Automatic Color Match for Planar Graphics

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Abstract
The automatic color match mechanism from the source planar graphics to the design graphics is studied. The color scheme of the source graphics is obtained by using color merging technology based on CIE Lab color space and K-means clustering method. Furthermore, the sub color scheme of each region with the same main color is obtained using image label technology. Based on these, the solution space of the color scheme of design graphics is constructed. Under comprehensively considering the factors such as the background and foreground, the configuration of the color ratio, the random creative demands and the color match of the similar foreground, the color scheme is matched from the source to the design graphics. The color scheme group is shown in image form for the designers to flexibly and conveniently choose and optimize. The algorithm is verified by a large number of design cases, which shows the feasibility of the algorithm.

Key words: Planar Graphics, Color Scheme, Color Match, Main Color Extraction.

1. INTRODUCTION
Currently, the automatic color match design based on the computer technology is mainly applied to product design, but not to vector graphics in art design (Liu and Li, 2012; Ding and Sun, 2010; Liu and Li, 2009). Vector graphics is concise, sharp color and exaggerated, giving a strong visual impact and artistic feeling. Therefore, it becomes one of the essential forms of art design for website design, character design, digital illustration, mark design and posters, etc.

From the point of view of creation, vector graphics become one of the most popular art forms in the picture reading era because of its own graphics features. Their contour, color and size can be edited conveniently in the software; individual element can freely convert from one background to another to integrate the whole art style, shorting the creative time.

The most intense visual impact of vector graphics to the audience is the color configuration, so the color match is the key point. Currently, the color match is done manual by designer. The most common and effective way of color match in the design disciplines is through decomposition, induction and combination of natural color and artificial color. The color configuration and color character of the source graphics is analyzed to maintain the area ratio and relationship of the main color. Therefore it can keep the main tone, spiritual characteristics and the overall style of the source graphics (Li, 2005; Zhou, 2009; Qin, 2010).

The main difficulty and problem of color match done manual by designer from the perspective of professional practice lie in two aspects: strong subjective consciousness and low efficiency. Designers have conventional techniques, however, the decomposition, induction and combination of color is relatively subjective, the color area ratio is also not accurate enough. The time of color match is relatively long and the range is relatively small, thus it is hard to compare the pros and cons of color match cases.

This paper studies the automatic color match technology of vector graphics, and can overcome the above disadvantages. It can automatically extract the main color by color cluster technology from the natural images, design graphics and paintings, etc., to get color scheme of the source graphics, the color match from the source to the design graphics and further the color match group.

2. EXTRACTION OF COLOR SCHEME OF THE SOURCE GRAPHICS
The color scheme of graphics generally consists of three aspects of information: color number, main color and color area ratio. Extracting color scheme of source graphics is the key for color match; the main color extraction is the core technology, which using K-means clustering method based on CIE Lab color space to extract the main color in this paper.

The commonly used color space has CIE Lab, RGB, Munsell and HSV color space. CIE Lab color space consists of three components: brightness L, red and green color channel a, blue and yellow color channel b. CIE Lab color space has the uniformity of perception, and is very close to the perception of human, that is, the visually similar colors adjacent in Lab space. It has the Euclidean distance invariance, i.e. two colors with small visual difference have small Euclidean distance in the Lab space, and whereas, two colors with large visual difference have large Euclidean distance. Therefore, the main color can be accurately extracted in the Lab color space.
space (Chen and Chen, 2008; Ren and Bai, 2013). The K-means clustering method is used to cluster the channel a and b to get the regions with different colors, and the cluster number is given by human in this paper.

The each region is further refined with brightness L, so as to split the region with same main color into sub regions with different brightness. The specific method is: each region is clustered using brightness L with K-means clustering method and the cluster number first set to 3. If any two clustering center distance is greater than 15, the region is split into 3 sub regions. Otherwise, the clusters number is decreased to 2, clustering again. If the two clustering center distance is greater than 15, the region is split into 2 sub regions (Li and Wang, 2010; Wang and Ding, 2003). Otherwise, nothing done.

The main color extraction is done in the RGB color space for each region. The main color generally can be set as the mean or the mode of the color in the region. According to the experiment, the mode can reflect the source graphic color style more exactly (Zhu and Liu, 2015; Li and Zhang, 2007).

Then area ratio of each region is calculated, and according to the ratio from high to low, the color scheme of source graphics is showed below as:

\[ P_i = \{(c_1, w_1), \ldots, (c_i, w_i), \ldots, (c_n, w_n)\} \quad (1) \]

where \( c_i, w_i \) represent the main color and the area ratio respectively, \( n \) as the region number.

The region may compose of many independent connected sub regions, such as each flower with the same color. These independent connected sub regions are in general in the foreground. In order to maintain the main tone, the spirit characteristics and the overall style of the source image, it is necessary to further segment the region which called the sub color scheme. Similarity to the main color scheme, the sub color scheme of each region is showed below as:

\[ P_{si} = \{(c_{i1}, w_{i1}), \ldots, (c_{iR}, w_{iR}), \ldots, (c_{ik}, w_{ik})\} \quad (2) \]

where \( c_{i}, w_{i} \) represent the color and the area ratio respectively, \( k \) as the sub region number of the region \( i \) in the main color scheme. A threshold area ratio is set in the sub color scheme extraction process, the sub region is filtered out as noise if the area ratio less than the threshold.

After the main color extraction, the source graphics color style is remained, while removing the noise regions and greatly reducing the region number.

3. MATCH OF COLOR SCHEME

In this paper, it is assumed that the area ratio of each region of the design graphics can be accurately obtained. For example, if the design graphics is the vector graphics, the area ratio can be easily obtained in the design stage; if the design graphics is the binary image, the area ratio can also be easily obtained using the simple segmentation method. So according to the ratio from high to low, the color scheme of design graphics is showed below as:

\[ P_t = \{(c_{n1}, w_{n1}), (c_{n2}, w_{n2}), \ldots, (c_{nm}, w_{nm})\} \quad (3) \]

where \( c_{n}, w_{n} \) represent the color to be set and the area ratio respectively, \( m \) as the region number. Each \( w_{ni} \) is known and \( c_{n} \) is need to choose from the source color scheme.

The color of the design scheme can be expressed as a function of the source color scheme and its own ratio:

\[ c_{n} = f(P_t, P_{si}, w_{ni}) \quad (4) \]

Based on the formula (4), four key points need consideration in the color match.

(1).Background and foreground. The background which is generally a large connected region, has the similar color; whereas, the foreground has many small independent connected regions with similar or different color.

(2).Configuration of the color ratio. The color ratio is one of the most important style of source graphics, as for with the same color but different color ratio, the visual effect will be great different. The color match is done according to the order of color ratio in this paper. The color match method can reproduce the color style of the source graphics by keeping the color ratio unchanged.

(3). Random creative demands. If the color match is done strictly according to the color ratio order, there is only one color match case, which greatly limits the creation. The color match can also be done, not according to the color ratio. Not according to the color ratio, the color scheme can be extremely free and lively, can constitute many color configuration and suitable for different creative intention. Therefore in the color match stage, it is need to add some random factors, as to find the outstanding design cases as many as possible. In this paper, the design color is randomly selected from colors with similar area ratio.
(4). Color match of similar foreground. There may be many regions with similar area ratio in the foreground, but this region may be the same or different color. Such as flowers, they are similar area ratio and similar color; such as pearls, they are similar area ratio, but different colors. This should consider in the color match design, it is specified by human, namely, the similar area region has the similar color or not set by human.

The specific color match steps are as follows: According to the area ratio from high to low, the main color $c_a$ is selected for each region $(c_{a1}, w_{a1})$ of the design graphics. The first two regions $c_{a1}, c_{a2}$ are assumed to be background, and the two source region with area ratio $w_i$ closest to $w_{a1}$, are selected, then one of the main color of these two source region is randomly set to be the main color $c_{ai}$. The other regions of the design graphics are assumed to be the foreground and their main color are needed to select from the sub color schemes in the foreground of the source graphics, which are formed by other regions except the two largest area region which are the background. For each region $w_i$, the only one sub region $w_{opti}$ from the sub color scheme of each source color region $(c_i, w_i)$, $i\geq 2$, with area ratio $w_{opti}$ closest to the $w_i$, is selected to form the optimum match sub regions set. Then the three best match sub regions are selected from the set. Finally, one of these three sub regions is randomly set to be the main color $c_{ai}$.

The criterion for similarity of the two area ratio is:

$$\text{abs}(w_i - w_j)/(w_i + w_j) \quad (5)$$

The less the value is, the more similar the two regions are.

There exist random selection one region from multiple regions, so repeatedly running the color match, the color match group can obtain.

4. DESIGN CASES OF COLOR MATCH

The algorithm is written using MATLAB, and the K-means algorithm and color space conversion function using the MATLAB built-in function.

First the accuracy extraction of the color scheme of the source graphics is verified with the master works. In order to easy observation, each region of color scheme of the source graphics is filled with the corresponding main color. The works are selected from the Wu Guanzhong and Van Gogh. The results are shown in figure 1 and 2. It shows that the main color is rightly extracted and the color style is remained.

Flower mission is widely applied in the fields of clothing, website, interface and interior design etc., with the regularly emission effect. The color match of the flower mission is studied. Three source graphics with different style are used to comprehensive validate color match effect; they are work of Wu Guanzhong, colored flower mission and Bohemia style skirt. The results are showed in figure 3 to 5. Flower mission is graphics with symmetrical and emitting feature; there are many regions with the same area ratio(ZHOU2005). These regions are set the same color.

Figure 1. Color scheme extraction of Wu work Figure 2. Color scheme extraction of Van Gogh work
**Results by proposed algorithm**

**Figure 3.** Results of Wu Guanzhong work

**Figure 4.** Results of flower mission

**Figure 5.** Results of Bohemia style skirt
We then study the color match for dragon, snake and horse, three animals of Twelve Chinese Zodiac, which is the spring festival logo design for the students of art design. And the student's match results are compared to verify the practicality and advantage of the proposed algorithm. These works take the Chinese word "spring" as the shape, to highlight the facial feature using symmetrical structure. We choose three cases from our algorithm results, and the designer can choose the best result from these cases to improve the efficiency.

**Figure 6. Results of dragon**

![Source design](image1)
![Result by students](image2)
![Result by proposed algorithm](image3)

**Figure 7. Results of snake**

![Source design](image4)
![Result by students](image5)
![Result by algorithm](image6)
Figure 8. Results of horse

Through above the color match cases with two total different method, one by human designer another by our algorithm, we find that the human designer case is monotony and time consuming, while in the other case, color is more stable, color ratio is more flexible, which gives the designer more choices and the efficiency is far greater than the human designer.

5. CONCLUSIONS

(1) This paper used CIE Lab color space and K-means cluster method to extract main color, which reproduces the source graphics’ color style.

(2) After communication with the designers, comprehensively considering the factors, such as graphics background and foreground, color ratio configuration, random creative demands and similar foreground color, the proposed algorithm obtains better color match effect, which cohesive to source graphics color style, providing designers broader possibilities for color recreation.

(3) Sub color scheme of each region with similar color is the key for the success of our algorithm, because we can differ the regions with similar area ratio in the foreground.

(4) This paper generates color match cases, not considering the designer personal preference; the next step is to use genetic algorithm, through the designer’s choice, embodies the designer’s intention.

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