



Color Quality Evaluation of Urban Street Buildings Based on Artificial Intelligence and Street View Images: Taking Zhongshan Road Historical and Cultural Street in Shenyang as an Example

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Abstract. Historical and cultural streets not only are an important part of the urban historical context, but also show the urban memory. The color of the building facades in the historic and cultural streets greatly affects the visual quality of the environment. This study took the Zhongshan Road historical and cultural street in Shenyang as the site, and used Python to capture the street view image of buildings on both sides of a 1.7 km range within the Zhongshan Road historical and cultural street by Baidu Street View (BSV). At the same time, physical psychology were used to evaluate and analyze the Building Color Quality (BCQ), and further identified the existing problems and proposing optimization suggestions. It is helpful for planning and management of building colors in urban historical and cultural streets and provides constructive suggestions for the dynamic development of the urban areas.

Keywords: Historic streets, Building color quality, Python

1 Introduction

Color is the most intuitive way for people to experience the urban, and can reflect the culture, personality, and quality of the urban [1,2]. Urban color, also known as "urban environmental color", generally refers to the overall color appearance of the public space components within the urban area in a broad sense [3]. British scholar Michael Lancaster proposed the concept of Colorscape, pointing out that color should be an important element in urban environments, and detailing the meaning of location and surrounding colors [4]. World experience has shown that reasonable color planning can be more conducive to shaping the spatial characteristics of an urban area, enhancing the functionality of the urban area, and harmonizing the urban color scheme. With the rapid development of urbanization, on the one hand, some streets with urban characteristics have not been well protected and have been destroyed; on the other hand, developers and advertisers have not fully considered the color relationship of the entire street

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when constructing buildings and advertising billboards, resulting in a decline in the appearance quality of urban streets [5]. The Zhongshan Road Historical and Cultural District in Shenyang urban area encompasses a large number of cultural heritage protection units, historical buildings, and architectural styles, showcasing the ethnic style of northern cities. The buildings in the street are mostly eclectic architectural styles from the Republican era, with colors mainly in beige, white, red, and gray. However, many modern advertising facilities, architectural styles, and colors on the street are incompatible with it, resulting in the disorderly scenery of the street. The informationized big data era provides more possibilities for overall and intuitive observation of streets. Street view technology is based on a three-dimensional panoramic perspective, focusing on human-scale data sources, and can provide high-resolution real-life image data for qualitative and quantitative analysis of building colors. In this study, the buildings on both sides of the road of Zhongshan Road Historical and Cultural Street in Shenyang were selected as the research objects, python was used to crawl the street scene information, and the building color quality (BCQ) of the research objects was evaluated by using the "visual intuitive method" through graphic, and it was analyzed and demonstrated[6], Summarizing and planning the design methods and planning suggestions for historical and cultural districts and modern building has a certain reference value for the refined planning and control of urban characteristic historical and cultural districts.

2 Method

2.1 survey region

This research area is located in Zhongshan Road Historical and Cultural Street, Shenyang, which is one of the three provincial historical districts in Shenyang. The street has witnessed the development process of Shenyang's modernization, retained the traditional spatial pattern in the early stage of building, the courtyard-style building cluster form and the traditional road and lane texture, and is a representative of the introduction of advanced urban planning ideas into northeast China [7]. Based on the current situation of the street and the current research situation, this study selects the section from Zhongshan Square to Youth Street in the historical and cultural street of Zhongshan Road, with a total length of 1.7 km, and divides the street into five areas according to the intersection of the street: Area A (East of Zhongshan Park-Beiwuma Road), Area B (Beiwuma Road-Beiliuma Road), Area C (Beiliuma Road-Bajing Street), Area D (Bajing Street-No.192 Zhongshan Road) and Area E (No.192 Zhongshan Road-Qingnian Street) (Figure 1).

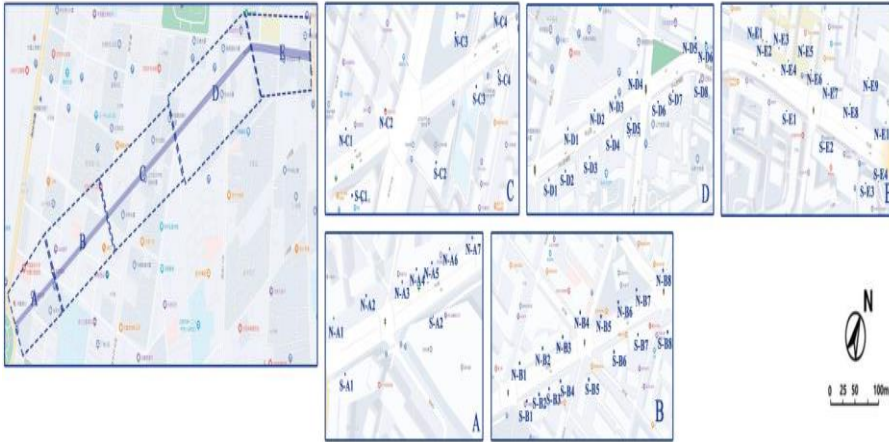


Fig. 1. Study area and map

2.2 Data acquisition and data preprocessing

This study first divides and numbers the buildings along the street in the research area of the street, and then uses python to climb the street view pictures of the buildings in the research area in the BSV map. In order to get the building image from the pedestrian's point of view, the horizontal angle when downloading the image is 0, and the dynamic street view images of the building for many years are obtained through the "time machine" function (the street view images of some buildings only have one or two years), so as to achieve multi-directional and multi-timeline image collection [8]. Through collecting and organizing the external wall images of the main road of Zhongshan Road historical and cultural street, there are 61 building facade images, including 35 building facades on the north side of the street and 26 building facades on the south side of the street. Compared with the traditional sample collection method of manual photography, the method of combining Python with BSV has the advantages of intelligence, rapidity, accurate control, and wide coverage of architectural images. Its disadvantage is that it can only capture images at a resolution of 700*700. By comparing the high-resolution and low-resolution experiments, the RMSE scores of the high-resolution and low-resolution scores are less than 0.5, so the resolution has little influence on the evaluation results. In order to ensure the color accuracy of the collected images, all samples need to be pre-processed. The images were processed using the Automatic White Balance (AWB) algorithm to make the sample images comparable with each other (Figure.2).



Fig. 2. Sample image

2.3 Data processing

This study invited 35 experts from teachers and researchers majoring in urban color and related design to evaluate the BCQ of Zhongshan Road historical and cultural street in Shenyang. Before evaluation and judgment, use slides and rough preview of sample photos of all building facades, allowing appraisers to establish evaluation standards. Each slide is played for 25 seconds. The evaluator learns the color information of all samples and scores them independently with a Likert scale: 1 (low quality samples) -7 (high quality samples). A total of 35 questionnaires were received, and the recovery rate was 100%. After screening, 35 valid questionnaires were finally obtained. Then input the evaluation data into EXCEL and standardize it. The results are as follows:

$$Z_{ij} = \frac{(R_{ij} - \bar{R}_j)}{S_j} \quad (1)$$

$$SBE_i = \frac{\sum Z_{ij}}{N_i} \quad (2)$$

In Equation (1): Z_{ij} was the standardized value given by evaluator j for the observed sample photo i . R_{ij} was the rating value given by evaluator j for the observed sample photo i . \bar{R}_j was the average of the rating values of all building color sample photos by evaluator j . S_j was the standard deviation of the rating values of all building color sample photos by evaluator j . In Equation (2): SBE_i was the standardized score of BCQ for sample photo i . N_i was the total number of evaluators.

3 Results

3.1 Comparative analysis of building color quality

The BCQ evaluation results of 61 samples are shown in Table 1. The first 15 samples are high quality samples and the last 15 samples are low quality samples. Through the comparison between high-quality samples and low-quality samples, the building color quality of the Zhongshan Road's historical and cultural street is analyzed. In high-quality samples, the building colors are uniform and clear, with red and beige as the main colors and dark gray, black and white as auxiliary colors. Some samples retain more historical and cultural styles, and the colors are mainly historical colors (such as N-B2, N-B8, N-E4, N-E5). The colors of some samples are well integrated with the colors of modern facilities (such as billboards), and the color styles of building facades are harmonious and unified (such as N-E8, N-B8, N-B7). NE-8 has the highest evaluation score for architectural color quality (1.55), and the overall facade of the building is mainly retro brick red. The color of modern billboards is also close to the main color of the building, with a small amount of light blue and yellow as decorative colors. In the integration of modernity and history, the overall color style is unified and clear. In the low-quality samples, many buildings are surrounded by modern decorations such as billboards and plaques that are incompatible with the colors of the buildings themselves, and some decorations are not designed with the color of the buildings in mind (for example, S-B5). There is a large area of glass curtain wall with strong reflectivity on the facade of individual buildings, which is easy to cause light pollution (such as N-C3). There are some unfinished buildings (such as N-D4) in the street, and the building colors are not harmonious.

Table 1. Color quality ranking order for samples

Sample No.	Standardized value	Sample No.	Standardized value	Sample No.	Standardized value
N-E8	1.55	N-A6	0.14	S-C3	-0.3
N-B2	1.16	S-B2	0.12	N-A4	-0.37
N-B8	1.07	N-D3	0.06	N-B4	-0.37
N-B7	1.01	S-A1	0.05	S-C4	-0.4
N-E6	1.01	S-C1	0.05	S-B6	-0.43
N-B6	0.91	N-D6	0.03	N-B5	-0.48
N-A3	0.81	N-E1	0.01	S-D1	-0.5
N-E4	0.62	N-C2	-0.03	S-D3	-0.54
N-E5	0.59	S-D2	-0.05	N-D4	-0.6
N-E3	0.57	S-C2	-0.1	S-D8	-0.61
N-A1	0.55	S-E2	-0.11	N-E9	-0.61
N-B3	0.54	N-A5	-0.12	S-A2	-0.66
N-B1	0.52	S-D6	-0.13	N-C1	-0.7
S-E3	0.41	S-B8	-0.16	S-B7	-0.72
N-A2	0.34	S-B1	-0.18	S-E1	-0.72
S-D7	0.34	S-B4	-0.19	S-D4	-0.77
N-E2	0.33	S-D5	-0.22	N-E7	-0.78
N-D5	0.22	N-C4	-0.23	N-C3	-0.83
N-D2	0.19	S-B3	-0.24	S-B5	-1.01
N-D1	0.16	S-E4	-0.24		
N-E10	0.16	N-A7	-0.28		

3.2 Comparative analysis of BCQ within different blocks

Table 2. Statistical analysis of BCQ in different blocks

Block No.	Total mean value	Median value	Difference value
A	0.051	0.05	0.001
B	0.097	-0.17	0.267
C	-0.318	-0.265	-0.053
D	-0.173	-0.09	-0.083
E	0.199	0.245	-0.046

In order to obtain the overall BCQ information of Zhongshan Road historical and cultural street, we further compared the average BCQ values according to the five designated areas. As can be seen from Table 2, the order of building color quality in five areas is as follows: BCQE (0.199) > BCQB (0.097) > BCQA (0.051) > BCQD (-0.173) > BCQC (-0.318). In area B, with the highest BCQ, the main color of the building is prominent, the colored blocks are well distributed, and the whole is harmonious and unified. In areas E and B with higher BCQ, the number of billboards on the facade of the building is less (Table 2). By comparing the average, median and difference of BCQ in five blocks, it can be seen that the fluctuation and distribution balance of BCQ are mainly divided into positive skewed distribution and negative skewed distribution (Figure 3).

Positive skew distribution: statistically calculate the BCQ score of each block. If its average value is greater than the median, it indicates that there is an extreme value with statistically significant influence in this block. The extreme value of the statistical value distribution curve of this block deviates to the left of the X axis, which indicates that the overall BCQ score of this block is more distributed in the poor interval.

In the historical and cultural street of Zhongshan Road, the BCQ of blocks A, B, C and D is positively skewed, which shows that the high-scoring building color samples of these four blocks have a positive impact on the overall color quality of the blocks.

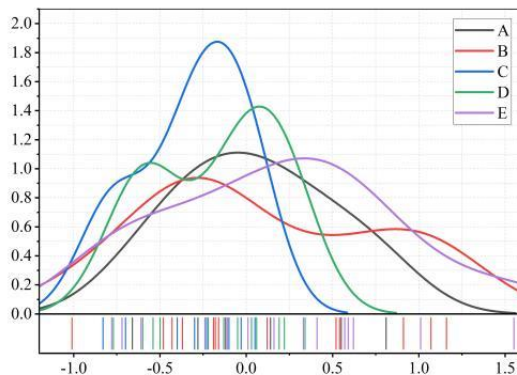


Fig. 3. The block BCQ distribution map

The average score in area C is the lowest, ranging from -1.5 to 0.5. The overall chromatographic quality of the sample is poor, and S-C1 is the highest quality sample in area C. The building facades of N-C3, S-C2 and S-C4 are composed of blue and gray glass curtain walls. The color of the facade of S-C3 is a highly saturated green, which is inconsistent with the beige and red tones of historical buildings in the block. The overall color of the S-C1 building facade is clear, the saturation and contrast are low, and there are not too many complicated billboards, glass curtain walls and other factors that affect visual comfort. Although the BCQ of block A ranks low on the whole street, the N-A3 of block A is a high-scoring sample. The facade of N-A3 is mainly red, with a small amount of white and light red as decorative colors. There are no billboards with different colors and styles on the facade of the building, and the plaques of the shops are white and yellow that match the color of the facade itself, so the whole building is clean and comfortable.

Negative skew distribution: statistically calculate the BCQ score of each block. If the average value is less than the median value, it represents the statistically significant minimum value of these building samples in the whole street environment. The extreme value of the statistical value distribution curve of this block deviates to the right of the X axis, which indicates that the overall BCQ score of this block is distributed in a better interval. According to statistical analysis, the BCQ of E block is negatively skewed. The building color samples with low scores have great influence on the overall color quality of blocks. In block E, N-E9 ranks higher, but S-E1 and N-E10 are low-scoring samples. The building facade of S-E1 is blue-gray, and the billboards and plaques on the building facade account for a large proportion. The colored blocks are messy and there is no correlation between the colors, and the colors of the building facade are disorderly. The building facade of N-E10 is mainly taupe, the window glass is blue, the building color is relatively old, and there is a blue fence with high saturation outside, so the distribution of color blocks is not harmonious and the visual comfort is low. To sum up, the positive and negative skewness distribution of street BCQ data is an abstract representation of street color quality. It not only reflects the positive and negative effects of a few discrete data samples in the block, but also provides sample positioning for the update and optimization of street colors.

4 Discuss

4.1 Modern outdoor facilities have a great influence on the building color of historical and cultural streets

The integration of modern shops and historical buildings in Zhongshan Road historical and cultural street lacks effective color management. It is a common problem in the street that the color of the new building is not uniform with the original building color. For example, the color of the building is not related to it, and the billboards and plaques on the facade of the building are not harmonious with the color of the building itself. Some of the outdoor facilities are in harmony with the color of the building facade itself. That is, they respect the color of the building and the environment itself and express the information they want to convey. This is positive for the development of

Zhongshan Road, an historical and cultural street. However, some outdoor facilities will use more striking and bright colors that are contrary to the overall environment itself in pursuit of benefits. The color of these outdoor facilities will disturb the color of the street and the building itself, which will destroy the color of the overall environment. To solve this problem, it is necessary to plan the outdoor facilities specifications of historical and cultural streets as a whole, such as location, size and color. While developing modern businesses, it also protects the original color environment of the street, and chooses colors that are related to the color of the building facade itself. Prevent the color confusion of the building facade in the street, create a relatively comfortable visual environment with history and culture, and reduce the impact on the color quality of the building facade itself.

4.2 The number and layout of building facade colors are related to the integrity of their colors

The number and color layout of a building's facade affect the color integrity of the whole building itself. Unified and orderly color layout within a hue range can improve visual comfort. The choice of color greatly affects people's spatial perception of historical and cultural streets, and then affects the overall color environment of the streets. Reduce the color difference in the building facade appropriately and control the number of colors, so that people can feel the integrity of the building's facade color when walking around the street. Excessive color layout will reduce visual comfort, and the facade color of Zhongshan Road, an historical and cultural street, is often dominated by historical colors, supplemented by other colors. However, building facades with too many colors will cause a feeling of color confusion, which is not conducive to the overall color planning of the street. We should pay more attention to the relationship between adjacent colors in the planning process and increase the overall color coordination.

4.3 The preservation of historical style is related to the color quality of street buildings.

In historical and cultural streets, its historical style depends largely on the color quality of the buildings and other supporting facilities on the whole street. In the overall planning of the street, representative buildings with historical value should be considered. The historical buildings in the historical and cultural street of Zhongshan Road are mainly modern eclecticism, and the design style and color style of modern buildings are quite different from those of historical buildings. In the historical and cultural street of Zhongshan Road, the overall harmony between the colors of modern buildings and some supporting facilities and the colors of historical buildings needs to be improved. Color elements can be extracted from historical buildings and applied to modern construction to preserve the overall historical style of the street.

5 Conclusion

By analyzing the evaluation of the color of the building facade in Zhongshan Road historical and cultural street, this paper finds that the building facade in Block E with good color status mostly adopts low saturation and retro color, and the billboards and plaques on the building facade also conform to the color style of the building itself. N-E8, the building with the highest evaluation score, is a good combination of historical culture and modern development. The color of modern commercial elements such as plaques and billboards in blocks with poor color status (such as Block C) spans greatly with the color of the building itself, and does not form a unified color system with the original buildings in the block, which has a great impact on the overall color of the block. Building colors should adapt and coordinate with each other. The lack of protection and maintenance of the facade color of Zhongshan Road, an historical and cultural street, leads to the lack of visual sensitivity of the facade color of some historical buildings. On this basis, we can establish a set of color atlas of architectural facade color in Zhongshan Road, a historical and cultural street, so as to plan the color relationship in the street more intuitively and clearly and formulate optimization strategies. As for the relationship between historical buildings and modern buildings in urban areas, we should adapt the historical atmosphere of buildings to the development of the times and realize the dynamic development of "old and new symbiosis" streets [9]. It is particularly important for the overall color design and planning of the Zhongshan Road historical and cultural street.

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