Research Article

Application of Art in Computer Graphic Design

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Received 18 July 2022; Revised 17 August 2022; Accepted 26 August 2022; Published 14 September 2022

1. Introduction

Design is an art form, a way for people to express themselves that adheres to a set of carefully established rules in order to give things, performances, and experiences meaning. The design has the ability to solve issues, just like all other kinds of art, but there is no assurance that it will [1]. A degree in art and design covers a variety of visual arts, including graphic design, painting, and drawing. Students majoring in art and design study fundamental design concepts, colour theory, critical thinking, and artistic methods. One of the key elements that influence the calibre of art and design works is colour matching. Modern art design makes extensive use of computer technology. To create high-quality art pieces, designers must thoroughly research computer colour matching. This paper is based on a knowledge of the colour matching of the art design. This paper uses computer technology to successfully select the hue and colour quantity rate of a mathematical framework. At the same time, it should select the style of colour matching style, background hue, and colour quantity. It is proposed to employ cyan, magenta, yellow, key (CMYK), hue-saturation-brightness (HSB), red, green, and blue (RGB), and other modes to get the approximate hue sum, which can serve as a useful benchmark for the modernization of art design. The experimental results demonstrate that the two groups of colour matching selected for this paper have high colour difference accuracy, but the formula accuracy provided by the weight factor for colour difference is superior to that provided by other weight factors whether it is the formula accuracy provided by computer colour matching or the accuracy of actual art images.
colours can be loosely separated. To successfully choose the performance hue in the aforementioned colours, it is needed to first consider the true meaning of the art design works as well as the designer's subjective perception. In order to properly create the design works with acceptable structure, clear colours, and powerful themes, it is necessary to pick the primary colour of the colour matching that occupies a considerable area and the corresponding auxiliary colours. It is important to separate the primary colour from the contrast colour when combining and matching two or more tones. To create art design pieces using image colours, it is necessary to concentrate on the primary colour and emphasise the supporting function of the contrast colour [6].

A chromaticity rate refers to the scale of colour strength, formed by the comprehensive tone and colour shading, which has a certain impact on people's visual perception and psychological dynamics. People will experience discontent if the chromaticity rate is improperly chosen [7]. Therefore, to precisely determine if the colour intensity needs to be altered while creating computer-aided art, it is required to use the design system. When colour amounts are correctly reduced and when colour matching and hues are consistent, viewers will have a strong feeling of elegance and will recognize the “advanced grey” stage in the image [8]. It will provide people with a powerful visual effect and display a lively image performance if the colour quantity is correctly increased. In light of this, it is necessary to colour and alter the design work. In order to present creative beauty in its true form, it is important to make full use of computers to change colours that are apparent and disorganised [9].

One of the fundamental techniques for computer colour matching is full spectrum colour matching. It traditionally matches each wavelength point equally. In fact, there are clear disparities in the colour perception changes brought on by the identical size changes of the object at various wavelengths [10]. At certain wavelengths, there exist changes, but the colour cannot change in line with them, demonstrating strong inertia. At other wavelengths, the changes are small, but there are large colour perception differences, demonstrating a strong sensitivity. Therefore, different weights should be matched with various wavelengths. Give more weight to sensitive wavelengths for key matching, and give less weight to insensitive wavelengths. Even though there are already two different types of weight factors, they are unable to capture the variations in colour perception at different wavelengths [11].

According to the design of the colour sensitivity function model and the investigation of its laws, this paper provides colour difference weight factors for full spectrum colour matching [12]. This research effectively chooses the hue and colour amount rate of a mathematical framework using computer technology. It should choose the background colour and amount at the same time as the style of colour matching. To get the approximate hue sum, which can act as a helpful benchmark for the modernization of art design, it is recommended to utilize CMYK, HSB, RGB, and other modes. The experiment results show that the two colour matching groups chosen for this study have high colour difference accuracy, but the weight factor for colour difference provides formula accuracy that is superior to that of other weight factors, whether it is formula accuracy from computer colour matching or formula accuracy from actual art images.

The remainder of the paper is organized as follows: Section 2 is composed of the related work. Section 3 discusses the colour matching style selection for computer graphics creation based on mathematics. Section 4 discusses the computer art design colour matching method based on mathematics. Section 5 discusses the experimental results, and finally, the paper is concluded in Section 6.

2. Related Work

The core principle of computer colour matching is the absorption and scattering theory of light in fully opaque material, known as the Kubelka–Munk theory [13]. In theory, the Kubelka–Munk function has a linear connection with concentration, but in actuality, it has a nonlinear relationship. This is mostly because the Kubelka–Munk theory was founded on the following three assumptions:

(1) The colour layer has an unlimited thickness.
(2) Light is adequately dispersed in the pigment layer and is totally diffused. In fact, light is not necessarily fully diffused in the medium.
(3) The medium has two light pathways, one upward and one downward, and they are perpendicular to the interface.

In practice, the Kubelka–Munk function has a nonlinear relationship with concentration due to theoretical flaws and other factors [14]. In order to reconcile theory and experience, the surface reflection factor is frequently utilised to address theoretical flaws in practice. Etters et al. believe that the substrate determines the surface reflection factor. The surface reflection factor is the reflectivity at the maximum absorption wavelength when printing and dyeing with strong absorbing colours. After careful consideration, this strategy has certain drawbacks. Even if no surface reflection exists, the reflectance at the maximum absorption wavelength is not always zero [15]. Zeng Hua et al. proposed the surface reflection factor that is determined mathematically in order to create a linear dye database for the colour difference weight factor, which makes the Kubelka–Munk function and concentration tend to be linear in practice [16].

3. Colour Matching Style Selection for Computer Graphic Creation Based on Mathematics

This section is further divided into the following subsections.

3.1. Colour Matching Style. The majority of the time, contrast type, scattered type, and central type are combined to create colour matching styles. Use the contrast type to divide the color matching board into useful parts and useless parts, so that the color matching board can convey a strong sense of contrast [17]. For example, colour contrast, such as warm
and cold tone contrast, will often be separated into left and right or up and down halves. The term "scattered type" refers to an open configuration that is unconstrained and unrestricted, avoiding the centralised appearance of a single hue in the design but yet successfully dispersing it with a specific meaning to create an air of comfort and freedom. Placing the design topic in the middle of the image is referred to as the central configuration. This technique can successfully convey the design’s substantive meaning and inspire confidence and peace of mind [18]. It is important to highlight that this layout is more conventional and conservative than modern, making it unsuitable for demonstrating strong practical qualities.

3.2. Background Tone. Effective background tone selection is essential in the computer art design process if the design subject is to be highlighted. The three categories of dark colour, light colour, and white colour are typically used to categorise it. Dark backgrounds, such as black, brown, and dark blue, have high visual tension and evoke a feeling of mystery, which is the basic foundation for the dark type [19]. Because of this, it could emphasise the design’s primary elements and show their solid coherence and vibrant qualities. A light background differs slightly from a white background. The latter can express the primary hue while at the same time reducing the sharp contrast, giving the sense of being clean, basic, and organised. The former displays a more graceful and gentle sensation based on colour.

3.3. Colour Quantity. Effective colour selection and colour quantity management are essential throughout the computer-aided design and colour matching process in order to prevent the phenomenon of colour confusion in design works caused by excessive colour selection, which would negatively affect the outcome [20]. The division of colour schemes dictates that a painting should generally employ not more than three colours. It is of the kind with a few colours that might make people feel simple and at ease. In light of this, it is imperative to closely regulate the colour type matching when using polychromatic number types in accordance with the design theme and content when the number of colours is unrestricted. This allows for the display of a lively, upbeat, and colourful feeling [21].

4. Computer Art Design Colour Matching Method Based on Mathematics

This section is composed of the following subsections.

4.1. Establishment of a Linear Dye Database. The basic theory of computer colour matching is the Kubelka–Munk function theory, and its basic expression is

\[
\frac{K}{S} = \frac{(1 - R)^2}{2R},
\]

(1)

where \( k \) is the absorption coefficient of light in opaque medium, \( s \) is the scattering coefficient of light in opaque medium, \( k/s \) is the Kubelka–Munk function, which can be written as \( f(R) \), and \( R \) is the reflectivity of opaque medium [22]. Theoretically, the Kubelka–Munk function is linear with concentration, and its expression is

\[
f(R) = \phi C + [f(R)]^{(i)},
\]

(2)

where \([f(R)]^{(i)}\) is the Kubelka–Munk function of the substrate, \( \phi \) is the Kubelka–Munk function value of the unit concentration of the beam material, \( C \) is the concentration, and \( f(R) \) is the Kubelka–Munk function value after printing and dyeing on the substrate. \( \phi \) is known as the process of establishing a dye database.

The Kubelka–Munk function expression after using the surface reflection factor \( R_0 \) is

\[
f(R) = \frac{(1 - (R - R_0))^2}{2(R - R_0)}.
\]

(3)

The computer colour matching theory deviates from a linear relationship for a number of reasons; to get the surface correction factor, start by reversing this departure. To extract the spectrum information of colours, dyes with various concentration levels are utilised. Accordingly, after modification using formula (3) the spectral data of the dye and the matrix are:

\[
[f(R)]^{(i)}_k = \frac{[1 - (R^{(i)}_k - R_0)]^2}{2(R^{(i)}_k - R_0)},
\]

(4)

\[
[f(R)]^{(o)}_k = \frac{[1 - (R^{(o)}_k - R_0)]^2}{2(R^{(o)}_k - R_0)},
\]

(5)

where \([f(R)]^{(i)}_k\) and \([f(R)]^{(o)}_k\) are the Kubelka–Munk function value and reflectivity at the \( \lambda \) wavelength at the \( i \)th concentration while printing and dyeing, while \( T \) represents the substrate. Therefore, substituting (4) and (5) into (2), the Kubelka–Munk function of unit concentration of each dye can be written as

\[
\phi^{(i)}_k = \frac{[1 - (R^{(i)}_k - R_0)]^2/2(R^{(i)}_k - R_0) - [1 - (R^{(o)}_k - R_0)]^2/2(R^{(o)}_k - R_0)}{C_k}.
\]

(6)

In (6), \( C_i \) represents the concentration value of the \( i \)th concentration when printing and dyeing. In addition, (6) shows that the difference in the unit Kubelka–Munk function between various concentrations should tend to be the least if the Kubelka–Munk function and concentration also tend to be linear.
\[ \sum_{i \neq j} [\phi_i^{(i)} - \phi_j^{(j)}]^2 \rightarrow \min. \] (7)

Equation (7) can be rewritten as follows since it is valid for all wavelengths:
\[ \int_{\lambda_1}^{\lambda_2} \sum_{i \neq j} [\phi_i^{(i)} - \phi_j^{(j)}]^2 d\lambda \rightarrow \min. \] (8)

When there are \( k \) different types of dyes, equation (8) can be rewritten because the surface reflection factor is dependent on the substrate and is unrelated to the kind of dyes.
\[ \sum_{i}^{k} \int_{\lambda_1}^{\lambda_2} \sum_{i \neq j} [\phi_i^{(i)} - \phi_j^{(j)}]^2 d\lambda \rightarrow \min. \] (9)

Find the minimal value of (9), replace formula (6) with it, and then \( R_0 \) will be obtained.

The cotton polyester combination T65/C35 serves as the foundation, and three dispersion dyes—red dye 3B, yellow dye RGFL, and blue dye 2BLN—were employed to dye the substrate with eight different concentration values. The surface reflection factor \( R_0 = 0.06020 \) is derived on the basis of cotton polyester combination T65/C35 using the above-described approach.

4.2. Use the CMYK Mode to Realize Approximate. CMYK mode can be used to reconcile gradient colours and approximation colours in the process of computer-based art design colour matching based on mathematics. Cyan, magenta, and yellow (CMY) often have three representational values. In order to achieve the light and shade changes of design works, it is important in actual reconciliation to restrict value changes to a specific range. In addition, minor adjustments to CMY can alter the colour, while the K value remains the same. Take the pink water cup as an example. To emphasise the material qualities of the water cup and to boost the authenticity and stereoscopic quality, it is first necessary to choose the proper colour to fill the water cup. Then, by region selection, we modify the edge and middle colour difference appropriately. Since the edge’s dark section contains two colours, the CMY value is essentially unchanged. To obtain the darker pink edge region, we increase the K value to the brightness level. Additionally, it is important to make sure that the colour K value of the middle brightest region does not change. Because it progressively moves towards the yellow area and if accompanying C magenta and Y yellow are overlaid to generate orange, there will be a transition from pink to orange tone when the \( y \) value of CMY grows sufficiently. Orange’s high brightness makes it ideal for use as the water cup’s focal point because it effectively draws attention to the product’s three-dimensional design and authenticity. It also strengthens the impact of approximation in colour and draws attention to the practicality of computer-aided design colour matching.

4.3. Use the HSB Mode to Realize Approximate. HSB mode is similar to the approximate hue and method of the CMYK mode. The variation of the \( H \) value and the \( B \) value must be kept within a reasonable range while performing the gradual hue sum of the HSB mode on a computer. The two often alter just slightly, whereas the \( s \) value varies considerably. Based on this, it is possible to achieve the progressive blending of the same hue saturation property. Additionally, the \( B \) value can be completely utilised based on minor adjustments to \( H \) and \( s \) values, and then by properly modifying and altering it, the same tone lightness characteristic can be changed. According to the experience summary, the HSB mode is the simplest and fastest technique to contrast hue and sum. Typically, the blending process is divided into two steps: first, we use the colour ring to identify the contrast colour and then use the HSB mode to adjust the lightness and saturation in accordance with the colour’s specific values and colour coefficients. By doing this, it can effectively improve the harmony of the contrast colour matching by encouraging close correspondence between the specific values and colour coefficients of the contrast colour. As a result, the designer’s awareness of the nature of colours and ability to match colours will be improved. At the same time, it could also encourage the successful integration of art design works.

4.4. Use the RGB Mode to Realize Approximate. RGB mode refers to the three primary colours of optics. The letters \( R \), \( G \), and \( B \) represent red, green, and blue, respectively. In nature, any colour that can be seen by the naked eye is formed by the mixing and superposition of these three colours, called additive mode. To provide a smooth transition between comparable tones while utilising the RGB mode for the gradual tone sum, it is necessary to maintain the appropriate colour system value in line with subjective perception. This can be performed by adjusting the other two values to make them complementary.

For example, when designing a website, it is necessary to use the RGB mode for colour gradients using the canvas drawing function and circular statements. Such as the circular statements used to fill colours are “cxt.fillstyle = RGB” (“+ (30×i) +”, “+ (255–30×i)+”, 255). This could be used to examine how the \( B \) value in the statement is always kept at 255 but increases by 30 each time the loop is run based on the preceding loop. As a result, the value of \( G \) will be 255 less than the value of \( R \), causing it to take on a specific complementary connection with the same quantity of state. It successfully demonstrates the transformative impact from blue tone to blue-purple tone after six cycles, illuminating the RGB mode’s genuine adjusting effectiveness.
5. Experimental Results

The cotton polyester mixture T65/C35 is utilised as the foundation in order to evaluate the colour matching impact of the colour difference weight factor. Five dispersed dyes, including scatter red dye 3b, dispersion yellow dye RGFL, dispersed blue dye 2BLN, dispersed dark blue HGL, and dispersed black S-2BL, are used to create a tiny dye colour sample database. The lighting source was the Commission Internationale de l’Eclairage (CIE) standard light source D65, and the weight factors w11 and II are calculated using equations (7) and (8), respectively, in order to match the traditional colors dark green and blue and the corresponding color difference weight factors. By using the international lighting commission’s cie976 (L*a*b) colour space difference calculation, the colour matching impact is quantified.

Figure 1 and Figure 2 display the corresponding equation (unit: g/L) and colour difference. In these tables, EA stands for the colour difference produced when a light source is illuminated, and ED stands for the colour difference produced when a D65 light source is illuminated. According to the data in Figures 1 to 4, when matching dark green or blue, the colour difference for computer colour matching using the colour difference weight factor is relatively small, better meeting the needs of computer colour matching. Despite the great degree of colour difference accuracy in the two colour matching
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groups selected for this study, the formula accuracy provided by the weight factor for colour difference is superior to that provided by computer colour matching and genuine art pictures.

6. Conclusions

An art and design degree includes instruction in graphic design, sculpture, painting, and drawing. Students majoring in art and design are taught fundamental design concepts, colour theory, critical analysis, and creative techniques. Colour matching is one of the most important factors in determining the quality of art and design. In the framework of mathematical operation, the use of computers for successful colour matching in art design is to satisfy the inescapable demands of the growth of modern society and is a crucial approach to creating wonderful artworks. Its colour matching technique not only has a high degree of universality but can also significantly increase the designer’s design skills and completely exhibit the observability of the design works, therefore fostering a positive creative environment.

The object colour sensitivity function is expanded for computer colour matching based on the linear database, and a colour difference weight factor is developed. The results of the colour matching demonstrate that this approach has pretty excellent outcomes and can more effectively satisfy the needs of computer colour matching. The weight factor
accurately reflects the variation in colour perception brought on by the shift at each wavelength, which is the main source of its perfect effect.

**Data Availability**

The datasets used and analyzed during the current study can be obtained from the corresponding author upon reasonable request.

**Conflicts of Interest**

The author declares no conflicts of interest.

**Acknowledgments**

The paper was supported by the following project. (1) Ganzhou Federation of Social Sciences, Research on the application of red culture in Ideological and political teaching based on AR technology, 2021-028-0526. (2) Jiangxi Basic Education Research Project, Research on the realization of Hakka living appliances and aesthetic education in primary and secondary schools in southern Jiangxi, SZUGKMS2021-977. (3) Jiangxi University Humanities and Social Sciences Research Project, Research on aging design based on the life form of the elderly in Gannan cities and towns, YS21224. (4) Science and Technology Research Project of Jiangxi Provincial Department of Education, Design and implementation of AR technology in Library Document push system, GJJ219108.

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