HSB Color Strategy model Based on Color Cognition and Color Emotion

Shibo Ji [1], Xia Li*

Beijing Key Laboratory of Network System and Network Culture, Beijing University of Posts and Telecommunications

2274793862@qq.com[1],1031488677@qq.com*

Abstract. This paper aims to explore a color strategy model that quantify the parameters of color cognition and emotion using the HSB color model. This model uses scientific methods and technical tools to quantify cognition and emotion, which can be applied to digital ecology scenarios like universal digital terminals. To achieve this, we use machine learning models to study the color cognition law of individual physiological dimensions and the PAD emotional space algorithm to study the color emotion law of psychological dimensions. A decision model with two inputs (cognitive words and affective words) and one output (desired color) is constructed using a holistic generative design approach. This interdisciplinary research integrates principles from art, psychology, and computer science to explore the color strategy model of physiological and psychological dimensions which marks the beginning of theoretical research on interdisciplinary subjects such as Kansei Engineering.

Keywords: Color Strategy Model, Color Emotion, Color Cognition, HSB, PAD

1 Introduction

Color is the most sensitive element in people's visual perception of objects. Research shows that when a user encounters a target object, color attracts primary visual attention during the first 20 seconds [1]. Color can not only bring people a visual impact through its strong, intuitive, and vivid appearance but also arouse people's inner touch with its real, delicate, and rich emotional experience [2]. Thus, from cognition to emotion, the perspective of design attention has also begun to focus more on human factors and emotions. In people's digital production and life, it is important and necessary to explore the law between color and individual preference to predict color schemes of product or color ecological decisions in scene.

Color trend is the product of the combination of objective law and subjective prediction, which needs to be analyzed and predicted with the help of scientific analysis and artistic sensitivity [3]. In the existing literature, the angle and method of color prediction are single. In this paper, we utilize generative techniques along with parametric design, machine learning, and the PAD emotional space algorithm to investigate the relationship between color perception and emotions. We map the physiological and

R. Appleby et al. (eds.), *Proceedings of the 2nd International Conference on Intelligent Design and Innovative Technology (ICIDIT 2023)*, Atlantis Highlights in Intelligent Systems 10,
https://doi.org/10.2991/978-94-6463-266-8_22

psychological dimensions onto the three elements and two parameters of the HSB model for our research. To stimulate the identification and association of individuals, and resonate with products or scenes with color attributes, the regularity is embodied in a color decision model with two inputs (cognitive words and affective words) and one output (desired color). Based on this, it also serves digital applications and color ecological scenarios in the fields of humanized design and emotional design in the future.

2 HSB color model on Color Prediction

The symbolic function of color endows color with differences in people's minds, and this difference is distributed in functional symbols, psychological symbols and cultural symbols [4]. The scientific problem to be solved in this paper is based on the symbolic function principle of color, and the parametric model is constructed to achieve the purpose of individualized and ecological color decision-making. When studying the law of color decision-making, it is necessary to use a certain color principle or color model. The CMYK model is often used in printed products, the RGB model is more inclined to the pixel light and color principle of the screen display. HSB model is the most suitable color model for human visual recognition characteristics. It is also the most common carrier in color prediction. Therefore, the HSB model is highly compatible with the color vision of the human eye. This paper uses it to analyze the individual's desired color.

3 The perspective of physiology and psychology

Modern color concepts comprise aesthetic and emotional concepts [5]. Aesthetic color, which prioritizes the structural relationship and logic of color in physiology. And another one, emotional color, which stimulates personal aesthetic emotions by expressing different colors through varying levels of color elements in psychology. Furthermore, the concrete imagination and abstract association are carried out through the connotation differences of color characters, so that the performance of colors is full of differentiated cognitive and emotional rhythms, which is related to the study of color emotions.

According to the existing researches at home and abroad, it can be seen that independent qualitative research lacks the rationality and objectivity of data. Most of the research on the emotional experience of color is based on the establishment of a relationship model between user perception and color matching, and lacks the feedback of users' subjective emotions, the versatility of digital scenes and the humanization of UCD. Moreover, in the research conclusion, more attention is paid to the matching of colors in certain specific scenes, and the user's own cognitive needs and emotional needs are not put in the first place for research, thus, the humanization of the output results is somewhat weak.

In the aspect of color language, we advocate the combination of aesthetic color concepts and emotional color concepts from the perspective of physiology and psychology.

Because of this, it is innovative and necessary to improve the model of single-dimensional parameter variation and integrate the two-dimensional method of physiology and psychology.

4 H for physiology, S and B for psychology

The HSB color model quantifies three attributes of color and is highly compatible with the human eye's color vision. H represents hue (chroma), S represents saturation (purity), and B represents brightness (lightness).

Hue is the most distinctive characteristic when different colors are distinguished from each other which is also the basis for the existence of colors. Hue is expressed in degrees (0°-360°), depending on the wavelength. The difference in hue is the most intuitive and obvious in the law of color cognition. Therefore, the H factor is used to study the color cognition law in the individual physiological dimension. From the perspective of the study of color cognition rules in the physiological dimension, this paper uses the H angle value (0°-360°) as the carrier parameter.

Colors have a unique personality and charm due to their varying internal styles and combinations of saturation and brightness. Under balanced conditions, if the brightness and saturation of the color are high, it will give people a bright and positive feeling, otherwise it will give people a negative and dull feeling. In principle and performance, when H is constant, S and B will each control the amount of black and white mixed into the color, so as to collaboratively change the saturation and brightness of the hue to express different colors. These two independent elements of S and B are combined to study the law of color emotion in the individual psychological dimension. The saturation and brightness of colors preferred by different individuals reflect the differences in our ability to express color emotions. More accurate and attractive color emotion associations are reflected in the improvement of visual perception acceptance and visual perception cognitive ability. Therefore, from the psychological dimension of color emotional law research, this paper uses the percentage values of S and B (0%-100%) as the carrier parameters.

The three elements interact with each other, which presents the two carrier parameters are not only a fused whole but also have differences in color representation. Thus, color perception is studied in a physiological dimension. The individual's color cognition is reflected in the color personality of his physiological preference, which is most intuitively expressed by the H angle value. The study of color emotion in a psychological dimension. The individual's color emotion is reflected in the color temperature and weight of their psychological feeling, which is most directly expressed by the comprehensive range value of S and B.

5 Variation of two parameters

5.1 H reflects cognitive words

The hue, H angle value will most intuitively reflect one of the input parameters through the color personality, cognitive words.

Using qualitative and quantitative analysis methods to do user researches to summarize several types of image cognitive words with the color impression system of Shigejun Kobayashi in Japan. Next step lets the user choose the desired hue for the associated cognitive word. There are 12 expected hues provided by the experiment, ranging from 0 degrees to 330 degrees, and every 30 degrees is used as the H value range. Make full use of individual color cognition, through the differential expression of color personality, score the selected hue with a five-point system, and perform mathematical statistics to obtain sample data.

The design generation method based on the generative confrontation network is to independently generate an ecological intelligent model through training according to the input design stimulus data (parameters contained in the design). To improve the performance of the training model, the data in the hue database corresponding to color cognitive words are randomly divided into 3 subsets: training set, validation set, and test set. Construct the structure of the input layer-hidden layer-output layer to establish a decision-making model. If a cognitive word corresponds to multiple hue values, the FCM clustering algorithm should be used to select the representative color [6].

5.2 S and B reflect emotional words

Saturation S and brightness B combine to affect the color temperature and color weight. The combination of the two range values reflects one of the input parameters, emotional words, through feelings such as color temperature and color weight.

Given a set of colors that are close or similar in hue, with distinct differences in saturation and brightness. Let the individual refer to the Chinese version of the PAD scale to calculate the user's emotional value. Scored sequentially from v1 (-4 for angry to +4 for interested) to v12. As shown in Table 1.

Table 1. Dimensions and corresponding vocabulary in the PAD emotion scale

Emotional dimention	Classification	The two directions of vocabulary
	P1	angry - interested
Pleasure-displeasure	P2	contemptuous - friendly
	P3	painful - happy
	P4	exasperated - excited
	A1	sleepy - awake
Arousal-nonarousal	A2	calm - excited
	A3	relaxed - interested
	A4	stiff - surprised
	D1	controlled - controlled
Dominance-submissiveness	D2	submissive - dominant
	D3	humble - haughty
	D4	Influenced - influential

After obtaining the sample data, calculate the P value, A value, and D value. The degree of closeness between the actual measured color emotional experience state and the normative 14 PAD benchmark values represents the emotional tendency of the color corresponding to the emotion. In the emotional space, it is expressed as the distance relationship between the measured emotional state and the coordinate positions of the 14 basic emotions. Among them, the basic emotional type with the smallest spatial distance from the measured emotional state is the PAD emotional tendency of the measured emotional state.

$$L_n = \sqrt{(P - p_n)^2 + (A - a_n)^2 + (D - d_n)^2} \quad (1)$$

$$n = [1,14], n \in Z$$

Formula. 1.

In formula 1, L is the coordinate distance between the measured emotional state and the 14 basic emotions in the emotional space. Among 14 distances, the minimum distance is $L_{min}=L_n$, and n corresponds to the basic emotional type which is its PAD emotional tendency.

5.3 H, S and B collectivly effect

The representational relationship between the three elements which are two carrier parameters should be studied as a whole. As shown in figure 1, through model training, we establish a mapping relationship between input cognitive words and output data H. Combined with the PAD emotion algorithm simultaneously, the mapping relationship between the input emotional words and the output data S and B is clarified. Get the desired HSB value based on individual color perception and emotion.

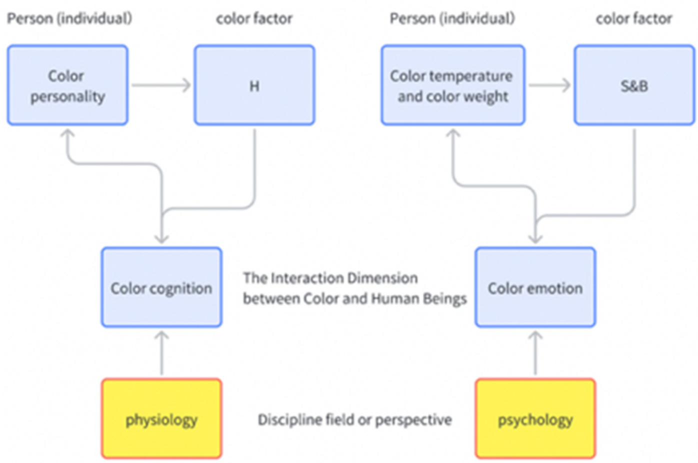

Fig. 1. Research Logic Diagram

6 Summary

This paper enriches the previous research perspectives and methods on color perception imagery, and innovates the technical route of interdisciplinary integration. Embody the color cognition of physiological dimension in the input parameter of the model, cognition words. And mapped to the carrier parameter H hue angle value; the color emotion of the psychological dimension is reflected in the input parameter of the model, the emotion word. And map the S and B range values in the vector parameters. Based on this, a color decision model is constructed. Individual users input the two parameters of cognitive words and emotional words in the database, and the model will obtain the expected H, S, and B values through training and sentiment analysis. In this way, the desired color with greater preference weight is formed, and the ultimate goal of color decision-making is completed.

In future research, we will continue to enrich the samples of machine learning, so that the digital and intelligent functional attributes of color have enough humanistic and social care. At the same time, the interaction between colors will be studied in more dimensions, so that the color decision model not only can predict the desired color but also can provide color-matching schemes for various scenes under dynamic and static conditions. As a result, color function attributes are dynamically inherited, enriching more color application scenarios in the digital ecosystem.

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