the current population are outputted as the color matching results; if the iteration is not finished, the individual with the largest color harmony value in the population in each generation will be retained directly to the next generation, and the other individuals will undergo chromosome block color change, an evolutionary operation, to adjust the block color and obtain a new population. As the number of genetic generations increases, this simple genetic algorithm that preserves the optimal individuals can reach global convergence.

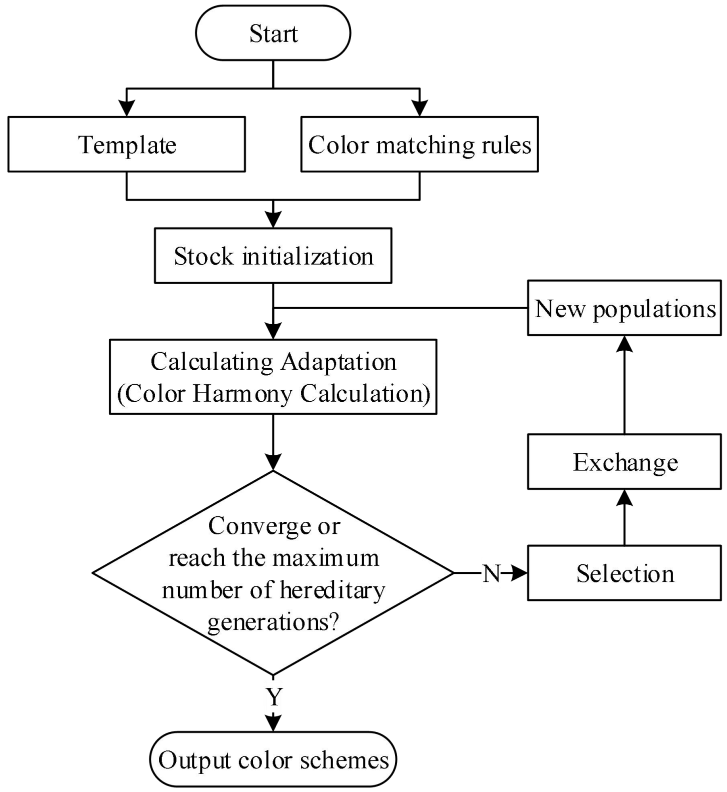

Figure 2. Color matching optimization flowchart.

3. Results and analysis

3.1. Empirical Analysis of Color Extraction Model

3.1.1. First color extraction

In most cases, objects in a dataset cannot be divided into explicit clusters, so forcing certain objects to be assigned to specific clusters is rigid and can be erroneous. Therefore, each object and each cluster is assigned a weight indicating the degree to which the object belongs to that cluster. Of course, probability-based methods can be used to assign these weights, but since it is sometimes difficult to determine an appropriate statistical model, using the improved clustering algorithm presented in this paper is a better choice. Before starting the first product color extraction in visual communication design, after setting the number of clusters to 1~10 classes, the specifics of the number of all clusters are obtained, and in the contour plot, the length of the contour reflects the cluster score, and the thickness reflects the number of samples in the cluster, and the clustering effect of different number of clusters is shown in Table 1. Up to this point, by analyzing the contour coefficient values and contour plots of each cluster, the optimal number of colors for this sample image was fixed to 8 classifications, and its average contour score was 0.694.This method was applied to each sample image, and the distribution of the color values and the average contour values were comprehensively compared and analyzed to find out the optimal number of clusters. From the above steps and methods, 421 images were clustered and extracted separately, and a total of 2216 colors were obtained. According to the results of the first color extraction, it can be seen for the unique color scheme overall brightness and saturation of the higher, and most of the colors in the usual packaging design is not common, the hue of the wide range.

Table 1. Clustering effects with different numbers of clusters.

Number of clusters	Average contour score
1	0.684
2	0.604
3	0.648
4	0.612
5	0.682
6	0.643

7	0.643
8	0.694
9	0.635
10	0.642

3.1.2. Second color extraction

The number of colors obtained from the initial clustering is still too large to determine the main color corresponding to the representative perceptual imagery, so a second clustering is also needed to obtain the most representative colors. The second color extraction uses an improved clustering method, which is an algorithm that uses the relationship between each sampling point and the center of the cluster to classify them, and is faster to process and simpler to implement than fuzzy clustering. Using the improved clustering algorithm maintains the basic shape of the image for extracting colors from a single image, and then the improved clustering algorithm is used again for secondary clustering to finally obtain the representative colors of a product package, the summary of the contour coefficient scores is shown in Table 2, and the color values and codes are shown in Table 3. As can be seen from the data in the table, comparing the average contour score, the larger the value indicates that the samples in the same cluster are closer together, and the different samples are farther apart, the better the clustering effect. It can be seen that the optimal number of clusters for "Label 1" is 9, and the coefficient of rotation is 0.881. The optimal number of clusters for "Label 2" is 5, and the coefficient of rotation is 0.883. The optimal number of clusters for "Label 3" is 10, with a coefficient of rotation score of 0.871. After determining the optimal number of clusters, the main color extraction procedure based on improved clustering algorithm is carried out through python4.6 by writing the corresponding code to extract the colors of the product packaging in the visual communication design, and ultimately the 24 representative colors are obtained, which also provides the theoretical basis for the subsequent color matching.

Table 2. Summary of contour coefficient scores.

Number of clusters	The contour coefficient score of Label 1	The contour coefficient score of Label 2	The contour coefficient score of Label 3
1	0.792	0.691	0.852
2	0.727	0.814	0.786
3	0.731	0.721	0.831
4	0.764	0.826	0.711
5	0.666	**0.883**	0.762
6	0.815	0.628	0.733
7	0.648	0.624	0.826
8	0.807	0.809	0.656
9	**0.881**	0.624	0.674
10	0.753	0.772	**0.871**

Table 3. Color values and coding.

Coding	H	S	V
C1	120	44	31
C2	129	36	75
C3	124	25	53
C4	110	26	55
C5	116	23	77
C6	149	29	49
C7	136	30	62
C8	149	22	43
C9	113	24	53
C10	119	14	46
C11	138	30	66
C12	116	27	47
C13	131	41	50
C14	140	48	37
C15	143	32	53
C16	112	15	36
C17	106	38	50

C18	119	11	75
C19	117	12	71
C20	137	14	46
C21	102	34	45
C22	142	12	78
C23	112	49	78
C24	125	17	39

3.2. Empirical Analysis of Color Matching Model

3.2.1. Color matching rule analysis

Using the Apriori algorithm mentioned in this paper to analyze the 24 representative colors extracted, this paper takes the C3 color as an example, and lists some of the two-color and three-color collocation rules with higher support and confidence, as shown in Table 4. First of all, the stronger associated colors are obtained by delineating the threshold value, according to which the minimum support degree is set to 0.07 to obtain a more reasonable number of rules. Then remove the repeated co-occurrences in the rule, such as "C3-C4" and "C4-C3" two groups of colors have the same support of 16.33%, that is, in 421 images In 421 images, there are about 69 images in which these two colors appear simultaneously. Meanwhile, the confidence level of "C3-C4" color matching is 51.44%, which means that under the premise of C3 color appearing, there is a half probability that both C3 and C4 colors will appear at the same time. Correspondingly, the "C4-C3" color scheme is based on the premise of C4. In addition, the probability value of two colors co-occurring is 45.37%. In the rules, the higher confidence collocation "C3-C4" is regarded as a group of co-occurring colors, and finally 4 two-color and 2 three-color collocation rules are obtained. From the obtained correlation data, we can see that the colors are rich and diverse, and are not limited to certain color combinations.

Table 4. Partial samples of two-color and three-color combinations.

Number of colors	Matching rules	Support rate/%	Confidence level /%
Two-color combination	C3-C4	16.33	51.44
	C3-C2	10.79	37.71
	C6-C3	11.07	45.52
	C1-C3	7.18	26.63
Three-color combination	C3-C2-C4	5.74	18.62
	C6-C3-C4	5.48	24.63

Color matching will also form a kind of reconciliation relationship, in the color system proposed the same reconciliation, similar reconciliation and control of the three ways of reconciliation. From the point of view of color tone, the same tone is matched with different hues in the same tone; similar tone is matched between two adjacent tones, and the picture has a certain level but is not outstanding; the distance between two tones of control tone is farther away, and there is a certain difference in brightness and saturation between different colors, and the overall level of the picture is more outstanding. In the color association rules of visual communication design, basically it is similar to "C3-C6" the same hue or "C3-C2" between adjacent hues, the brightness and saturation values are similar, in the visual communication design, the picture has a certain level but not prominent; the distance between the two hues of control and harmony is farther away, the overall level of the picture is more prominent. The brightness and saturation values of the colors are similar, visually weakening the contrast and showing a dignified and elegant style. The establishment of color matching rules has a certain significance for recommending color matching, through the association algorithm can dig out the most representative color co-occurrence matching, but from the point of view of design recommendation based on the same support threshold division of the color rules have certain limitations, according to the user's preference selected the center color according to the size of the associated confidence value to recommend the color matching, to provide a more diversified program for the design. In this paper, we take C3, C6, C15, C21 as an example, and list the matching colors with the top 5-7 confidence ranking when they are used as the central color, and an example of the color matching network is shown in Figure 3. The central color is located in the center of the color network, and its corresponding matching colors are distributed in a ring around the periphery, and the larger the area of the color points means the higher the confidence level. In Figure 3, the solid line connection indicates the two-color matching relationship between the center color and the matching color, and the dotted line correlation indicates the matching relationship between the rest of the matching colors under the premise of selecting the center color, such as "C6-C2" to form a two-color matching at the same time, it can also be used to form a three-color matching rule with C3 or C4. The center color and its associated colors form a relationship with each other. The center color and its associated colors form a different color network, which can provide a reference for the design of color matching.

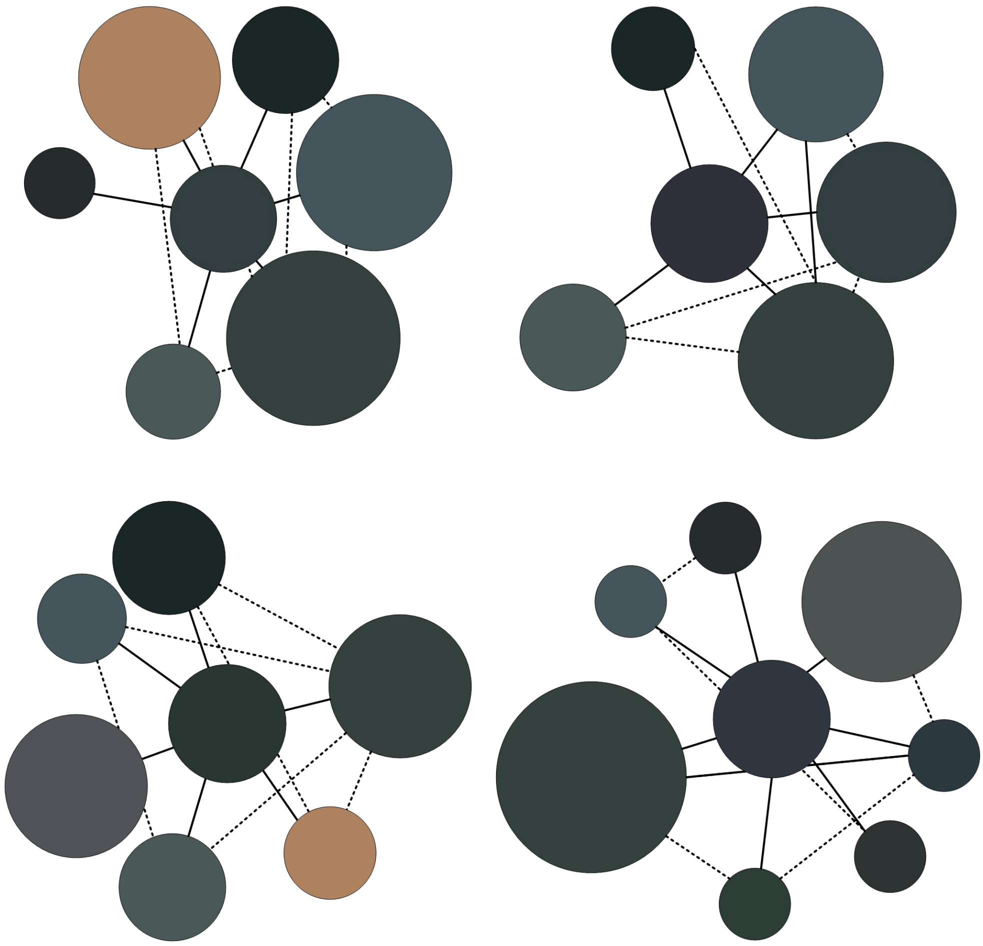

Figure 3. A web example of color matching.

3.2.2. Color combination optimization results based on genetic algorithm

The initial population number of the genetic algorithm is 421, the probability of variation is 0.5, and the number of iterations is 200, and the objective is that the larger the value of color matching beauty and color matching harmony, the higher the color comfort. Based on the MATLAB platform, the beauty and harmony of the color matching scheme of the proposed method were synchronously optimized in the experiment, and the distribution of the optimized solution set of color combinations is shown in Figure 4. In Fig. 4, the opaque ink and emerald dots represent the high-quality solutions obtained in the process of evolution; the transparent blue dots represent the non-quality solutions, and the higher the transparency the older the number of solution generations, and the dark orange dots represent the partially optimized solution set obtained, whose color matching harmony is distributed in the range of 2~10, and the beauty is distributed in the range of 0~3. It not only shows the mutual constraints of the color matching beauty and the color matching harmony, but also verifies that the genetic algorithm has been used in the color combination optimization. It not only shows the mutual constraint relationship between color matching aesthetics and color matching harmony, but also verifies the effectiveness of genetic algorithm in color combination optimization and provides technical support for the optimization of color matching in visual communication design.

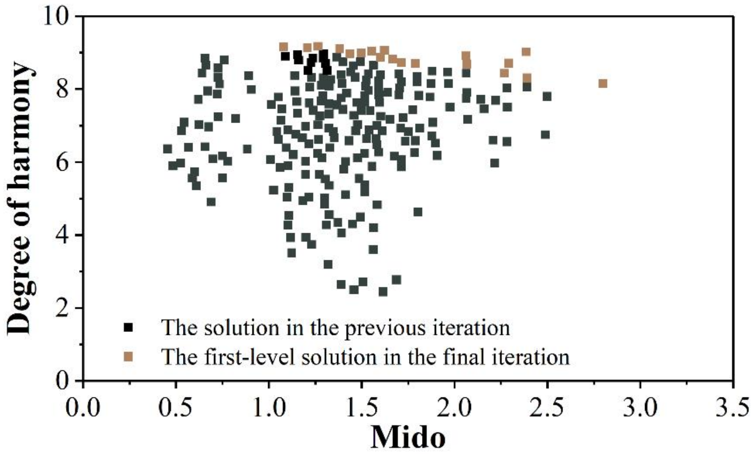

Figure 4. Color combination optimization solution set distribution.

3.2.3. Analysis of model application examples

In order to further prove the validity of the model in this paper, the color matching of the living room in visual communication design is taken as an example to carry out the analysis of model application examples. According to the position and role of different color-assigning regions in the living room, the color matching of the living room is divided into basic color (wall and floor), matching color (furniture) and accent color (curtains), with a total of four color-assigning regions. Among them, the base color comes from the primary color database, and the matching color and accent color come from the secondary color database. The four regions to be color-assigned are selected from the primary or secondary color color databases, and the genetic operations such as tournament selection, two-point crossover, and single-point mutation are used to make the population evolve during the global search process. The initial population of the genetic algorithm is 100, the mutation probability is 1.0, and the number of iterations is 1000, which finally results in the color matching data, and the color matching data of the living room is shown in Table 5.Q1, Q2, Q3, and Q4 represent the color-assigning regions of wall (basic color), ground (basic color), furniture (matching color), and curtains (accent color), respectively, which results in a total of 20 kinds of color matching for the living room, and the user can choose the appropriate color matching according to his personal preference. Users can choose the right color scheme for their rooms according to their personal preferences, which also improves the efficiency of designers. In summary, this paper reveals the effectiveness of the model in color matching.

Table 5. Data on color matching in the living room.

Region	Plan 1		Plan 2		Plan 3		Plan 4		Plan 5	
	Color	Data	Color	Data	Color	Data	Color	Data	Color	Data
Q1		S1230-Y		S2320-Y30R		S5010-Y30R		S1240-Y20R		S3907-Y50R
Q2		S1420-Y70R		S8020-R30B		S7020-Y70R		S4120-R40B		S2005-R80B
Q3		S2650-Y50R		S9030-R		S5010-R30B		S2907-Y70R		S1030-Y70R
Q4		S2860-R		S2430-Y30R		S2450-Y20R		S4130-R70B		S8305-R20B
Region	Plan 6		Plan 7		Plan 8		Plan 9		Plan 10	
	Color	Data	Color	Data	Color	Data	Color	Data	Color	Data
Q1		S1405-R		S2050-Y40R		S2070-R30B		S6010-R40B		S2060-Y30R
Q2		S2070-Y30R		S5040-R80B		S8040-R30B		S8030-R10B		S8105-R20B
Q3		S1305-R20B		S6090-R50B		S4010-Y70R		S7020-Y30R		S2040-R10B
Q4		S4010-G80Y		S1520-R60B		S3020-R50B		S8010-G50Y		S4070-Y
Region	Plan 11		Plan 12		Plan 13		Plan 14		Plan 15	
	Color	Data	Color	Data	Color	Data	Color	Data	Color	Data
Q1		S1002-Y50R		S3045-Y50R		S0800-N		S2025-Y30R		S0520-R80B
Q2		S6020-R70B		S7090-R20 B		S7070-Y30R		S4050-R60B		S1000-N 4
Q3		S4020-R10B		S6030-Y		S2050-Y40R		S3060-Y80R		S1530-R40B
Q4		S2050-Y50R		S7070-R70B		S4080-R30B		S3070-Y30R		S2025-Y20R

Region	Plan 16		Plan 17		Plan 18		Plan 19		Plan 20	
	Color	Data	Color	Data	Color	Data	Color	Data	Color	Data
Q1		S0407-Y50R		S2002-Y50R		S5020-Y		S3002-B		S0903-Y60R
Q2		S2040-R60B		S6010-R30B		S3050-Y60R		S9002-R		S1520-Y40R
Q3		S6090-B		S7050-R90B		S8005-R20B		S8040-Y50R		S6040-Y80R
Q4		S4020-B		S8040-B30G		S4060-R		S4020-Y60R		S3040-G60Y

4. Conclusion

In the new era of visual communication design, color, as an important part of visual design, can not only attract people's eyes and improve recognition, but also convey different emotions and information. In this paper, with the help of improved clustering algorithm to obtain image color features, on this basis, using association rule mining algorithm to construct color matching rules, given that color matching belongs to the combinatorial optimization problem, genetic algorithm can be used to complete the design of the color matching model, and the use of the model to carry out an in-depth exploration of the color matching in visual communication design. The results of this paper are as follows:

(1) The improved clustering algorithm is used to extract colors from 421 images, and a total of 2216 colors are obtained, and its optimal number of colors is 24 types, which reflects the feasibility of the improved clustering algorithm in terms of color extraction.

(2) The 24 representative colors are encoded and processed, after which the Apriori algorithm is used to construct the color matching rules, and taking C3 as an example, 4 two-color and 2 three-color matching rules are finally obtained, which lays a theoretical foundation for the construction of color matching model. In addition, in the exploration and analysis of the color matching of the living room in the visual communication design, 20 optimal color matching of the living room is obtained through the model in this paper, which fully demonstrates the effectiveness of the model in color matching.

About the Author

Dan Xu, female (1981.02-), Han ethnicity, native of Tianmen, Hubei Province, holds a master's degree and is an associate professor. Research interests: Oriental aesthetics and cultural communication.

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