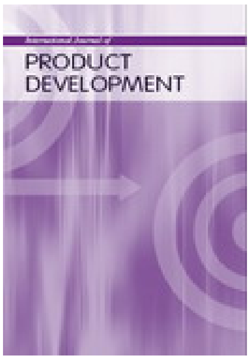

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Colour matching method of product interactive interface based on user experience

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Abstract: In this paper, a colour matching method of product interactive interface based on user experience is proposed. Firstly, the colour matching visual information of product interaction interface is collected in the adjacent block area. According to the visual information collection results, the colour matching element features of product interaction interface are extracted by wavelet transform. Secondly, the RGB feature decomposition model of colour matching elements in product interaction interface is established to complete the visual information fusion of colour matching in product interaction interface; Finally, considering the user experience, the colour matching reconstruction model of product interactive interface is constructed to realise the colour matching of product interactive interface. The experimental results show that the proposed method has high colour gamut coverage and image signal-to-noise ratio, high user experience satisfaction and good colour matching quality and effect of product interaction interface.

Keywords: user experience; visual information fusion; wavelet transform; product interaction interface; colour matching.

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1 Introduction

With the continuous progress of the times, the ways of information transmission have become richer and more diverse. At present, the fastest way of information transmission is the internet. As the main information carrier in network interaction, web pages have attracted more and more attention (Wan et al., 2021; Vyas and Frasincar, 2020; Xiong et al., 2019). With the passage of time, the web interface has developed from a static web page dominated by text and pictures in the past to a dynamic responsive web interface containing various multimedia forms such as sound, light and electrical effects. The design of web interface is undergoing a great historical change. In the information age, the application scope of the internet is expanding. The sales of services, manufacturing and other industries are carried out through their own websites, which will affect the visual perception of visitors (Huang, 2020; Tang and Ye, 2020). At the same time, people have higher and higher requirements for the colour matching of product interactive website interface. The product interactive web interface design with good visual effect and user experience is more easily accepted by users and more and more welcomed by users. Therefore, the research on the colour matching visual style of product interactive web interface has extensive theoretical and practical significance.

At present, scholars in related fields have studied the colour matching theory and achieved some results. Wang (2019) proposed a reasonable colour matching method of interior decoration materials based on genetic algorithm. Through the genetic coding of chromosomes in the genetic algorithm of three-dimensional components and colour composition, RGB is transformed into HSL, the colour disharmony coefficient is calculated, the harmony degree of colour matching of interior decoration materials is analysed and the visual comfort degree is obtained. The colour matching fitness function of interior decoration materials is composed of three parts: colour matching harmony, colour matching harmony and visual comfort. Using the selection of genetic algorithm, cross-over and mutation operations to obtain the individuals with the highest fitness, set the stop iteration conditions and get the reasonable colour matching results of interior decoration materials. The experimental results show that the colour comfort of this method is high, but there is a problem of low colour gamut coverage. Shen et al. (2021) proposed the design method of automatic colour matching system for cultural and creative products based on virtual reality technology, applied Virtual Reality technology (VR technology) to automatic colour matching and designed the system framework in B / S three-tier architecture, including data access layer, business logic layer and presentation layer. The hardware includes spectrophotometer, central processing unit, storage device and virtual reality somatosensory interaction device and four key devices are introduced in detail. The software part takes BP neural network algorithm as the core, trains and processes RGB three colour values and constructs the automatic colour matching model of cultural and creative products according to the training results to realise colour matching. The experimental results show that the method has high processing efficiency, but there are problems of low image signal-to-noise ratio, poor colour matching effect, and low-user experience satisfaction.

This paper aims to solve the problems of low colour gamut coverage, low image signal-to-noise ratio and low-user experience satisfaction existing in traditional methods, and proposes a user experience-based colour matching method for product interaction interface. The technical research route of this method is as follows:

Firstly, the visual information of colour matching of product interactive interface is collected, and according to the information collection results, the element features of colour matching of product interactive interface are extracted by wavelet transform method and the three-dimensional distribution feature quantity of colour matching of product interactive interface is obtained.

Secondly, according to the feature extraction results, the RGB feature decomposition model of the colour matching elements of the product interaction interface is established and the visual information fusion is realised through the model.

Thirdly, based on the results of visual information fusion of product interaction interface colour matching, fully considering user experience issues, a reconstruction model of product interaction interface colour matching is constructed to realise product interaction interface colour matching.

Finally, by comparing with the traditional methods, it is concluded that the proposed method has high colour gamut coverage, high image signal-to-noise ratio and high-user experience satisfaction.

2 Colour matching method of product interaction interface

The product interaction interface is a platform for information exchange. In the design process, the isomorphism of information should be realised, that is, users and designers can transmit information accurately and quickly (Yang and Zheng, 2020; Wu et al., 2020; Raduntz and Meffert, 2020). That is, the design information must be correctly recognised and understood by users, and produce psychological communication between users and designers on aesthetic concepts, product functions and so on. Product interaction interface design based on user experience is user-centred and designed from the perspective of users. Its design goal is not limited to the product itself, but runs through the whole life cycle of the product. Designers should pay more attention to users, understand and respect different cultures and affect the quality of products through the design process (Disser, 2020; Chinello et al., 2019).

2.1 Collection of visual information on colour matching of product interaction interface

Colour is a kind of material with great visual attraction. The interaction between human beings and commodities begins with people's understanding of its colour matching (Yang et al., 2020). In the process of interaction between people and products, colour matching can be understood as a semantic symbol. The information it conveys to users is divided into two levels: the colour matching design at the functional level conveys the functional semantics of products; The colour matching design at the emotional level conveys the emotional semantics of the product. In order to realise the colour matching of product interactive interface based on user experience, it is first necessary to collect the visual information of colour matching of product interactive interface, and carry out the colour matching of product interactive interface from the starting point of improving user experience.

Suppose that in a closed region, the marginal distribution parameter of each sub-region is α, and the amount of autocorrelation statistics is β. Based on the description of the information collection method, the information distribution function γ of the colour matching of the product interaction interface under the user experience is obtained, and the correlation equation of the colour matching of the product interaction interface in each sub-region is obtained as follows:

$$f(x,y) = \left(\frac{\partial \gamma}{\partial x^2} - \frac{\partial \beta}{\partial y^2}\right) + \delta \times \alpha \tag{1}$$

In formula (1), $f(x,y)$ represents the information distribution sequence of the colour matching of the product interactive interface, where x and y both represent the pixel points and δ represents the state parameter of the colour matching of the product interactive interface; ∂ represents the interface information arrangement. Let $\delta = \frac{\gamma}{\beta}$, determine the visual effect of the colour matching of the product interactive interface by the position of δ, and calculate the inter-class bit rate ε of the colour matching of the product interactive interface. Taking the centre frequency F as the rotational invariant moment, the colour matching fusion parameter Q of the product interactive interface is obtained, and then the edge pixel point distribution sequence of the colour matching of the product interactive interface is collected:

$$\epsilon_N = \gamma \times \varepsilon + \frac{Q \times \varepsilon}{F} \tag{2}$$

In formula (2), F represents the pseudo-edge pixel. Using the method of matching the window function of the pixel point y, the information collection formula for the colour matching of the product interactive interface is obtained as follows:

$$P(x, y) = \sqrt{2} \times \gamma \times \left[\cos \frac{1}{\theta} - \sin \vartheta^2 \right] \tag{3}$$

In formula (3), θ represents the time window value of product interaction interface colour matching visual perception, and ϑ represents product interaction interface colour matching visual parameters. According to the above analysis, in the adjacent block area, complete the collection of visual information of product interaction interface colour matching.

2.2 Feature extraction of colour matching elements in product interaction interface

Based on the collection results of colour matching visual information of product interaction interface, the feature of colour matching elements of product interaction interface is extracted by wavelet transform (Zhang et al., 2019; Yan et al., 2019). Wavelet transform is a new transform analysis method. It inherits and develops the idea of localisation of short-time Fourier transform, and overcomes the shortcomings that the window size does not change with frequency. It is an ideal tool for feature extraction. Its main feature is that it can fully highlight some aspects of the problem through transformation, and carry out multi-scale refinement. Combined with the collected visual information of interactive interface colour matching, the three-dimensional distribution characteristic quantity of product interactive interface colour matching is obtained as follows:

$$W(x, y) = \frac{E(x, y)}{\gamma} + \frac{\delta}{x'y'} \tag{4}$$

In formula (4), $E(x, y)$ is the central moment of the distribution of the product interface area with $x'y'$. Through pixel marking, the edge contour marking in the process of colour matching of product interactive interface is carried out, and the contour line of colour matching of product interactive interface is obtained as:

$$R(x,y)=\frac{\gamma^2}{2(x'y')} \tag{5}$$

Through the method of neighbourhood feature matching, the pixel distribution matrix of product interaction interface is obtained as follows:

$$T(x,y)=\begin{bmatrix} 0 & -\cos\mu & 1 \\ \cos x' & -\sin y' & 1 \\ \sin\mu & 1 & 0 \end{bmatrix} \tag{6}$$

In formula (6), x, y is parallel to the colour distribution $x'y'$ of the product interactive interface, and μ is the value of the parameter abscissa of the product interactive interface pixel. Calculate the wavelet parameters of the feature distribution of product interaction interface colour matching elements in each sub-region, and obtain the product interaction interface colour matching element features extracted by wavelet transform as follows:

$$Y(x,y)=\delta(Z)\times Y_0(x,\mu)+\frac{1}{\delta}(Z)\times Y_0(x,\rho) \tag{7}$$

In formula (7), ρ is the parameter ordinate value of the animation scene pixel, Y_0 is the eigenvalue function value, and $\delta(Z)$ is the state parameter function value in:

$$Y_0(x,\mu)=\gamma\times\frac{\gamma x}{2x^2y^2}+\frac{\gamma y}{\delta} \tag{8}$$

$$\delta(Z)=\left(\frac{\mu}{x}+\frac{y}{\rho}\right)\times\delta(x,y) \tag{9}$$

According to each area, the features of the colour matching elements of the product interaction interface are extracted to provide a data basis for the fusion of the colour matching information of the product interaction interface.

2.3 Colour matching of product interface

Based on the above extracted colour matching element features of product interaction interface, the RGB feature decomposition model of product interaction interface colour matching element is established, and the RGB decomposition results of product interaction interface colour matching visual fusion are obtained through visual information fusion:

$$U(x)=\begin{cases} \max\{U(x),1\} \\ \min\{0,\gamma+U(x)\} \end{cases} \tag{10}$$

In formula (10), $U(x)$ is the local decomposition value of the colour matching cognition of the product interface. In the multi-dimensional colour matching vision of product interaction interface, the distribution vectors of colour matching images of product interaction interface are obtained as u_{mn} and o_{mn}. According to the colour matching vision of the product interaction interface, in the $p_1 \times p_2 \times \cdots \times p_m$ three-dimensional adjacent space of each pole, the multi-dimensional product interaction interface visual information set is expressed as:

$$F(x) = u_{mn}\left(o_{mn}p_1, o_{mn}p_2, \ldots, o_{mn}p_m\right) \tag{11}$$

Thus, the three-dimensional field feature distribution set of colour matching visual elements of product interaction interface is constructed as follows:

$$\omega(x) = (x' - y')^2 \times F(x) \tag{12}$$

Set $\left\{x', y' \middle| x' = 1, 2, \ldots, m, y' = 1, 2, \ldots, n\right\}$ in image G, and use Harris matrix for colour matching of product interaction interface Visual fusion, the product interaction interface colour matching visual information fusion model is defined as:

$$K(x, \gamma) = L(x, \gamma) + \omega(x) \tag{13}$$

In formula (13), $L(x, \gamma)$ is the marginal quantity of visual colour cognition of product interaction interface; $\omega(x)$ is the multi-objective information function. Through the above steps, the product interaction interface colour matching visual information fusion is realised.

On the basis of visual information fusion of product interaction interface colour matching, and fully considering the problem of user experience, this paper constructs the colour matching reconstruction model of product interaction interface. User experience refers to an emotion generated by users when using or enjoying services, it covers all levels between people and products. User experience is a long-term and cyclic process. Based on this feature, the colour matching design of product interaction interface is carried out. Combined with the three-dimensional distribution fusion of the colour matching image of the product interaction interface, the visual reconstruction parameters of the colour matching of the product interaction interface are obtained as follows:

$$\tau(x, \gamma) = \frac{\sigma \times b}{K(x, \gamma)} \times \left(\sigma - K(x, \gamma)\right) \tag{14}$$

In formula (14), σ is the basic value of product interaction interface colour collocation reconstruction and b is the fusion index of product interface colour collocation reconstruction. Through the adjacent pixel information fusion method, the low-level visual structure reconstruction of the colour matching visual elements of the product interaction interface is carried out. The RGB decomposition value of the colour matching visual elements of the product interaction interface is:

$$\varphi(x) = \frac{R_{GB}\left(F(x) - U(x)\right)}{\tau(x, \gamma)} \tag{15}$$

In formula (15), R_{GB} is the initial value of the colour matching visual elements of the product interface. The colour matching reconstruction model of the product interaction interface is established as follows:

$$\operatorname{sim}(x) = \frac{\sqrt{xy} \times \varphi(x)}{\tau(x, \gamma)} \tag{16}$$

To sum up, the specific steps of product interaction interface colour matching are given: (1) the visual information of product interaction interface colour matching is collected in adjacent blocks, and the feature of product interaction interface colour matching elements is extracted by wavelet transform. (2) The RGB feature decomposition model of colour matching elements in product interaction interface is established to complete the visual information fusion of colour matching in product interaction interface. (3) Considering the user experience, the colour matching reconstruction model of product interaction interface is constructed to realise the colour matching of product interaction interface.

3 Experimental simulation and analysis

In order to verify the effectiveness of the colour matching method of product interaction interface based on user experience, experimental research is carried out.

3.1 Experimental scheme design

1. *Experimental hardware and software environment*: Take a product interactive interface as the research object, the experimental configuration is Intel Xeon E5 2620 v4 2.1 GHz, the operating system is Windows 10 and the product interactive interface colour matching and visual replay are carried out in the Visual C++ visual compilation environment. Structure and information perception, optimise the colour matching image of the output product interactive interface, and uniformly set the number of iterations to 500 times.
2. *Source of experimental data*: The images used in the experiment are all from The MNIST Database, which includes a test set of 60,000 examples, from which images of product interaction interfaces are selected as experimental objects for experimental research. In order to ensure the accuracy of the experimental results and reduce the error of the results, MATLAB simulation software is used to process the experimental results.
3. *Experimental index*: take the image signal-to-noise ratio as the evaluation index. The higher the signal-to-noise ratio of the image, the better the colour matching quality of the product interaction interface; The gamut coverage is used as the evaluation index. The higher the gamut coverage, the better the colour matching effect of the product interaction interface; Taking the user experience satisfaction as the evaluation index, the user satisfaction score is obtained in the form of user scoring. The higher the score, the higher the user experience satisfaction.
4. Wang (2019) method, Shen et al. (2021) method and the proposed method are used to compare and verify the effectiveness of the proposed method.

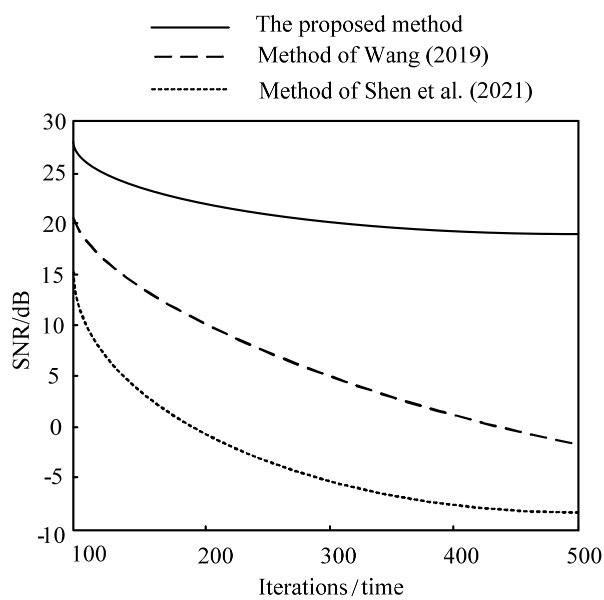
3.2 Analysis of experimental results

1 *Analysis of image signal-to-noise ratio*: In order to verify the colour matching quality of the product interaction interface of the proposed method, the image signal-to-noise ratio is used as the evaluation index and its calculation formula is as follows:

$$SNR = 10lg\frac{P_S}{P_N} \tag{17}$$

In formula (17), P_S refers to the effective power of the signal, and P_N refers to the effective power of the noise. Wang (2019) method, Shen et al. (2021) method and the proposed method are used to compare and the signal-to-noise ratio of the colour matching image of the product interaction interface of different methods is obtained as shown in Figure 1.

Figure 1 Colour-matching image signal-to-noise ratio of product interaction interface for different methods



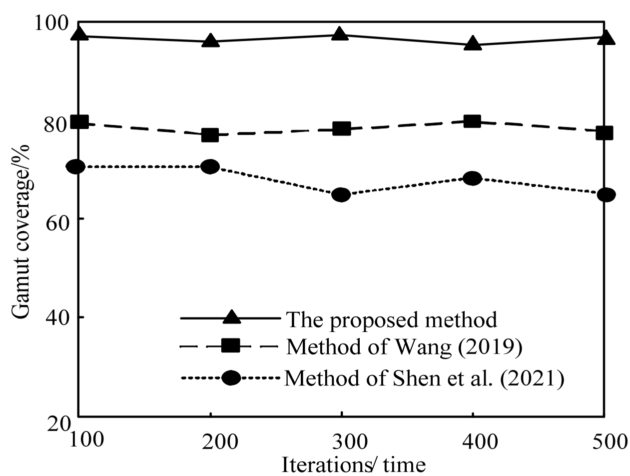
Analysis of Figure 1 shows that with the increase of the number of iterations, the signal-to-noise ratio of the colour matching image of the product interaction interface of different methods decreases accordingly. When the number of iterations is 500, the signal-to-noise ratio of the colour matching image of the product interface of Wang (2019) method is –2 dB, and the signal-to-noise ratio of the product interface colour matching of the method of Shen et al. (2021) method is – 8 dB. And the signal-to-noise ratio of the colour matching image of the product interaction interface of the proposed method is as high as 18 dB. It can be seen that the signal-to-noise ratio of the colour matching image of the product interaction interface of the proposed method is high, which can effectively ensure the quality of the colour matching of the product interaction interface. This is because the proposed method uses the wavelet transform method to extract the colour matching element features of the product interaction interface, and obtains the three-dimensional distribution feature quantity of the colour matching of the product interaction interface. The image colour matching is processed according to the feature quantity, which is conducive to improving the signal-to-noise ratio of the colour matching image.

2 *Colour gamut coverage analysis*: On this basis, the colour matching effect of the product interaction interface of the proposed method is further verified, and the colour gamut coverage is used as the evaluation index. The calculation formula is as follows:

$$C = \frac{V}{0.1952} \times 100\% \tag{18}$$

In formula (18), V refers to the area of the colour gamut of product interaction interface colour matching. Wang (2019) method, Shen et al. (2021) method and the proposed method are used to compare, and the colour gamut coverage of the product interaction interface of different methods is obtained as shown in Figure 2.

Figure 2 Colour gamut coverage of product interaction interface colour matching with different methods



It can be seen from the analysis of Figure 2 that when the number of iterations is 500, the average colour gamut coverage of product interaction interface in Wang (2019) method is 80.3%, and the average colour gamut coverage of product interaction interface in Shen et al. (2021) method is 68.3%. The average colour gamut coverage of the proposed method is 96.8%. It can be seen that the colour gamut coverage of the product interactive interface colour matching of the proposed method is high, indicating that the colour matching effect of the product interactive interface of the proposed method is good. This is because the proposed method constructs the RGB feature decomposition model of the colour matching elements in the product interaction interface, and realises the visual information fusion through this model, so as to improve the colour gamut coverage of colour matching.

3 *Comparative analysis of user experience satisfaction*: Based on the above analysis, the application effect of the proposed method is further verified. Taking user experience satisfaction as the experimental index, Wang (2019) method, Shen et al. (2021) method and the proposed method are compared, respectively. The user experience satisfaction results of different methods are shown in Table 1. Among them, user experience satisfaction is based on user scoring. 100 users are selected to score different methods. The higher the score, the higher the user experience satisfaction.

Table 1 User experience satisfaction of different methods

Number of users/ person	*The proposed method/s*	*Wang (2019) method/s*	*Shen et al. (2021) method/s*
20	94.6	85.3	79.8
40	93.2	86.9	73.1
60	91.4	82.5	67.6
80	90.6	76.1	67.5
100	89.1	70.7	65.7

Table 1 shows that with the increase of the number of users, the user experience satisfaction scores of different methods decrease. When the number of users is 40, the user experience satisfaction of Wang (2019) method is 86.9 points, the user experience satisfaction of Shen et al. (2021) method is 73.1 points and the user experience satisfaction of the proposed method is 93.2 points. Therefore, the user experience satisfaction of the proposed method is higher. This is because the proposed method fully considers the user experience and constructs the colour matching reconstruction model of the product interaction interface, which can improve user satisfaction.

5 Conclusions

In order to improve the colour matching effect of product interactive interface, a colour matching method of product interactive interface based on user experience is proposed to improve user experience and realise the colour matching of product interactive interface. The main innovations of this method are as follows:

1 Establish the colour matching correlation equation of different sub-regions of the product interaction interface, collect the visual information of the colour matching of the product interaction interface, and use the wavelet transform method to extract the characteristics of the colour matching elements of the product interaction interface, so as to provide a basis for the colour matching.

2 Construct a RGB feature decomposition model of colour matching elements of product interaction interface, and integrate visual information through this model. At the same time, on the basis of fully considering user experience issues, build a colour matching reconstruction model for product interaction interface to improve user satisfaction and achieve product interface colour matching.

3 The experimental results show that the image signal-to-noise ratio of the proposed method is high, the colour gamut coverage is as high as 96.8%, the colour matching response time is only 9.1 s and the users are more satisfied with the proposed method, indicating that the colour matching quality and effect of the product interaction interface of the proposed method are better. However, this method does not consider the aesthetic rules of product interaction interface design. Therefore, in the following research, the relevant principles of product interaction interface design are considered, so as to further improve the quality and effect of colour matching of product interaction interface.

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