Vectorization Analysis of Cultural Creative Design Based on the Recognition Model of Virtual Reality Technology

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Abstract

In order to solve the problem of large color matching errors exhibited in the previous color matching system, this study proposes a special color automatic matching system for cultural and creative products based on virtual reality technology. In this study, virtual reality technology (Technology) is applied to the proposed system design. Based on the three-tier architecture, the system framework is designed. The architecture includes a data access layer, a business logic layer, and a presentation layer. The hardware includes a spectrophotometer, a central processing unit, a storage device, and a virtual reality somatosensory interaction device, and the four key devices are introduced in detail. The software part takes the BP neural network algorithm as the core, trains and processes the three color values, constructs the automatic color matching model of cultural and creative products according to the training results, and realizes the logical operation and analysis of the system software. The experimental results show that although there is still a certain error between the color matching of the cultural and creative products output by the system and the actual color matching of the test samples, the maximum absolute error of the matching is relatively small, both of which are less than 0.05, which proves the effectiveness of the research to a certain extent. The error between the 6 groups of actual matching samples and the predicted matching samples is < 1.5, which proves that the color difference is related to human vision, indicating that the matched samples have no color difference and achieve the expected effect. Although there are some errors between the designed system and the expected color matching, the error is small, so the color difference does not affect the visual presentation effect.

1. Introduction

With the continuous improvement of industrialization and the continuous improvement of people’s way of life, culture and creative products have become an important part of the culture. The innovative cultural value, retention value, and information transmission value of cultural and creative products have become the core of cultural and creative products. With the advent of the digital age, cultural, and creative products, the carriers of digital technical symbols have emerged, which have the dual characteristics of the integration of technical symbols and digital art. Digital cultural and creative products with technical symbols can not only increase the content and form of cultural and creative products but also conform to the law of the development of cultural and creative product design. Today, with the rapid development of the digital age, product design with digital technology symbols cannot be avoided by the design industry. The digital age has included a series of information technologies, such as networks and new media virtual simulations. The application of its main technical symbols has brought the possibility of innovation from multiple perspectives. In the future of cultural and creative product design, the integration of digital technology is not only an innovative design but also more likely to become the mainstream form and new media of creative product design in the digital era. Such cultural and creative products are more satisfied with the needs of market users and are also conducive to breakthroughs in the design of cultural and creative products [1, 2]. Exploring the design and research of
2 Literature Review

Mallika Jecan studied virtual reality technology as purely professional computer technology [3]. Trivedi et al. mentioned virtual reality technology. At the fifth annual meeting of the computer application society of the Chinese Society of Civil Engineering, virtual reality was proposed as one of the three emerging cutting-edge technologies in the world at that time. So far, the Chinese academic circles have paid attention to virtual reality technology [4]. Li and Hou comprehensively introduced the concept, characteristics, short development history, three-dimensional interactive tools, and interactive technology based on the natural skills of virtual reality technology [5]. Liu and Pan started from the technical level, mainly studied the relationship between virtual reality technology and animation art, and paid attention to the changes brought by virtual reality to the animation experience [6]. Gao et al. analyzed the performance technology of virtual reality and thus elaborated the significance of studying virtual reality for vision, hearing, force/touch, and smell/taste [7]. Li et al. regard virtual reality as a core relationship between humans and images and analyze the interaction and symbiosis between humans and images from a macro perspective [8]. Taking “immersion” and “illusion” as clues, this study traces back the historical space of virtual reality fantasy to the frescoes in a mistery villa and discusses the relationship between virtual art and the viewer’s perception and consciousness. Akdere et al. introduced the development process of AR and VR projects, the process of the unity3d software industry, and the application skills of unity3d software interface and nodes so that readers can understand how to use unity3d to develop products [9].

Although many color combinations have been developed, there are no color combinations for commercial and creative products. As a result, there will be some variations of the appropriate colors, there will be significant differences between the product and the ideas and strategies, and the special rules will disappear. Based on this, this material has developed an expert process for automatic color mixing of cultures and creative products to meet the design and implementation requirements of equipment, use virtual (technology) in design, and design consists of four phases: design, hardware design, software development, and system testing.

3 Research Methods

The key to creating a culture and a creative product is how to engage with the culture of the product. It is important to use color to achieve the above goals. Vision is the most sensitive to color. Different colors combine to give a different feel and meaning to the product. Use porcelain as an example: blue and white porcelain is white and blue, and white represents purity; the green symbolizes spring and energy in Han culture and is good. White glazed porcelain is mainly monochromatic white, and there are many types of white. The higher the whiteness, the stronger the meaning of sweetness and purity. Therefore, once there is a problem with the matching white and the soul of white glazed porcelain will be lost. Different colors can create different visual effects together, and once they are wrongly matched, there will be nondescript phenomena. Therefore, to design good cultural and creative products, virtual reality technology is applied to color matching to help designers “experience” the effect of color matching and adjust the design scheme in time so that the design of cultural and creative products can achieve the expected goal.

3.1 System Framework Design. The automatic color matching system framework of cultural and creative products based on virtual reality technology is designed with reference to the b/s three-tier framework mode, including a data access layer, business logic layer, and presentation layer [10].

3.1.1 Data Access Layer. Be responsible for directly operating the database and adding, deleting, modifying, and searching for data resources. The access layer in this system mainly stores many cultural and creative product samples, color matching schemes, and various operation program codes.

3.1.2 Business Logic Layer. The operation on specific problems, which can also be said to be an operation on the data layer, is the core layer of the entire system [11]. In the system, it is mainly composed of integrated circuit chips, which are responsible for the color matching operations.

3.1.3 Presentation Layer. Generally speaking, it is the interface presented to the user, which is responsible for the successful display of color matching to the user. In the past, the display results of color matching systems were mostly two-dimensional images, lacking an intuitive three-dimensional sense. In the designed system, the display results are mainly displayed through VR technology, which is more intuitive.

3.2 System Hardware Design. The main hardware used in the color automatic matching systems of cultural and creative products based on virtual reality technology includes a spectrophotometer, a central processing unit, a storage device, and a virtual reality somatosensory interaction device. The following is a specific analysis.

3.2.1 Spectrophotometer. The function of the spectrophotometer is to measure the color composition of samples, which is the key to color matching and adjustment. The
spectrophotometer in this system is a CS-580. The equipment features are as follows:

1. Color display, true color 2.8 inches, and resolution 320 × 480
2. Φ8/4 mm two kinds of measuring calibers are suitable for measuring in various scenes
3. The interface can use the power adapter for direct charging operation
4. Soft rubber buttons are measured at the back of the fuselage, which conforms to the ergonomic design
5. The storage capacity of the instrument is 100 standard samples and 20000 samples; it is automatically saved during measurement and records can be cleared

3.2.2. Central Processing Unit. The central processing unit is responsible for the overall control and all operations of the system and is the core part of the system [12]. In this system, an STM32 F429/F439 microcontroller based on ARM® Cortex™ M 4 is selected as the central processor.

3.2.3. Virtual Reality Somatosensory Interaction Device. Virtual reality somatosensory interaction devices are the key to the effectiveness of automatic color matching when users read cultural and creative products. The device is mainly composed of a helmet-mounted display and data sensing gloves. The role of an HMD is to provide users with three-dimensional scenes in virtual reality. The HMD selected in the system is a 3 GLASSESS 2 display. We use a Plug and Play display that does not require drivers and realize voice interaction function through Cortana. The main function of data sensing gloves is to accurately and real time transmit the posture of the human hand to the virtual environment so that users can naturally interact with the establishment of three-dimensional images through gestures, such as opening applications with simple gestures, selecting and adjusting the size of targets, and dragging and dropping holograms, which greatly enhance the interactivity and immersion [13]. The data sensing gloves in this system are CybergloveII data gloves. The device can measure up to 22 joint angles with high accuracy. It adopts advanced anti-bending induction technology, which can accurately convert the movements of hands and fingers into digital real time joint angle data.

3.2.4. Storage Devices. The main function of the storage device is to store programs and various types of data. Since a large amount of sample data must ensure the accuracy of color matching, it is insufficient to rely only on the memory capacity of the central processor of the system. A storage expansion device is also required in the system [14]. The storage expansion device in the system is BBA-364.

3.3. System Software Program Design. The overall process flow of the software of the automatic color matching system for cultural and creative products based on virtual reality technology is shown in Figure 1.

In the entire system color matching process, the key algorithm is the application of the BP neural network algorithm. For this system, the input value of RGB is three color values of a sample color, and the output value is the proportion of various colors of cultural and creative products, that is, the color scheme [15, 16]. The basic process of creating automatic color schemes of cultures or products based on the BP neural network algorithm is as follows:

Step 1 (prepare the samples): many supporting data models require training BP neural network models. Therefore, the first step in the development of automatic color schemes for cultural or creative products based on the BP neural network algorithm is to develop a model library. The content of the library model should be selected according to the cultural objectives and the creative material.

Step 2 (sample data collection): RGB color characteristic values are collected by a spectrophotometer.

Step 3: standardize RGB color characteristic values. The RGB color characteristic values collected by a spectrophotometer cannot be directly input into a neural network and need to be standardized. The method used is the Premnmx function in MATLAB.

Step 4 (neural network model construction [17]): the problem to be solved by the designed system is the prediction of the color ratio of cultural and creative products.

Creating a neural network is initially divided into two phases: training and experimentation. The sample data are usually divided into two categories, with the most common being used as training models and the smaller ones as test samples. Training: the training sample set is input into the BP neural network model. After the hidden layer transfer function processing, it reaches the output layer. Finally, through the output layer transfer function operation, the color matching scheme of cultural and creative products is obtained [18]. At this time, it is necessary to judge whether the difference between the actual cultural and creative product color matching schemes and the expected cultural and creative product color matching schemes is less than the preset threshold. If the difference is less than the initial one, complete the training of the BP neural network model. If the value difference is greater than the pre-order value, the price difference should be used as the difference between the input value and the weight of each layer to be changed. Constantly, until the weight measurement affects the color contrast of the urine, a concept of culture and creative products to meet demand.

Experiments: test samples were incorporated into a set of BP neural network training models and color models for culture and product development.

The input quantity of BP neural network input layer is shown in the following formula:

$$O_j^{(1)} = x(j), \quad j = 1, 2, 3, 4.$$  \[(1)\]
The input and output quantities of the BP neural network hidden layer are, respectively, shown in formulas (2) and (3):

\[ \text{net}_1^{(2)}(k) = \sum_{j=0}^{m} \omega_j^{(2)}O_j^{(1)}(k), \]  
\[ o_1^{(2)}(k) = f[\text{net}_1^{(2)}(k)], \quad i = 1, 2, \ldots, 5, \]  
where \( \omega_j^{(2)} \) is the weighting coefficient from the input layer to the hidden layer of the BP neural network, and the input layer, hidden layer, and output layers correspond to the above marks (1)–(3), respectively, and \( M \) is the number of neuron inputs. A hyperbolic tangent function is adopted as the excitation function for hidden layer neurons:

\[ f(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \]  

The input and output quantities of BP neural network output layer are, respectively, shown in formulas (5) and (6):

\[ \text{net}_i^{(3)}(k) = \sum_{i=0}^{d} \omega_i^{(3)}O_i^{(2)}(k), \]  
\[ o_i^{(3)}(k) = g[\text{net}_i^{(3)}(k)]. \]  

It is obtained from the following formula:

\[ o_1^{(3)}(K) = K_p, \]  
\[ o_2^{(3)}(K) = K_i, \]  
\[ o_3^{(3)}(K) = K, \]  
where \( \omega_i^{(3)} \) is the weighting coefficient from the hidden layer to the output layer and \( g(x) \) is the activation function of neurons in the output layer:

\[ g(x) = \frac{1 + \tanh(x)}{2} = \frac{e^x}{e^x + e^{-x}}. \]  

The performance index function is as

\[ E(k) = \frac{1}{2}[r(k + 1) - y(k + 1)]^2. \]  

In order to speed up the convergence, an inertia term is added to make the search converge to the global minimum quickly. The formula of the neural network weight coefficient is modified according to the gradient descent method as

\[ \Delta \omega_i^{(3)}(k + 1) = -\eta \frac{\partial E(k)}{\partial \omega_i^{(3)}} + \alpha \Delta \omega_i^{(3)}(k), \]  

where \( \eta \) is the learning rate and \( \alpha \) is the momentum factor. (11) can be obtained from (7):

\[ \frac{\partial u(k)}{\partial o_1^{(3)}(k)} = e(k) - e(k - 1), \]  
\[ \frac{\partial u(k)}{\partial o_2^{(3)}(k)} = e(k), \]  
\[ \frac{\partial u(k)}{\partial o_3^{(3)}(k)} = e(k) - 2e(k - 1) + e(k - 2). \]  

Thus, the output layer weight calculation formula (12) of the BP neural network can be obtained:

\[ \Delta \omega_i^{(3)}(k + 1) = \eta[e(k + 1)\text{sgn}\left(\frac{\partial y(k + 1)}{\partial u(k)}\right) + \alpha \Delta \omega_i^{(3)}(k)]  
\]  
\[ \frac{\partial u(k)}{\partial o_i^{(3)}(k)} \frac{\partial o_i^{(3)}(k)}{o_i^{(2)}(k)} \frac{\text{net}_i^{(3)}(k)}{o_i^{(2)}(k)} \]  
\[ + \alpha \Delta \omega_i^{(3)}(k), \quad j = 1, 2, 3, 4; i = 1, 2, 3. \]  

4. Result Analysis

4.1. System Test and Analysis. In order to test the automatic color matching performance of the system, silk fabric is taken as an object for color matching research, and the color
difference in color matching is taken as the inspection standard.

4.1.1. System Test Environment. The system test environment is shown in Table 1.

4.1.2. Test Samples. In this study, 150 types of silk fabrics are selected as objects to build a sample library.

RGB color characteristic values are collected by a spectrophotometer to obtain 150 groups of original sample data sets, which are standardized to obtain training sample sets and inspection sample sets [19]. Among them, 80% of the data is used as the training sample set, and the remaining 20% is used as the test sample set, as shown in Table 2.

4.1.3. Neural Network Parameter Setting. Neural network parameter settings are shown in Table 3.

4.1.4. System Color Matching Results. The benefits of automatic color schemes for comparison of materials and design based on neural network algorithms are shown in Table 4 (the last 6 groups are selected for explanation).

It can be seen from Table 4 that although there is still a certain error between the color matching of cultural and creative product output by the system and the actual color matching of test samples, the maximum absolute error of
matching is relatively small, both less than 0.05, which proves the effectiveness of the study to a certain extent.

4.1.5. Color Difference Statistical Results. The above research results are not intuitive enough and have little practical reference significance. Therefore, in order to further test the color matching effect of the system, the color difference is used as an indicator for further testing [20, 21]. Color difference detection is used to analyze the color difference after extracting the image color characteristic value. The color difference test results are shown in Table 5 and Figure 2.

It can be seen from Table 5 and Figure 2 that the errors between the 6 groups of actual matching samples and the predicted matching samples $R$, $G$, and $B$ are $\Delta E < 1.5$, which proves that the color difference is related to human vision, indicating that the matched samples have no color difference and achieve the expected effect [22, 23].

5. Conclusion
To sum up, the emergence of cultural and creative products has promoted and inherited many traditional cultures. Culture and creative products have been transformed and
renewed according to traditional culture, making commercial products, not the cultural benefits. Color harmony is key to the design and production of commercial and industrial products. As a result, this design has created an automatic color transition for cultural and creative products based on virtual machines. Test results show that the system is viable and useable. However, this study still has some shortcomings; that is, in the color matching test, three colors with different proportions are designed, which has certain limitations and needs further testing and research.

**Data Availability**

The data used to support the findings of this study can be obtained from the corresponding author upon request.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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