Intelligent Extraction of Color Features in Architectural Space Based on Machine Vision

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Abstract. Architecture itself has artistic characteristics, and architectural color will change with the change of environmental parameters. The analysis of the color characteristics of the building space is conducive to the color analysis and auxiliary design of the building. The current color feature extraction methods are prone to a sharp increase in signal-to-noise ratio, resulting in a low extraction rate. In order to solve the above problems, a new intelligent extraction method of building space color features is designed based on machine vision. The color information transmission channel model is established, and the transmission path function is introduced to obtain the mathematical model of intelligent extraction of building space color features. The intelligent extraction is realized through the reliability calculation model. Using machine vision, color information and texture information are organically combined to extract construction land information. The experimental results show that in the process of extracting color features, the extraction results of this method will not appear mutation points, the stability is well guaranteed, and the extraction accuracy can reach more than 99%, indicating that this method has good application effect.

Keywords: Machine Vision · Architectural Space · Space Color · Color Characteristics · Feature Extraction · Intelligent Extraction · Extraction Method

1 Introduction

Architectural color is a complex theoretical system, involving many dynamic and variable environmental parameters. In the real environment, the architectural color depends on the architectural form and is affected by various factors, such as the nature of the sky, green space, water, sunshine intensity and changes in sunshine angle, and the purity of the air. In addition, the regional color background is also a factor that cannot be ignored.

Architecture itself has artistic characteristics, and architectural color will change with the change of environmental parameters. The analysis of the color characteristics of the building space is conducive to the color analysis and auxiliary design of the building. However, because architecture itself has the characteristics of art discipline and involves a large number of perceptual knowledge and understanding, some factors

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that affect architectural color are difficult or have no better method to quantify [1, 2]. To solve this problem, this research is based on machine vision, and extracts the color features of architectural space. This paper focuses on the innovation of research ideas and methods, focusing on the color of single building itself. The general research ideas are as follows:

① Establish color information transmission channel model;

② The transfer path function is introduced to establish the color feature extraction model of building space, and the intelligent extraction is realized through the reliability calculation model.

In this study, in the process of collecting research materials, it is inevitable to encounter the following situations: the image content not only includes the building itself, but also includes the surrounding environment images of the building. These environmental elements are very different from buildings in terms of color perception. If they are not distinguished and included in the calculation of architectural color, it will undoubtedly have a greater impact on the analysis results. In order to highlight the main target position of the building in the image and reduce the interference of other images, an image preprocessing link should be added before using computer-aided methods to study the collected materials.

The main operation of image preprocessing is divided into two steps: first, extract the content of research value in the image, and eliminate irrelevant factors and interference factors; The second is to select an identifier that is easy to identify in program calculation and replace it on the excluded content in the picture, so as to exclude the marked content in the calculation process.

2 Building a Mathematical Model for Intelligent Extraction of Architectural Space Color Features

The mathematical model of intelligent extraction of building space color features established in this paper is based on the principle of machine vision. In the principle of machine vision, the intelligent camera sends network data to the data network according to the image detection results. The intelligent camera is the server of the communication network, which can save the building space color information to different memory spaces in the communication network. When configuring the building space color information, The network data parameters in the memory space need to be allocated to different offset addresses. The operating terminal in machine vision is used to detect the building space color information parameters in the offset address. After the detection is completed, the detection results are output. The communication terminal in machine vision reads and writes the building space color information detection results, displays the detection results on the intelligent camera, and obtains the configuration information of communication data [3].

In order to calculate the reliability of architectural space color information of machine vision, it is necessary to build a mathematical model for intelligent extraction of architectural space color features. Through this reliability mathematical model, the data processing capability of the transmission path of architectural space color information can be evaluated, so as to realize the extraction of architectural space color information. Reliable transmission, first of all, a model of the transmission channel model of architectural space color information is established:

$$P_L = A + 10\gamma \lg(d/d_0) + X_f + s \tag{1}$$

where, γ represents the data transmission capacity coefficient; d represents the distance between the operator and the communication terminal in the machine vision system; s indicates the buffer size of the transmission path; A represents packet loss rate of color information in building space during data transmission; X_f is the time interval of data transmission path, γ, A, X_f are respectively expressed by the following formula:

$$\begin{cases} \gamma = a - bh_b + c/h_b \\ A = 20 \times \lg(4\pi d_0/\lambda) \\ X_f = 6 \times \lg(f/2000) \end{cases} \tag{2}$$

Among them, a, b, c, h_b represent natural numbers between 0–10.

Usually, the loss of the color information transmission path in the building space is closely related to the communication time of the communication terminal in the machine vision system. The loss of the color information transmission path in the building space affects the stability of the color information transmission channel in the building space. The transmission path is used to calculate the rate at which the building space color information is sent to the communication terminal, detect the transmission status of other building space color information transmission paths, evaluate the ability of different building space color information transmission paths to process data, and dynamically configure the building space color information according to the level of capability. Flow, receive discrete components in the data transmission path, and use the following formula to calculate the transmission path function of building space color information:

$$f(r) = K\frac{r}{\sigma^2}\exp\left(-\frac{r^2 + r_d^2}{2\sigma^2}\right)I_0\left(\frac{rr_d}{\sigma^2}\right) \tag{3}$$

where, r_d represents the loss of the transmission path of color information in the building space; σ represents the delivery rate of color information packets in the building space; r represents the color information of the building space without loss; I_0 is the attenuation coefficient of data transmission channel; K represents the instantaneous power generated by transmitting the color information of part of the building space [4]. The detection process of communication terminal is shown in Fig. 1.

Observing Fig. 1, we can see that the data transmission capability of this path is evaluated according to the established building space color information transmission path function, and buffer spaces with different capacities are allocated to communication terminals. Different data blocks in the building space color information leave the same data transmission path. In order to avoid storing excessive architectural space color information in the communication terminal, the uplink and downlink in the data transmission channel are set to be independent of each other to reduce the path loss rate caused by the attenuation of the transmission path, so that the architectural space color

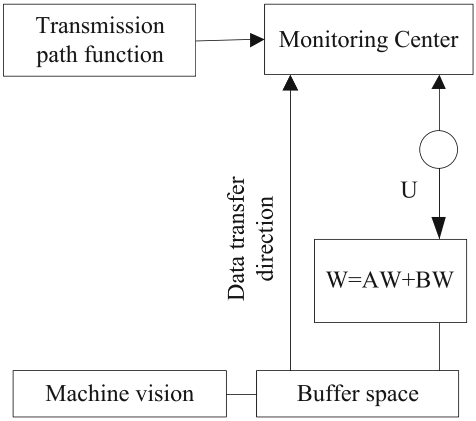


Fig. 1. Communication terminal detection process

information The transmission path characteristics conform to the Rice distribution, and the time interval of the current data transmission path is determined, and the reliability mathematical model is obtained by combining the building space color information transmission path function:

$$F(r) = 1 - Q\left(\sqrt{2K}, \frac{r}{\sigma}\right) \tag{4}$$

where, Q represents the reliability coefficient of color information in building space, and the relationship between the transmission path of color information in building space and the loss rate of data packets can be intuitively expressed through the reliability mathematical model [12, 13].

3 Intelligent Extraction and Calculation of Architectural Space Color Features Based on Machine Vision

According to the mathematical model of intelligent extraction of architectural space color features, the intelligent extraction of architectural space color features based on machine vision is calculated [5, 6]. The Monte Carlo statistical technology is used to obtain the distribution of building space color information transmission channel and data transmission path distribution, the distribution analysis method is used to calculate the success probability of building space color information transmission in the transmission path, and Rice distribution is used to calculate the transmission time of building space color information. For description, the single transmission data volume of building space color information follows the $N(\mu, \sigma^2)$ distribution, and the transmission rate of building space color information is determined. The ability of spatial color information is good, which can ensure the stable and safe transmission of architectural spatial color information in the communication network. Under the condition that the communication link maintains normal connection, the probability of normal transmission of architectural spatial color information to the communication terminal is:

$$a_{link} = P(t \leq t_d) \tag{5}$$

Assume that the distribution of effective components of building space color information communication link is $f_{T_R}(t_R)$, and B $f_r(t)$ represents the distribution of communication channels for single transmission of building space color information. According to the distribution characteristics of building space color information transmission channels, the relationship between the distribution of communication links and the transmission time of building space color information is exponential. The distribution between them can be expressed by the following formula:

$$f(t_R, t) = f_{T_R}(t_R) f_T(t) \tag{6}$$

The following formula is used to express the successful transmission probability of the communication channel where the architectural space color information is located:

$$a_l = \int_0^\infty \int_0^t R_T(t) f_{T_R}(t_R) dt_R \tag{7}$$

where, t_R represents the probability of communication link congestion. When calculating the transmission capacity of the communication channel where the building space color information is located, it is necessary to obtain the busy probability of the communication link, and combine it with the probability of successful transmission of the communication channel to obtain the transmission efficiency of a data node in the building space color information. According to the transmission performance of the building space color information transmission channel, Obtain the transmission performance index of the communication link and data transmission path, which can calculate whether the path is connected or busy when the communication link transmits the color information of the building space, and the probability that the color information of the building space can be reliably transmitted to the communication terminal, which can be calculated through the main channel in the data transmission channel [7].

The reliability calculation model is shown in Fig. 2.

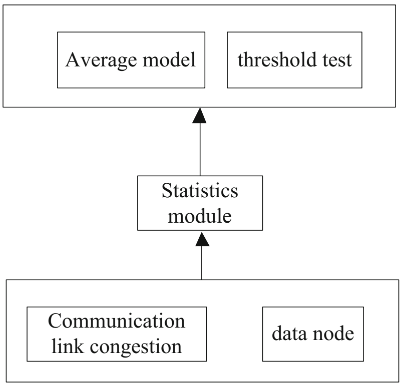


Fig. 2. Reliability calculation model

Through this calculation model, the ability and effect of the communication channel to transmit architectural space color information can be calculated. During the communication process of network data, the time interval samples for the transmission of architectural space color information on the unit transmission channel are $x_1, \ldots, x_n$, i is the transmission channel, and N is the time. The total number of interval samples, use the following formula to calculate the average value of the probability of successful transmission on this transmission channel:

$$\overline{X_N} = \sum_{i=1}^{N} x_i/N \tag{8}$$

where, x_i represents the time taken for building space color information to be transmitted in the communication link, and $\overline{X_N}$ represents the average value of the probability of successful transmission of building space color information in the transmission channel,

In order to fairly calculate the reliability of building space color information, it is necessary to fuse the probability of successful transmission of building space color information in the communication link and transmission channel.

The average iterative value of successful transmission probability is:

$$\overline{X_{N+1}} = \frac{\overline{X_N} \times N + x_{N+1}}{N + 1} \tag{9}$$

In the fusion process, the transmission path of building space color information conforms to normal distribution, and the transmission channel conforms to Rice distribution. After fusion, the reliability of building space color information obtained in different paths and different transmission channels is:

$$S_N = \sqrt{\sum_{i=1}^{N} \left(x_i - \overline{X_N}\right)^2/(N-1)} \tag{10}$$

where, S_N represents the reliability of the color information of the building space. After the reliability calculation of building space color information is completed, the transmission path and channel of building space color information with the highest transmission success rate are selected as the optimal data transmission link [8–10].

4 Analysis on Color Characteristics of Architectural Space

The recognition principle of the GRB color space positioning method is to use the color difference of the image to use the HIS color space visual perception model to convert the data of each frame of the image into a signal for output. The conversion principle is shown in Fig. 3.

It can be seen from Fig. 3 that for the color signal of the building designed in this paper, the signal lamp will be affected by the external light, weather and mirror at every moment, making the correct color transmission of the signal lamp deviate. GRB color space positioning method is the most effective color signal recognition method to solve the above problems. Red, green and yellow are set as the most relevant colors in the GRB color space signal recognition side, so as to achieve the highest sensitivity of the method. After the GRB color space positioning method is used to identify the color

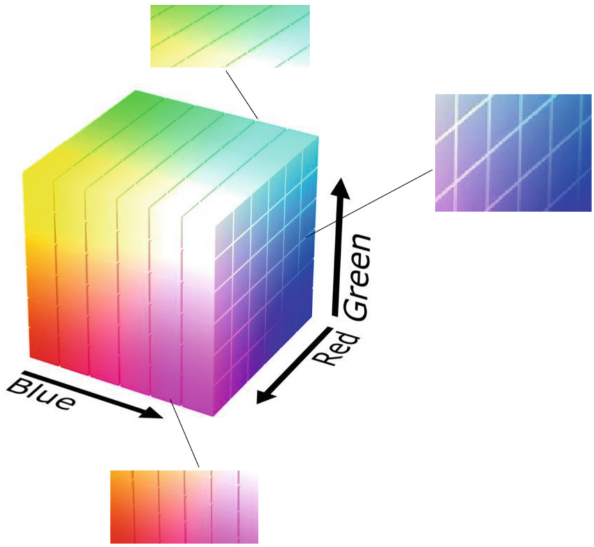


Fig. 3. Effect of space conversion of color signal

signal of the building space, the signal feature is extracted with the following formula, as shown below:

$$y = p \times \sum \sqrt{\frac{2\Pi\mu}{3k}} \tag{11}$$

Among them, p represents the space vector represented by various colors; μ represents the signal conversion factor; k represents the color signal component.

5 Building Abnormal Signal Alarm Judgment

The accuracy of machine vision is higher than that of traditional human vision. The signal captured by machine vision is mainly completed through camera calibration and image edge testing [11]. In order to achieve the effect of machine vision signal conversion, first of all, the signal centralized monitoring transmits the alarm information of the equipment in the mechanical room to the patrol robot in real time. The patrol robot automatically arrives at the location of the alarm equipment according to the received alarm information, and automatically recognizes the alarm board card, Check the accuracy of alarm information through image contrast intelligent analysis, and transmit the review results and confirmation pictures to the centralized signal monitoring system; Then, through the centralized signal monitoring terminal, it can realize remote manual control of the patrol robot to reach the designated position, take videos or pictures as required, and transmit them to the monitoring and reading terminal through the centralized signal monitoring network channel in real time. The machine vision signal conversion process is shown in Fig. 4 below.

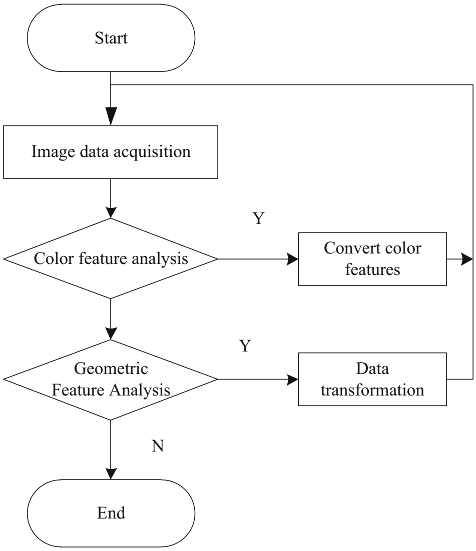


Fig. 4. Flowchart of machine vision signal conversion

6 Building Space Color Information Reconstruction Algorithm

Firstly, the reconstruction algorithm of building space color information is established, and the data reconstruction of the key index system of building space color information is realized through the relevant analysis technology, so as to extract the key data features of building space color information. On this basis, based on the data center, the important big data of building space color information is distributed and mined. The adaptive adjustment of big data mining is realized by adjusting the data stream content and data package ID [12]. Then analyze the state vector of the building space color information data subsystem, realize the design of the critical state mathematical model, complete the clustering analysis of the important index data mining of the building space color information under the optimal objective function condition, and obtain the reconstruction result of the unstructured high-dimensional large data building space color information a, such as formula (12) shown:

$$a = \sum w\left[I(x, y) - I(x + x_1, y + y_1)\right]^2 \tag{12}$$

Among them, x, y, x_1 and y_1 are the coordinate values of the change of color information sampling in the building space before and after the change; I is the frequency corner; w is the coefficient of function calculation.

The feature partition technology is used to realize the optimal mining of color information in building space. The fuzzy C-means clustering technology is used to establish the classification query objective function of unstructured multi-dimensional big data. The fuzzy feature extraction technology is used to mine the data sets generated by different dimensions layer by layer to realize the reconstruction of big data of building space color information and complete the feature extraction of building space color information.

In order to improve the effect of data analysis feature extraction algorithm in multi-dimensional environment, this paper designs a multi-dimensional image data acquisition model combined with entropy method. First, use the sliding window to realize dynamic update data analysis to reduce the adverse interference of abnormal data on incremental primary metadata. At the same time, the reverse k-nearest neighbor algorithm is used to monitor the real data outliers in the sliding window, and the abnormal value data information that affects the calculation can be effectively removed; Judgment extraction is implemented for data analysis. In the acquisition process, in order to avoid the divergence matrix of data analysis, a decomposition operation is performed on its eigenvalues: the space is obtained by detecting all data analysis information and its characteristics in the main element, and according to the entropy value method Detect the effective characteristic space of the pivot element, and project the multi-dimensional big data analysis of the current window to determine the data type, thereby realizing incremental image data acquisition. The dimension feature extraction process is shown in Fig. 5.

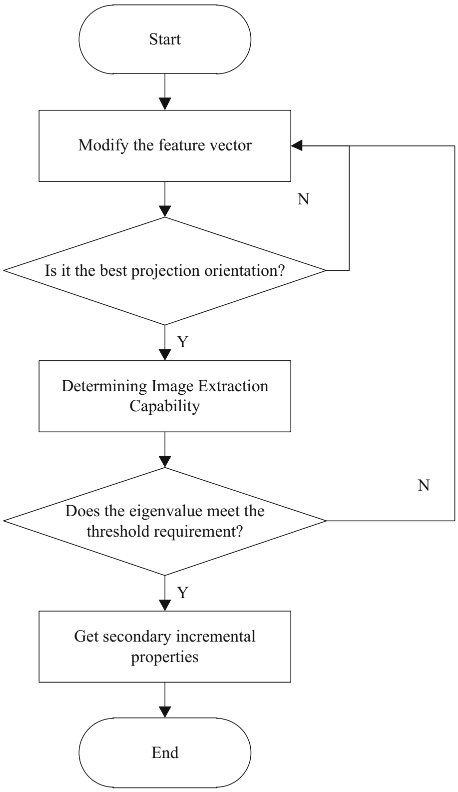


Fig. 5. Dimensional feature extraction process

Step 1: use the principal component analysis method to add and modify the feature vector of the internal covariance matrix data, substitute the feature vector into the benchmark function and measure its recognition ability. In order to select the best projection orientation, the standard model is established by using the datum function to select the best projection orientation.

Step 2: use the entropy method to determine the weighting and judgment ability of image data extraction, and the overall contribution of its main components. The sample matrix of the network with m indexes and n targets is set to f, the system is evaluated after normalization, and the entropy value and entropy weight of the i index are counted. The calculation process is as formula (13) shown:

$$h = -w\sum_{i=1}^{n} fma \tag{13}$$

Step 3: Complete the acquisition of level 2 incremental attributes. First, detect and obtain all the principal component information attributes with large comprehensive scores and overall contribution values from the database system. At the same time, perform subspace projection, transformation and update operations. The execution object is the main element. When high-dimensional data streams appear in the window data containing high-dimensional features, control the data type to make it far lower than the type of dimensions. At this time, the value of the intra class divergence matrix is the largest, That is, the highest dimension subspace can be solved under the operation order. At this time, the maximum function value can be obtained from the window data. For the calculation of high-dimensional representation value and representation vector resolution in the database, since matrix J is included, and the eigenvectors corresponding to matrix J are also the same, the method of directly solving matrix sample f can be converted into matrix J. To solve, that is, to directly find the eigenvalues of the matrix. The scatter matrix improvement method is used, assuming a time sample, the instantaneous average of each type in this time sample is p, and the total data flow at t time is $p(t)$, then the updated value of the average is as shown in formula (14):

$$p(t) = \left[n(t-1) + \frac{n(t+1)}{2}\right] \tag{14}$$

Machine vision method can realize intelligent acquisition on the basis of in-depth study on the structural characteristics of unstructured multi-dimensional big data building space color information. Therefore, this paper proposes an optimization model for extracting color information from unstructured multidimensional big data architecture space based on machine vision. The machine vision extraction optimization model is shown in Fig. 6.

According to Fig. 6, the weights are trained in the machine vision feature optimization model to obtain the relevant model configuration, and the corresponding sequence is generated according to the model configuration. Use association rule mining technology to achieve useful mining of architectural space color information, use machine vision methods to achieve deep learning, and use big data analysis technology to enrich machine vision training programs. Under the training of machine vision, the training task of machine vision is set to T, the color information extraction task of building space is set

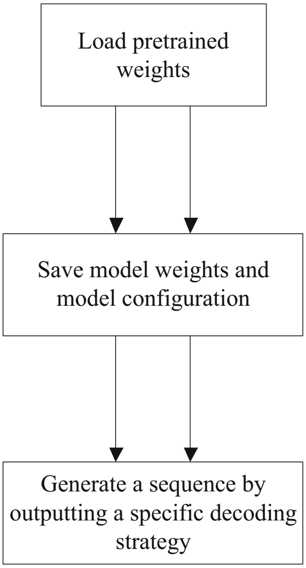


Fig. 6. Machine vision extraction optimization model

to d, and the time required for the extraction task is allocated. The completion time of the feature extraction scheme of building space color information is shown in the formula (15) shows:

$$T(x) = \max\left(\sum_{d=1}^{n}(t-1)\right) \tag{15}$$

Using the parallel data stream reconstruction method, combined with the depth learning calculation of machine vision, the key index features of building space color data analysis are extracted to achieve the feature extraction and analysis of the acquired data at the time limit level, and the temporal feature extraction algorithm of big data analysis color information flow is established. Assuming that the time limit sequence scalar of the image data extraction part of big data analysis association rule information at the time limit level is o, Using the characteristic quantification association rules, the maximum likelihood estimation method is used for the obtained data, the range of the modified association rule feature extraction method is locked, and then the maximum difference G generated by the feature extraction method for the data flow content at the time limit level is obtained through the inference of the fuzzy inference method, as shown in formula (16):

$$G = \frac{1}{mn}\sum_{i=1}^{n}\sum_{i=1}^{m} t \tag{16}$$

Through the method of automatic correlation coefficient, the correlation rules of nodes are extracted, and the automatic correlation coefficient is calculated. Under the framework of time dimension data, data flow rules related to nodes of distributed network structure are provided. Data flow models are obtained from the time sequence level through nonlinear time series method. Then, through the search of building space information, fuzzy C clustering algorithm is used to complete the allocation and arrangement of information under linear time conditions. The flow field distribution function of the association rule data structure represents the fuzzy nodes under the data attribute distribution. Based on the rule data, the combination form after analysis and matching through the nonlinear time series method can be represented as follows:

$$C = \min\{\max Z\} \tag{17}$$

In the formula, C represents the reliability of data access; Z represents the order of sampling samples according to the association rules. It provides a primary spatial framework for the analysis information flow of the acquired data from the perspective of time, and is implemented according to the clustering calculation C in the primary spatial structure. Feature extraction optimization from time perspective of color information analysis in architectural space.

7 Experiment and Result Analysis

In order to verify the effectiveness of the intelligent extraction method of building space color features based on machine vision proposed in this paper, the effectiveness of this method is verified by comparing with the traditional intelligent extraction method of reliability color features.

Starting with a set of building space color information packets from the communication link, to selecting the optimal transmission path, and then to the whole process of successfully transmitting to the communication terminal, the reliability model of building space color information based on machine vision constructed above is used and proposed. The reliability evaluation method based on this method is used to calculate the packet loss rate and packet delivery rate of building space color information. After the calculation method is used in this paper, the traditional calculation method is used to calculate the packet loss rate and packet delivery rate of traditional building space color information.

The experimental parameters as follows: the transmission rate of building space color information is set to 2216 Mbit/s, the success rate of building space color information packet transmission is 85%, the standard length of building space color information packet is 140284 bit, and the number of building space color information transmission nodes is 150.

Use formula (18) to calculate the packet loss rate of each building space color information extraction node:

$$\text{Packet loss rate} = 1 - \frac{\text{Total number of packets received by relay node}}{\text{Total number of packets sent by node}} \tag{18}$$

The results of packet loss rate calculated by this method and traditional methods are shown in Fig. 7.

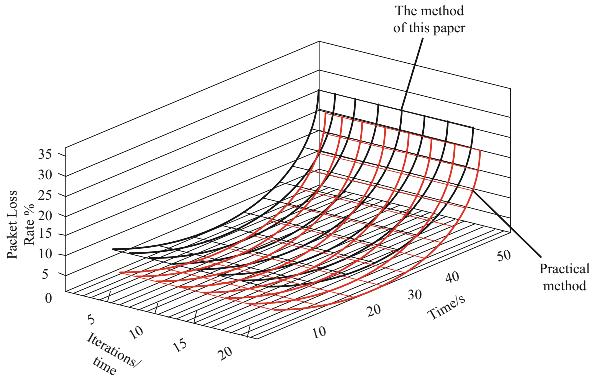


Fig. 7. Comparison of the method in this paper and the actual calculation of the packet loss rate

It can be seen from Fig. 7 that after using the reliability calculation method of building space color information proposed in this paper, with the increase of the transmission time of building space color information, the packet loss rate generated by building space color information nodes gradually increases, and tends to be stable near the standard loss rate, which is highly consistent with the standard loss rate. However, with the increase of the transmission time of the color information in the building space, the packet loss rate generated by the color information node in the building space has been increasing, far exceeding the standard loss rate, and the color information in the building space has been in an unbalanced state, which can verify that the packet loss rate generated by the color information node in the building space is far less than the traditional method, and the packet loss rate is more real stable.

In the absence of data packet loss, the transmission delays generated by the transmission of architectural space color information at different times are shown in Fig. 8.

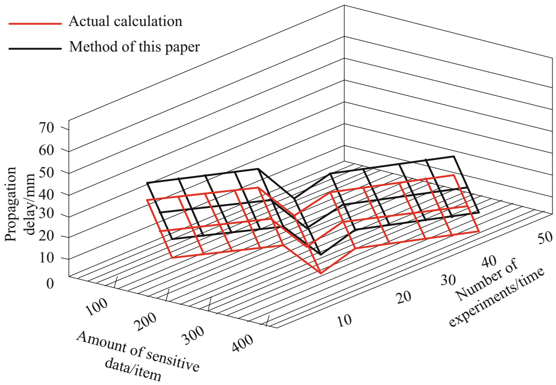


Fig. 8. Data transmission delay experimental results

It can be seen from the analysis of Fig. 8 that in this method, with the continuous increase of the amount of color information in the building space, the delay generated in the transmission process of the color information in the building space is small. During the single transmission, the packet delivery rate of the color information in the building space is gradually reduced. The calculated result has a small difference with the real result and a high degree of coincidence, This is because when analyzing the influencing factors of the reliable transmission of color information in building space, this paper introduces variables such as transmission path loss and network data buffer space, substitutes variables into the reliability model of color information in building space, calculates the successful transmission probability of the communication link of color information in building space, and conducts effective multipath attenuation operations on the transmission path, The transmission path distribution and communication link distribution of color information in building space are obtained by using Monte Carlo technology. The reliability model of color information in building space is constructed by using the principle of machine vision communication, and it is effectively evaluated and calculated. The factors affecting the reliability of color information in building space are comprehensively analyzed, so that the final calculation results are highly consistent with the standard results. In the traditional method for calculating the reliability of building space color information, the transmission delay of building space color information is relatively high, and the packet delivery rate increases with the increase of building space color information, and the calculated results are quite different from the standard results.

On this basis, the accuracy of the extraction results is verified with the average relative error as the indicator. The calculation formula of the indicator is as follows:

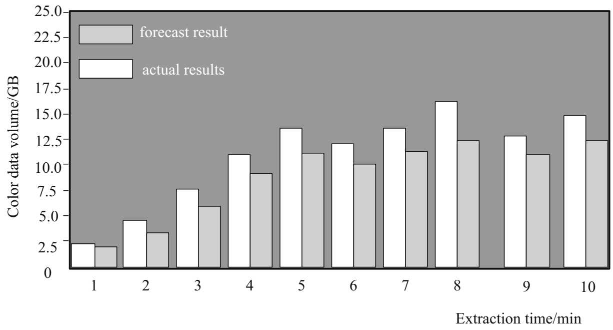
$$\varepsilon = \frac{1}{M}\sum_{m=1}^{M}\frac{\left|y_m - y_w^*\right|}{y_m} \tag{19}$$

where, ε represents the calculated relative error result; M represents the number of spatial color samples to be calculated; y_m represents the actual value obtained when calculating the m model; y_w^* represents the extraction result of the extraction model.

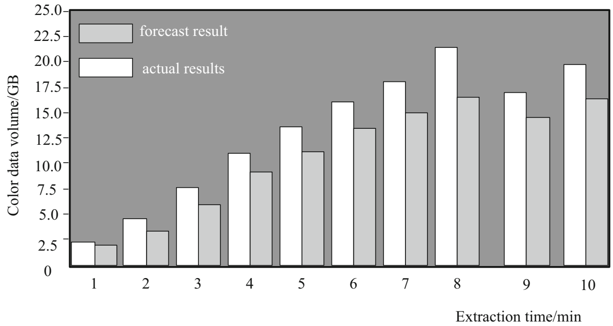
In order to form an experimental comparison, the traditional graph-based extraction method and PSOEM-LSSVM extraction method are used as the comparison method to complete the performance verification together with the method in this paper. The color feature extraction results of building space obtained by the three methods are shown in Fig. 9.

The relative error is calculated according to the figure above, and the results are shown in Table 1.

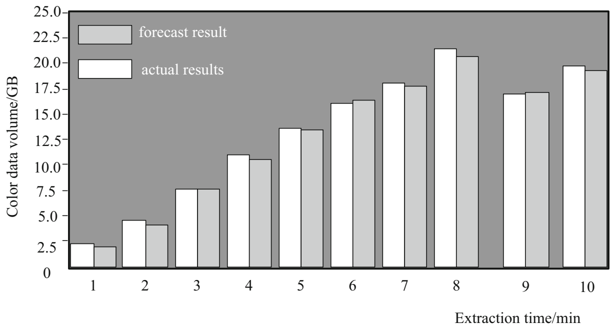
According to Table 1, with the increase of data volume, the extraction errors of traditional graph model based extraction methods and PSOEM-LSSVM based extraction methods are increasing. The extraction ability of the machine vision based extraction method proposed in this paper is significantly higher than that of traditional early warning methods. The extraction process is not affected by external factors, and the extraction relative error is always less than 0.02%, which has high applicability in real life.



(a) Graph model extraction results



(b) PSOEM-LSSVM extraction results



(c) Extraction results of this method

Fig. 9. Results of color feature extraction in architectural space

Table 1. Relative error calculation results

Sample number	Relative error/%		
	Graph model	PSOEM-LSSVM	Machine vision
1	1.43	2.58	0.01
2	1.58	3.02	0.02
3	1.61	3.69	0.01
4	1.66	4.28	0.01
5	1.67	4.99	0.01
6	1.82	5.22	0.02
7	1.94	5.74	0.01
7	1.99	6.10	0.02
8	2.01	6.66	0.01
9	2.20	6.93	0.01
10	2.25	7.24	0.02

8 Conclusion

This paper analyzes the current situation of architectural color analysis and auxiliary design, and proposes the optimization and innovation of the existing analysis methods and research methods. Through research and analysis, this paper puts forward a new idea and breakthrough point for expanding the digital analysis method of architectural color, that is, using the fuzzy cluster analysis method to make the architectural color analysis more intelligent and efficient.

In this paper, RGB images of single building color are selected as research samples, combined with computer image processing and recognition technology and fuzzy clustering method, and with the help of MATLAB 7.0 software tools. In the research work, the RGB color model most commonly used and the HSV color model most suitable for human eye recognition pattern are selected to facilitate the specific algorithm design of feature extraction and fuzzy clustering program. The example proves that the color feature extraction program can be well applied to the analysis and research of color digital images of buildings, to extract each feature data of single building color, thus preliminarily realizing the color quantization by computer aided means.

In the future research, we will consider to further optimize the research in this paper from the perspective of reducing the extraction time.

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