Evaluation of Street Building Color Quality Based on Artificial Intelligence and Street View Images - Taking the Duobao Road Historical and Cultural Block in Guangzhou as an Example

(IJCSNT) International Journal of Communication Systems and Network Technologies
ISSN Number: 2053-6283
Volume 14, Issue No. 2, 111–120

https://journals.mirlabs.in/index.php/ijcsnt
DOI-10.18486/ijcsnt/14.2.010
IJCSNT

Shi Yang[1]

Abstract

In the context of rapid urban renewal, the color style of buildings in historical and cultural blocks is vulnerable to constructive destruction, and it is urgent to establish a set of objective, efficient and quantitative evaluation methods that meet the needs of protection planning. To this end, this study proposes a set of evaluation frameworks for street building color quality. Firstly, high-resolution street view images of the Duobao Road historical and cultural district in Guangzhou are collected as the basic data source. Then, DeepLabv3+ (Deep Labelling version 3+) is used to accurately identify and extract the building facade areas in the image. In addition, multi-dimensional color features of the building facades are extracted and calculated. Finally, a comprehensive evaluation system for the color quality of street buildings is constructed that integrates objective quantitative indicators. The experimental results show that the overall color coordination score of the block buildings is high, and most of the main colors of the buildings meet the requirements of Guangzhou's traditional color spectrum (the highest matching degree is 92% and the error range is small), and the AI evaluation results are highly consistent with the expert evaluation. This method provides efficient and reliable technical support for the scientific evaluation and effective control of the architectural colors of historical and cultural blocks.

Keywords

Urban Renewal, Historical and Cultural Blocks, Architectural Colors, Artificial Intelligence, DeepLabv3+ Algorithm

Received: 1 May 2025; **Revised:** 29 July 2025; **Accepted:** 12 August 2025;
Published: 31 August 2025;

[1]Academy of Fine Arts, Guangdong University of Education, Guangzhou, Guangdong, China.

Corresponding author:
Email: hour37@163.com

Introduction

With the acceleration of urbanization, the architectural style of historical and cultural blocks, especially their color characteristics, are facing the risk of constructive destruction. Traditional architectural color protection methods mainly rely on manual evaluation, which has problems such as strong subjectivity and low efficiency. Therefore, how to scientifically and objectively evaluate and effectively control the architectural colors of historical and cultural blocks has become a difficult problem that needs to be solved urgently. Establishing a set of quantitative, objective and protection planning-compliant evaluation methods can provide important support for the color management and protection of historical and cultural blocks.

This study proposes a street building color quality evaluation framework that integrates artificial intelligence technology and street view image big data. Through DeepLabv3+, the building facades in the street view images are accurately extracted, and combined with the color quantification method in computer vision, the various characteristics of the building color are comprehensively analyzed. This method improves the efficiency of color evaluation and overcomes the limitations of traditional evaluation methods, providing a more scientific decision-making basis for color control in historical and cultural blocks.

The paper first introduces the background and significance of the research, then proposes an architectural color evaluation framework based on artificial intelligence, and elaborates on various experimental methods. Next, the paper presents the experimental results, conducts data analysis and discussion, and finally summarizes the main results of the study and its application prospects in practice.

Related Works

In recent years, more and more studies have begun to try to apply emerging technologies to the color analysis and evaluation of urban buildings. For example, Hong et al.[1] conducted an empirical study on the color planning of the historical and cultural city of Xuzhou, Jiangsu Province, and proposed a comprehensive planning strategy that can be combined with urban color landscapes of different scales, providing a new optimization direction for Xuzhou's urban color planning. Li et al.[2] developed a comprehensive cognitive framework based on the latest advances in data technology and sentiment analysis to evaluate the quality of urban architectural colors and visualized the complex relationship between architectural colors and human perception, providing a new perspective for improving the built environment and supporting sustainable development. Gou et al.[3] revealed the inherent laws of citizens' color preferences through quantitative analysis of three attributes: hue, black, and chroma, and compared them with the previous color adjective preference results of the research team, supplementing the accuracy of adjective descriptions and providing a reference for urban color planning. Jaglarz[4] pointed out the important role of color in shaping architecture and urban space, explored the theory of color harmony as an aesthetic principle of architectural design, and emphasized the key role of color as an element of urban space composition that affects observers. Zhang et al.[5] explored design factors to improve the quality of commercial streets, aiming to rationalize residents' needs, preferences and priorities, enhance a sense of belonging, and provide suggestions for the design optimization of urban street renewal in China to improve street quality and resident satisfaction. Wicks et al.[6] compared the effects of physical activities in outdoor green natural environments and urban environments on the mental health of the general adult population, and explored the role of environmental background in the psychological benefits of physical activities. Lai et al.[7] systematically reviewed the association between urban building environment attributes and cardiovascular risk factors and major cardiovascular disease events, providing important information for clarifying the relationship between urban environment and cardiovascular health and supporting healthy city planning policies. Ying et al.[8] provided a reference for green infrastructure to promote environmental sustainability, believing that it effectively coordinates environmental and socioeconomic development and becomes an important strategy for achieving sustainable development. However, existing research still has a gap in the application of artificial intelligence methods in the combination of traditional block color protection and innovation.

In order to solve the problem of innovation, some scholars have begun to consider using artificial intelligence methods, but most of the image analysis methods adopted do not fully consider the particularity of historical and cultural blocks. For example, Huang et al.[9] analyzed the current application status of artificial intelligence technology in intelligent buildings, studied the role of artificial intelligence systems in various aspects, and proved the necessity of artificial intelligence based on image recognition in mining and evaluating urban information. Mansuri and Patel[10] developed an AI-based automatic defect detection system using a regional convolutional neural network model for visual inspection and prepared a dataset from images taken from cemeteries in Surat, India, arguing that heritage is a potential part of a sustainable built environment. To address this problem, this paper used an AI-based deep learning model combined with street view image data to propose a new street building color quality evaluation method.

Methods

Street View Image Data Acquisition

The data collection of this study mainly relies on street view images of the Duobao Road historical and cultural district in Guangzhou. In order to ensure the collection of high-quality and representative architectural images, this paper selected the core area of the district as the data collection object. Specifically, this paper uses Baidu Street View API to collect a set of 360° panoramic images every 50 meters along the main street of Duobao Road. The images of each collection point cover the building facades on both sides of the street, ensuring the comprehensive capture of the color and style of different buildings.

During the image acquisition process, this paper paid special attention to the image resolution and acquisition angle to ensure that the image can clearly display the color characteristics of the building. In order to avoid the influence of external factors such as light and weather on the image quality, this paper collected the images during sunny days to minimize the interference of light changes on color performance. Through these high-resolution street view images, this paper can provide rich data support for subsequent architectural color analysis and provide basic data guarantee for color evaluation and protection planning.

Intelligent Extraction Of Building Facades

In the process of building color quality assessment, accurately extracting the building facade area is a crucial step. In order to improve the extraction accuracy and effectively remove non-building elements (such as vegetation, sky, vehicles, etc.) in the image, this study uses deep learning semantic segmentation technology - DeepLabv3+ model. The network model structure is shown in Figure 1:

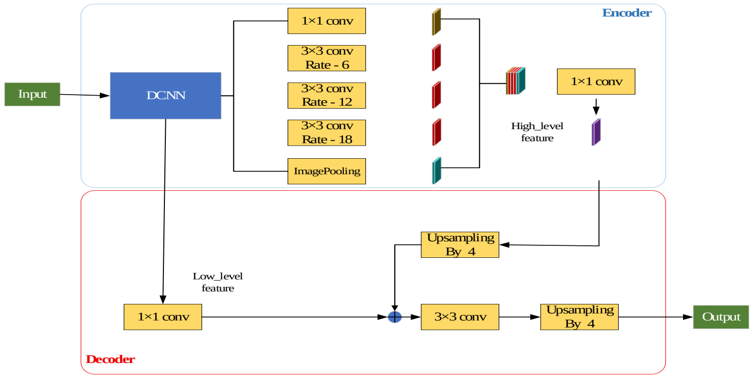

Figure 1. DeepLabv3+ network structure diagram

This model can accurately segment building facades in street view images, ensuring that the color characteristics of the buildings can be analyzed independently of other background elements. First, this paper preprocesses the collected street view images to ensure that the image quality meets the analysis requirements. Next, the DeepLabv3+ model is used to train the images. A large number of labeled building facade images are used during the training process so that the model can learn the characteristics of the building facade. It can be briefly expressed as formula (1):

$$I_{building} = DeepLabv3 + (I_{original}) \tag{1}$$

In formula (1), $I_{building}$ represents the extracted building facade area, and $I_{original}$ represents the original street view image. After training, the model can automatically identify the building part in the image and effectively distinguish it from other areas (such as roads, sky, trees, etc.)[11,12].

Through this process, this paper can not only obtain high-precision extraction results of building facades, but also provide more accurate data support for subsequent color feature extraction. This intelligent extraction method reduces the workload of traditional manual labeling, improves processing efficiency, and lays the foundation for the quantitative analysis of block building colors.

Color Feature Quantification Calculation Method

This study ensures that comprehensive evaluation can be carried out from multiple dimensions, mainly through main color analysis, color histogram statistics, and color harmony model calculation to quantify the various characteristics of building colors. First, the main color analysis identifies the main color of the building by calculating the dominant color in the building facade. This method is based on the HSV model in the color space. By extracting the most representative color range in the image, the main color tone of the building is determined. The color tone value can be expressed as formula (2):

$$H = atan2\left(\sqrt{(R-G)^2 + (R-B)^2}, (R+G+B)\right) \tag{2}$$

In formula (2), R, G, B and are the red, green and blue components of each pixel in the image, respectively. This process is crucial to understanding the overall atmosphere and cultural symbolism of architectural colors. As shown in Figure 2, the colors of the building facades are mainly concentrated in red, blue and yellow, reflecting the overall strong and warm color tendency of the block.

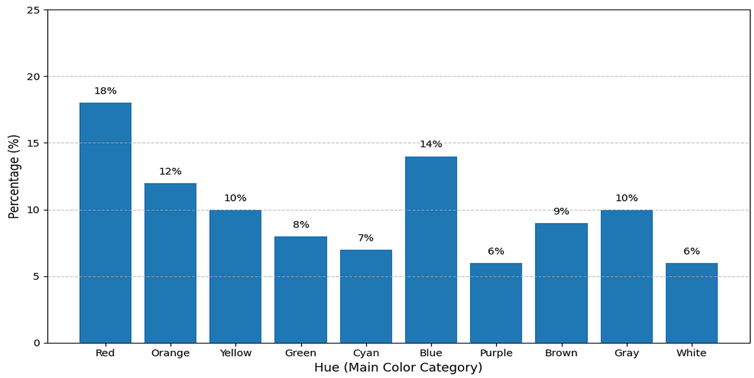

Figure 2. Schematic diagram of the main color distribution of the building facade

Secondly, color histogram statistics are used to quantify the diversity of building colors, which can be expressed as formula (3):

$$H_c = \sum_{i=1}^{n} h(i) \tag{3}$$

In formula (3), H_c is the color distribution histogram, $h(i)$ represents the number of pixels in the ith color interval, and n is the total number of color intervals. The color histogram is generated by calculating the distribution of colors on the entire building facade. This method can reveal the richness and uniformity of building colors and provide data support for subsequent color coordination analysis. The color histogram can help evaluate the visual appeal and color hierarchy of the building's exterior[13].

Finally, the color harmony model calculation applies the color contrast and harmony theory to judge the harmony between architectural colors. The commonly used color harmony calculation formula is formula (4):

$$C_h = 1 - \frac{|H_1 - H_2|}{180} \tag{4}$$

C_h is the color coordination score, H_1 and H_2 are the hue values of two adjacent colors, respectively, in degrees. By calculating the color difference of adjacent colors, this paper can evaluate the visual harmony of architectural colors. Color coordination is an important part of architectural aesthetics, which directly affects the integration of buildings with the surrounding environment.

Color quality evaluation system

First, as one of the important indicators of color quality, the color harmony model calculation method is used to evaluate the visual harmony between different colors on the building facade. By calculating the color difference of adjacent colors, it is evaluated whether the color matching meets the harmonious aesthetic standards. The coordination of architectural colors directly affects the visual sense of unity and overall beauty, especially in historical and cultural blocks, where color coordination is closely related to the traditional style of architectural style.

Secondly, inheritance evaluates the matching degree between architectural colors and traditional color spectrum. In order to ensure that the architectural colors are consistent with the characteristics of the historical and cultural blocks, this study compares the architectural colors with the traditional color spectrum and calculates their color spectrum matching degree based on the color control requirements in the Guangzhou Historical and Cultural City Protection Planning Regulations. Highly matching color schemes help preserve the historical charm of the blocks and maintain the continuation of traditional culture.

Finally, richness reflects the diversity and layering of architectural colors. Through the statistical analysis of color histograms, the distribution and diversity of building colors are evaluated to ensure that the color of the building facade is not monotonous and boring, but has a certain visual impact and aesthetic level. It can be expressed using Shannon entropy, as shown in formula (5):

$$H_{Shannon} = -\sum_{i=1}^{n} p_i log(p_i) \tag{5}$$

p_i is the probability of the ith color interval, and n is the total number of color intervals. The richness of color enhances the artistry and attractiveness of the building to a certain extent, especially playing an important role in the visual integration of the block.

Results and Discussion

Experimental Setup

This experiment aims to evaluate and verify the application effect of the architectural color quality evaluation method based on artificial intelligence in the the Duobao Road historical and cultural district in Guangzhou, mainly involving the evaluation efficiency of color coordination, inheritance, and human-computer collaboration.

(1) Experimental area

The Duobao Road Historical and Cultural Block in Guangzhou was selected as the experimental area, covering the core section of the block, and the analysis was based on a 500-meter street section.

(2) Data collection and processing

Baidu Street View API was used to collect street view images and obtain high-resolution image data. The DeepLabv3+ model was used to perform semantic segmentation on the images, extract the building facade area, and remove interference elements. The main and auxiliary colors of the building were extracted in the HSV color space, and the color contrast was calculated using the color difference formula, which was then matched in combination with the traditional color spectrum.

(3) Evaluation indicators

Color harmony: The color harmony and contrast were calculated using the harmony model and the color difference formula;

Inheritance: The matching degree between the building color and the traditional color spectrum was statistically analyzed to evaluate the cultural heritage compliance;

Evaluation effectiveness: The consistency between AI and manual annotation was analyzed using the Kappa coefficient to verify the actual application effect of the AI method.

Experimental Analysis

(1) Color coordination spatial modeling experiment

The color coordination spatial modeling experiment aims to evaluate the coordination of architectural colors in the Duobao Road historical and cultural district in Guangzhou. By calculating the angle between the hue rings of adjacent buildings in the street segment, the harmony model is used to analyze the coordination between architectural colors, and the GIS (Geographic Information System) heat map is used to visualize the areas with high incidence of color conflicts. The focus of the experiment is to identify the color conflicts between corner areas and new buildings and surrounding historical buildings. The specific data is shown in Table 1:

Table 1. Color coordination spatial modeling evaluation

Building ID	Adjacent Building Hue Angle	Color Coordination Score
1	20°	0.89
2	45°	0.78
3	30°	0.85
4	50°	0.75
5	15°	0.92

Through the analysis of the coordination of the building colors in a 500-meter street section, the experimental results show that the angle between the hue rings of adjacent buildings is generally small, and the color coordination score is as high as 0.838, especially for Building 1 and Building 5, whose coordination scores are 0.89 and 0.92 respectively, indicating that the two buildings are well integrated in color. However, the scores of Building 2 and Building 4 are lower, 0.78 and 0.75 respectively, indicating that the color coordination of these areas is poor, especially at the corners and the junctions of new buildings, where the color conflict is more significant.

(2) Traditional color spectrum intelligent matching verification experiment

The traditional color spectrum intelligent matching verification experiment aims to evaluate whether the architectural colors of the Duobao Road Historical and Cultural District meet the requirements of the traditional color spectrum by quantitatively analyzing the matching degree between the architectural colors and the color spectrum of traditional buildings in Guangzhou. The experiment uses the CIEDE2000 (Commission Internationale de l'Eclairage Delta E 2000) color difference formula to compare the main color of each building with the color spectrum reference color, calculate the color difference and statistically calculate the matching degree. Through this method, buildings that match the traditional color spectrum can be identified, providing data support for future color protection and planning, as shown in Figure 3:

According to the analysis of the color spectrum matching of the 10 buildings, the color spectrum matching of Building 3 is the highest, reaching 92%, and the error range is small, indicating that its color is the best match with the traditional color spectrum. The matching degrees of Building 7 and Building 9 are 90% and 88% respectively, and the color difference between the two is small, showing a high degree of consistency. Building 2 has the lowest matching degree, which is 78%. The error bar shows

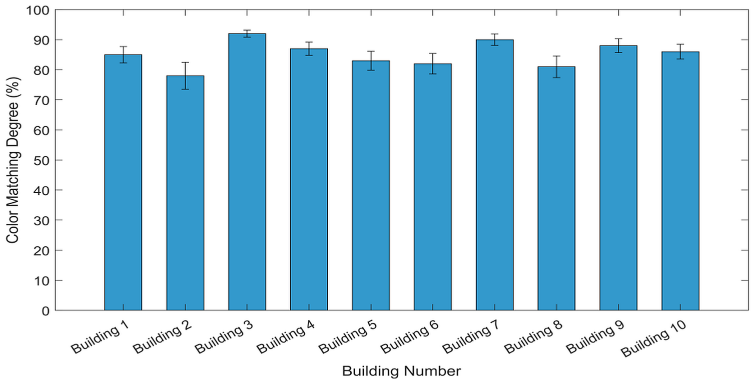

Figure 3. Traditional color spectrum intelligent matching verification evaluation

that its color difference is large, indicating that the color matches the traditional color spectrum poorly. Overall, the matching degree of most buildings is above 80%, indicating that their colors generally meet the requirements of the traditional color spectrum, but some buildings have obvious color differences. These results provide strong data support for color protection planning.

(3) Human-computer collaborative evaluation performance comparison experiment

This experiment aims to compare the consistency of the AI algorithm and the expert group in the color matching of 50 buildings through color evaluation. The AI algorithm (DeepLabv3+ building facade extraction, main color analysis and color inheritance evaluation mentioned above) is used to automatically calculate the color matching of each building) to automatically evaluate the building color and compare it with the evaluation results of the 10-person expert group. The Kappa coefficient is calculated to quantify the consistency between the two. The experiment verifies the application effect of AI in building color evaluation by analyzing the difference in matching between AI and the expert group, as shown in Figure 4:

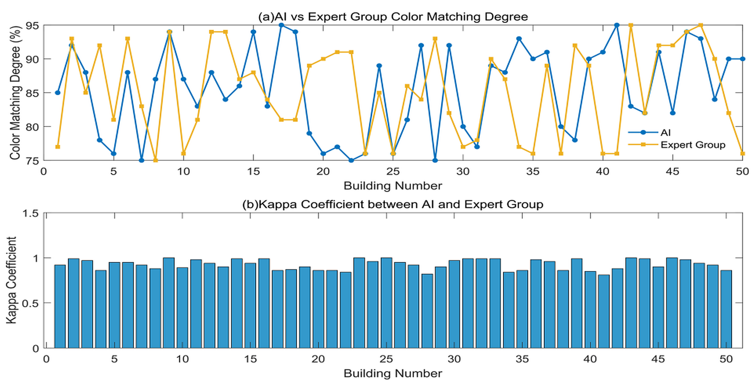

Figure 4. Comparative evaluation of human-machine collaborative evaluation performance

Figure 4a and Figure 4b respectively show the color matching comparison curve of AI and the expert group on 50 buildings and the bar chart of Kappa coefficient. The AI matching degree and the expert group matching degree of most buildings are not much different, showing a high consistency in color judgment. The calculation results of the Kappa coefficient show that the consistency between AI and the expert group is strong, with the highest Kappa coefficient being 1.00 and the lowest Kappa coefficient being 0.81. These results show that the application reliability of AI algorithm in architectural color evaluation is high, which can effectively assist the expert group to complete the color evaluation task, and has good practicality and accuracy.

Conclusions

This paper proposes a building color quality evaluation method based on artificial intelligence and street view images, aiming to provide a more scientific and objective color evaluation method for historical and cultural blocks. This paper successfully constructed a multi-dimensional color evaluation framework by extracting building facades using the deep learning model DeepLabv3+ and combining it with the color quantification method in computer vision. The experimental results show that the AI algorithm has a high degree of match with the expert group, indicating that this method has good reliability and practicality in color quality evaluation. However, the method in this paper still has certain limitations, such as the small area of data collection and possible recognition errors in areas with high color complexity. Future research can expand the scope of data collection and improve the accuracy of the algorithm to adapt to different types of historical blocks, while combining richer historical and cultural background information to enhance the refinement and accuracy of color assessment.

References

[1] Hong X, Ji X, Wu Z. Architectural colour planning strategy and planning implementation evaluation of historical and cultural cities based on different urban zones in Xuzhou (China)[J]. Color Research & Application, 2022, 47(2): 424-453.

[2] Li X, Qin J, Long Y. Urban Architectural Color Evaluation: A Cognitive Framework Combining Machine Learning and Human Perception[J]. Buildings, 2024, 14(12): 3901-3912.

[3] Gou A, Shi B, Wang J, et al. Color preference and contributing factors of urban architecture based on the selection of color samples—Case study: Shanghai[J]. Color Research & Application, 2022, 47(2): 454-474.

[4] Jaglarz A. Perception of color in architecture and urban space[J]. Buildings, 2023, 13(8): 2000-2014.

[5] Zhang L, Xu X, Guo Y. Comprehensive Evaluation of the Implementation Effect of Commercial Street Quality Improvement Based on AHP-Entropy Weight Method—Taking Hefei Shuanggang Old Street as an Example[J]. Land, 2022, 11(11): 2091-2093.

[6] Wicks C, Barton J, Orbell S, et al. Psychological benefits of outdoor physical activity in natural versus urban environments: A systematic review and meta-analysis of experimental studies[J]. Applied Psychology: Health and Well-Being, 2022, 14(3): 1037-1061.

[7] Lai K Y, Webster C, Gallacher J E J, et al. Associations of urban built environment with cardiovascular risks and mortality: a systematic review[J]. Journal of urban health, 2023, 100(4): 745-787.

[8] Ying J, Zhang X, Zhang Y, et al. Green infrastructure: Systematic literature review[J]. Economic research-Ekonomska istraživanja, 2022, 35(1): 343-366.

[9] Huang W, Ren J, Yang T, et al. Research on urban modern architectural art based on artificial intelligence and GIS image recognition system[J]. Arabian Journal of Geosciences, 2021, 14(1): 1-13.

[10] Mansuri L E, Patel D A. Artificial intelligence-based automatic visual inspection system for built heritage[J]. Smart and Sustainable Built Environment, 2022, 11(3): 622-646.

[11] Sheng H, Cong R, Yang D, et al. UrbanLF: A comprehensive light field dataset for semantic segmentation of urban scenes[J]. IEEE Transactions on Circuits and Systems for Video Technology, 2022, 32(11): 7880-7893.

[12] Zhong W, Schröder T, Bekkering J. Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review[J]. Frontiers of Architectural Research, 2022, 11(1): 114-141.

[13] A. S. Tomar and G. S. Tomar, "Generative Artificial Intelligence for Cross-Domain Knowledge Synthesis and Intelligent Automation," *2026 IEEE 15th International Conference on Communication Systems and Network Technologies (CSNT)*, Al-Khobar, Saudi Arabia, 2026, pp. 1070-1075, doi: 10.1109/CSNT69054.2026.11502110

[14] A. S. Tomar and G. S. Tomar, "Cluster Head Selection Optimization for Lifetime Enhancement in WSN," *2026 IEEE 15th International Conference on Communication Systems and Network Technologies (CSNT)*, Al-Khobar, Saudi Arabia, 2026, pp. 24-30, doi: 10.1109/CSNT69054.2026.11502316.

[15] Zhang H, Deng Y. Artificial Intelligence Based Garden Landscape Design System and 3D Visualization Technology[J]. Computer-Aided Design & Applications, 2024, 21(1): 63-76.