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Color Perception Evaluation and Optimization of Traditional Villages Based on Intelligent Semantic Analysis

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Abstract: How to scientifically protect and update the color landscape of traditional villages to reflect their historical and cultural values while meeting modern aesthetic and functional needs has become an urgent problem to be solved. To this end, this study adopts an intelligent semantic analysis method, combined with CNN and big data analysis to quantitatively analyze and perceive the village colors. First, through field research, digital cameras and Chinese architectural color cards are used to collect the base colors of the village environment and historical and cultural colors. Then, Photoshop software is used to quantitatively analyze the collected colors, obtain color attribute values and numbers to form a color database. Then, a convolutional neural network (CNN) is used to process and analyze the collected color data. By training the model to recognize and understand the semantic features of color, intelligent analysis and evaluation of the village color can be achieved. According to the experimental results, it was finally found that CNN performed excellently in image pixel accuracy, with an accuracy rate between 95.2% and 100%, and a frame rate of 76.7FPS, demonstrating efficient image processing capabilities. The public generally believes that color landscapes should be coordinated with the history and culture of the village, retaining and strengthening traditional color characteristics. Based on the above research results, the principles and suggestions for color landscape optimization were proposed, emphasizing the maintenance and enhancement of traditional color characteristics, the management and control of artificial colors, and the improvement of the overall beauty of the landscape. Through the combination of intelligent semantic analysis and public perception evaluation, this study provides a scientific basis and new ideas for the color protection and renewal of traditional villages and promotes the harmonious unity of tradition and modernity.

1. Introduction

The color culture of traditional villages faces unprecedented challenges in the context of rapid urbanization. On the one hand, excessive commercialization and modernization trends have led to the loss of traditional colors; on the other hand, the lack of scientific color planning and management has led to a chaotic color environment. As an important part of human visual experience, color perception is not only related to aesthetic evaluation, but also directly affects people's emotions and behaviors. Therefore, it is necessary to scientifically evaluate and optimize the colors of traditional villages to protect cultural heritage, improve the quality of life of residents, and promote the development of tourism.

This study conducts a comprehensive perceptual evaluation and optimization study on the colors of traditional villages through intelligent semantic analysis technology combined with field research and modern image processing software. This paper not only collects and quantifies the color data of the village, but also uses CNN to extract the deep features of color and establishes a mapping between color and semantic description. This study also collects and analyzes the public's perception and evaluation to provide a scientific basis for the color protection and renewal of traditional villages.

The paper first introduces the importance and research background of color perception evaluation, and then explains the research methods, including the collection of color data, quantitative analysis, intelligent semantic analysis, and the collection of public perception evaluation; then presents the results of intelligent semantic analysis and discusses public perception evaluation; finally, the paper proposes principles and suggestions for color landscape optimization and summarizes the main findings and contributions of the study.

2. Related Work

Color perception is a common focus in many fields such as psychology, design and urban planning. It is not only related to the individual's visual experience, but also directly affects people's emotional reactions and behavioral choices. In order to explore the users' perception and evaluation of the current color of Harbin Central Street, Lu et al. [1] used semantic analysis, a quantitative analysis tool that uses "language" to conduct psychological assessments on the public, and combined street view images, color card software, and mathematical analysis software as basic tools for recording and analyzing color samples to conduct a questionnaire survey and research. The results showed that the respondents generally had a positive evaluation of the streetscape colors of the Central Avenue block, with a better visual perception of color and the worst spatial perception. They had a higher evaluation of streets with systematic color design and distinctive style. Skelton et al. [2] provided insights into the development of infants' color perception ability, indicating that infants' color perception ability gradually matures with age. Bortolotti et al. [3] analyzed the effects of different brightness colors on psychological functions through psychological experiments. In the study of the relationship between spatial environment color and color perception, Liu et al. [4] started from the relationship between space, color and people, based on color psychology, and listed from many aspects to explore the impact of color on people's physiology and psychology in urban or spatial design, in order to better guide urban or spatial design. Bian and huang [5] took the traditional Cantonese village in Lingnan, Guangzhou Huadu Gangtou Village, as an example, based on color geography, using the NCS natural color perception model, color network and other methods to analyze the color composition attributes and color proportions of buildings, and explained the characteristics of color evolution, providing a reference for rural planning and the protection and renewal of village building colors.

Mihajlović and Zdravković[6] investigated the effect of color category perception on visual

attention capture through experiments on attention, perception, and psychophysics. Prencipe and Provenzi[7] developed and tested a color perception model based on geometric principles. Lu et al. [8] aimed to use visual illusion to improve the presentation effect of the combination of clothing and human body. They conducted group experiments on color saturation and brightness under various hue conditions and measured consumers' arousal, attention, body perception and purchase intention under different conditions. With the research object of exploring the color needs of the elderly for entrance spaces of different properties and types of nursing homes, and with the purpose of improving the quality of life of the elderly, Liu et al. [9] studied the impact of different colors on the elderly and the elderly's perception of color, and starting from perception, they conducted research and analysis on the color status of entrance spaces and surrounding functional areas of many elderly care institutions in Beijing, Tianjin, Shenyang, Chengdu and other places. Cviljušac et al. [10] proposed a method to evaluate human observers' perception of color differences, which provides an effective tool for evaluating color differences and helps improve the color matching and quality control level in related industries.

From the above research, we can see that color is not only a visual element, it can also profoundly influence people's emotions and behaviors. From the color perception evaluation of Harbin Central Street to the development of infants' color perception ability, from the impact of color brightness on psychological functions in psychological experiments to the application of color in urban design and the protection and renewal of the color of traditional village buildings, these studies have demonstrated the close connection between color and human perception at different levels. By combining modern intelligent analysis methods with traditional color culture, this paper aims to provide new ideas and scientific basis for the protection and development of traditional villages, so that in future urban planning and color design, it is possible to better balance traditional characteristics and modern aesthetics and enhance people's visual experience and emotional connection.

3. Methods

3.1 Color Data Collection

In the study of color perception evaluation and optimization of traditional villages based on intelligent semantic analysis, color data collection includes two main links: field research and the use of digital cameras and architectural color cards.

Field research means going to villages to observe and record the village's architectural features, material usage, decorative style, etc. These factors directly affect the village's color expression. At the same time, during the survey process, it is necessary to communicate with local residents to understand their views and preferences on village colors, which can help to more comprehensively understand the social and cultural significance of village colors.

The village environment was photographed with a digital camera to capture the color details of the village. During the shooting process, architectural color cards were included in the photos as references, which provided a set of known color standards and helped to correct the colors in the later image processing to ensure color accuracy. This process needs to be carried out under different lighting conditions to capture the changes in color under different light and obtain more comprehensive color data, as shown in Table 1.

Table 1 contains six data collection samples, each of which records in detail the collected items, color attribute values, color codes, collection time and collection location. Building exteriors, temple roofs, street pavements, plant landscapes, signboards and traditional costumes are all included in the samples in the table. The color attribute values are expressed in RGB mode, and the color coding is based on the national standard of Chinese Architectural Color Cards. The collection

time is distributed in different time periods of the village, and the collection locations cover the center, north, main streets, east, commercial area and square of the village.

Table 1: Color data

No.	Collection Item	Color Attributes	Color Code	Collection Time	Collection Location
1	Building Exterior	RGB: 120, 60, 30	Code 123-4	09:00	Village Center
2	Temple Roof	RGB: 180, 45, 20	Code 201-2	10:30	North of Village
3	Street Pavement	RGB: 85, 85, 85	Code NV 5	14:00	Main Street
4	Plant Landscape	RGB: 35, 75, 45	Code 321-3	16:00	East of Village
5	Signage	RGB: 220, 20, 50	Code 532-1	11:00	Commercial Area
6	Traditional Costume	RGB: 100, 40, 60	Code 215-3	08:30	Village Square

3.2 Color Quantification Analysis

During color quantification analysis, Photoshop software is used to scientifically analyze the collected colors and obtain the color attribute values and numbers. The histogram tool of Photoshop analyzes the image color and displays the distribution of image pixels in various tonal areas such as dark tones, midtones and highlights in graphical form, providing a basis for color correction. Using Photoshop to observe the distribution of image pixels. The pixels are mainly concentrated in the bright tone area, indicating that the image is bright, while there are almost no pixels in the dark area, which means that the image lacks black pixels, resulting in loss of bright details.

Photoshop also provides tools such as levels, curves, and color balance. By adjusting these parameters, it can change the overall tone of the image to make it better meet design requirements. Through field research, digital cameras and Chinese architectural color cards were used to collect the base colors of the village environment and historical and cultural colors. Then, Photoshop software was used to quantitatively analyze the collected colors to obtain color attribute values and numbers to form a color database. Quantitative analysis of color is carried out through colorimetric cards and combined with Photoshop software processing to obtain accurate color attribute values and numbers. The acquisition of color attribute values requires the selection of a chromaticity system. This article uses the *National Standard for Chinese Building Color Cards* for encoding, which has a total of 1026 colors. Non color systems are calibrated using NV, while color systems are calibrated using HV/C. Adjacent brightness or adjacent chromaticity are visually equidistant. The quantitative analysis process is shown in Figure 1:

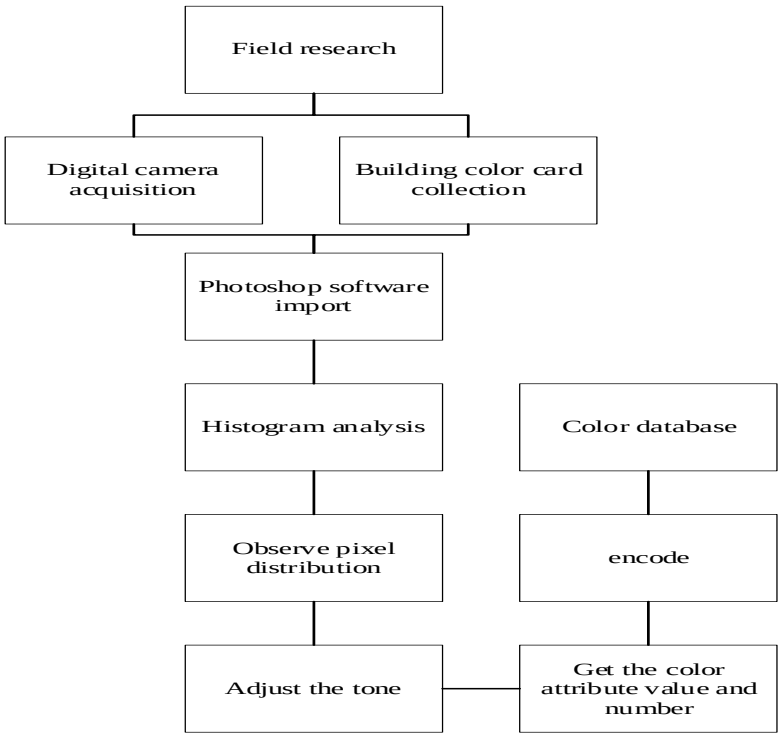

Figure 1: Quantitative analysis process

3.3 Intelligent Semantic Analysis

This study uses CNN to process and analyze village color data, which can automatically learn features from images [11-12]. Through this method, deep features of village colors can be extracted and models can be trained to recognize and understand the semantic features of colors, thereby achieving intelligent analysis and evaluation of village colors:

$$O(I;\theta) = CNN(I;\theta) \tag{1}$$

Among them, O refers to the output of the network, I is the input color image, and θ is the parameter of the network. CNN processes input data and performs recognition through the collaborative work of convolutional layers, activation functions, pooling layers, and fully connected layers [13-14].

The concept of semantic color has been introduced in the recognition and understanding of color semantic features, establishing a mapping between color and semantic description. By extracting semantic concepts that are understandable to humans, CNN can be provided with semantic interpretations[15]. This method helps to better understand the role of color in village culture and environment and provide a scientific basis for the optimization of color landscape.

In order to optimize the performance of the model, the gradient descent method is used to update the network parameters:

$$\theta_{new} = \theta_{old} - \eta\nabla_{\theta}J(\theta) \tag{2}$$

Among them, η is the learning rate, J is the loss function, θ_{new} refers to the new parameter set after the update, and θ_{old} is the current parameter set, that is, the parameters of the network before this parameter update.

By continuously iterating this process, the accuracy of the model can be improved and it can be more adapted to the needs of traditional village color protection and renewal. Such intelligent semantic analysis not only improves the analysis efficiency of color data, but also deepens the understanding of the role of color in village culture and environment.

3.4 Collection of Public Perception Evaluation

The collection process of public perception evaluation is mainly achieved through two channels: the use of social media and online platforms and the analysis of user comments, tags and interaction data.

Social media and online platforms, as important tools for information dissemination and communication, provide a broad platform for collecting the public's perception of the colors of traditional villages. Through these platforms, a large amount of user-generated content such as comments, pictures, videos, etc. can be obtained. These contents contain the public's intuitive feelings and deep attitudes towards the color of the village. For example, a research report by *The Paper* pointed out that there are obvious differences in the usage of mainstream social media applications among netizens, which shows that different social media platforms need to adopt different strategies to collect data.

The analysis of user comments, tags, and interaction data can directly understand public perception. By analyzing the content of user comments, we can understand the public's preferences and dissatisfaction with the village color. At the same time, user tags and interaction data (such as likes, shares, and discussions) can also provide quantitative indicators of public sentiment and attention, as shown in Table 2:

Table 2: User interaction data

User ID	Comment Count	Likes	Comment Date	Tags	Interaction Data (Replies/Shares)
U001	120	45	2024-07-10 08:30	Traditional/Warm	15/10
U002	35	18	2024-07-10 09:45	Dull/Traditional	8/2
U003	245	67	2024-07-10 11:20	Unique/Blue	20/18
U004	78	30	2024-07-10 14:00	Harmonious/Natural	12/7
U005	62	21	2024-07-10 16:15	Single/Suggestion	10/3
U006	195	56	2024-07-10 17:30	Historic/Modern	25/12

By integrating these data, we can conduct quantitative and qualitative analysis of the color landscape of traditional villages and make optimization suggestions. These suggestions aim to balance the protection of traditional colors with the integration of modern aesthetics, and ultimately form strategic guidelines for the protection of traditional village colors, promote the high-quality development of traditional villages, and achieve a harmonious unity of tradition and modernity.

4. Results and Discussion

4.1 Results of Intelligent Semantic Analysis

When discussing the results of the research on color perception evaluation and optimization of traditional villages based on intelligent semantic analysis, in order to comprehensively evaluate the application effect of CNN in this field and compare it with the current leading technology, this study selected Transformer as the comparison object. Figures 2 and 3 are comparative analyses of these models in terms of pixel accuracy and frame rate (FPS), aiming to reveal the efficiency and

accuracy of different models in processing village color data:

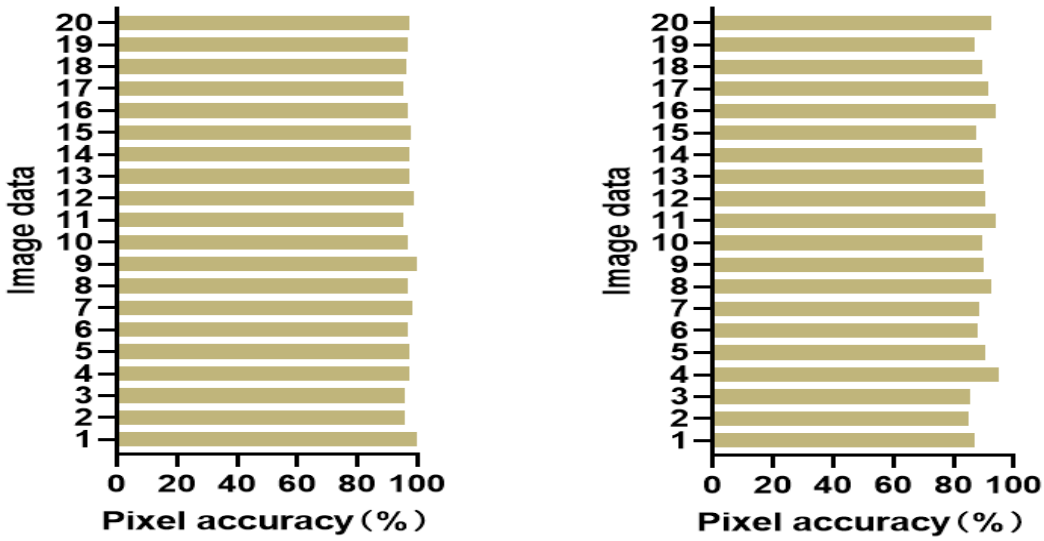

Figure 2: Pixel accuracy comparison between CNN (left) and Transformer (right)

As shown in Figure 2, the image pixel accuracy under CNN is between 95.2% and 100%, reaching an extremely high level. CNN's performance in image pixel accuracy is indeed very outstanding, thanks to its powerful spatial hierarchical structure learning ability and efficient capture of image features. CNN can automatically learn local features in images and gradually form global feature representation through multi-layer convolution layers and pooling layers, which makes it achieve significant success in image recognition and classification tasks. However, the highest pixel accuracy under Transformer is only 95%. Although this is a good level, it is still far from enough compared to CNN.

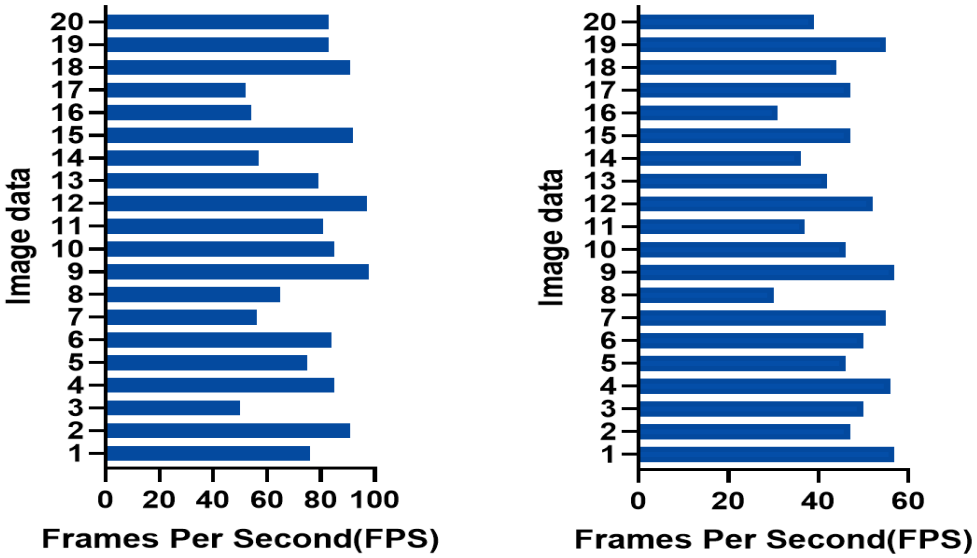

Figure 3: Frame rate comparison between CNN (left) and Transformer (right)

The data in Figure 3 shows that the image data under CNN reached an average of 76.7FPS, and the maximum even reached 98FPS. Such a high frame rate means that CNN can process image data very quickly. However, for the same image data, the average frame rate of Transformer is only

46.2FPS, and the highest is only 57FPS. Although this level is still acceptable in many applications, the Transformer has a significant disadvantage in processing speed compared to CNN. This is because the Transformer's self-attention mechanism is computationally more complex, especially when processing high-resolution images. Its computational complexity and number of parameters are usually higher than those of CNN, resulting in a decrease in processing speed.

4.2 Public Perception Evaluation Results

The public perception evaluation results reveal the naturalness and authenticity of user feedback as well as the public's opinions and suggestions on color landscape. Through intelligent semantic analysis technology, natural feedback from the public is collected from social media and online forums. These unfiltered feedback reflects the public's true feelings and attitudes towards the colorful landscape of traditional villages. The public generally believes that the color landscape should be coordinated with the historical culture of the village, retaining and strengthening the traditional color characteristics, while also making suggestions on how to incorporate modern elements. Some public feedback highlighted the role of colour in creating atmosphere and emotional connection, suggesting that seasonal changes, light effects and colour psychology should be considered in colour design. Specific suggestions from the public for the colour landscape included using local materials and traditional craftsmanship to maintain and restore historic buildings and adopting tones that harmonize with traditional colour in new buildings. The public also put forward suggestions for color management, such as developing color planning guidelines, providing training and consultation on color selection, and establishing a color review and monitoring mechanism.

4.3 Principles and Suggestions for Color Landscape Optimization

The study emphasizes the importance of maintaining and strengthening traditional color characteristics to ensure that the color landscape of the village is in harmony with its historical culture. This includes the extraction and quantitative analysis of the colors of the village's natural environment and cultural environment, as well as the analysis of the distribution trends of the basic attribute values of colors, so as to identify the current characteristics of the village's color landscape and put forward optimization suggestions such as improving the degree of color integration in the village and classifying and formulating architectural color control measures. At the same time, artificial colors need to be managed and controlled to standardize the use of colors and reduce color pollution. This includes controlling the colors of buildings in villages and highlighting the colors of public spaces. By formulating color planning guidelines and color selection training, the standardization of color management can be improved and a color review and monitoring mechanism can be established. The overall beauty of the landscape can be enhanced and a pleasant visual experience can be brought to people through a reasonable combination of plant colors. The configuration of plant colors needs to comprehensively consider factors such as plant species characteristics, growth environment, and landscape atmosphere, and reflect plant levels through means such as terrain transformation, shaping and pruning, so as to increase the richness and depth of the landscape.

5. Conclusion

This paper combines field research, color quantification analysis using Photoshop software, and intelligent semantic analysis using CNN to conduct a comprehensive evaluation and optimization study of color perception in traditional villages. The study solved the problem of how to

scientifically collect and analyze the color data of traditional villages and extracted the deep characteristics of color through intelligent semantic analysis technology, achieving the purpose of establishing a mapping between color and semantic description. This study also collected public perception and evaluation through social media and online platforms, providing a scientific basis for the color protection and renewal of traditional villages.

The research results show that CNN is superior to the traditional Transformer model in terms of image pixel accuracy and processing speed, demonstrating efficient image processing capabilities. The public perception evaluation reveals the public' s true feelings and attitudes towards the colors of traditional villages, and emphasizes that the color landscape should be coordinated with the village' s history and culture, and retain and strengthen traditional color characteristics. Based on these findings, this paper proposes principles and suggestions for color landscape optimization, aiming to promote the protection and development of traditional village colors.

Although this study has achieved certain results in the evaluation and optimization of color perception in traditional villages, due to the limitations of the research sample, the conclusions obtained may not be fully generalized to all traditional villages. At the same time, although intelligent semantic analysis technology can extract the deep characteristics of color, there is still room for improvement in explaining the complex relationship between color, culture and emotion. In addition, the collection of public perception evaluations mainly relies on social media and online platforms, which may result in sampling bias. Future research can be conducted in a wider geographical and cultural context to enhance the universality of the research conclusions, while establishing a long-term monitoring and evaluation mechanism to track the effectiveness of the implementation of color optimization measures.

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