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Research on Composition Optimization Method Based on Regression Algorithm in Teaching Fine Arts Landscape Oil Painting

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Abstract Composition is an important expression of the artistic power of fine art landscape oil painting, however, its teaching has long faced the dilemma of subjective judgment and vague guidance. This paper takes the evaluation of fine art landscape oil painting composition as an entry point, describes the feature selection method, evaluation algorithm process, and the realization of each feature evaluation in image evaluation. At the same time, combined with the idea of multiple linear regression, it puts forward the evaluation method of landscape oil painting image composition based on multiple linear regression. After the objective composition performance results are obtained through the calculation of the multiple linear regression method, the content-based image scaling algorithm is used. Under the premise of ensuring that the image content is not changed, image scaling is performed to construct a composition optimization model for landscape oil painting images. The model, guided by the results of the regression algorithm, increases the optimization score of the actual oil painting image composition from the original 0.26 to 0.849, showing high feasibility and application value.

Index Terms landscape oil painting, multiple linear regression, composition optimization model, image scaling algorithm

I. Introduction

Landscape oil painting has a unique charm, which can present the beauty of nature and humanistic scenery to the audience in a unique artistic language [1]. In landscape oil painting class, teachers will ask students to obtain unique feelings from the many information of natural scenery and create paintings on this basis, and then combine with their own artistic cultivation and life experience to elaborate and analyze the students' feelings and paintings at a deeper level, to stimulate the students' enthusiasm for creation, to cultivate the students' awareness of painting, and to improve the students' painting skills [2]-[5]. It can be said that the teaching of landscape oil painting is not only the process of students' observation, experience and creation of nature, but also a necessary means and way for them to “learn from nature” and improve their painting consciousness [6]-[8]. However, due to the preconceived “eight-legged” style of painting, one-sided understanding of the art of painting, the lack of painting experience and other reasons, students in the landscape oil painting sketching many problems need to be solved [9], [10].

The composition of landscape oil painting is the key factor for the success of the work. Composition provides a framework for the creation of mood in landscape oil painting, and a reasonable layout can guide the viewer's line of sight and make the viewer more easily understand the emotion and theme that the painter wants to convey [11], [12]. The composition of a painting involves the comprehensive use of points, lines and surfaces and the overall layout, especially in landscape oil painting, the interesting distribution of black, white and gray and their mutual support, and the careful layout of mountains, rocks, grass and wood in natural scenery are all important factors that affect the success or failure of the composition [13]-[15]. However, in the actual teaching of landscape oil painting life drawing, most of the students will only copy the natural scenery without choice and priority, lacking their own subjective consciousness [16], [17]. In such a case, the landscape oil painting works created lack of individuality, the composition is bland and no beauty, no tension, and it is very easy to make people feel bored [18], [19]. Therefore, the analysis and optimization of landscape oil painting composition with the help of intelligent technology can help students better understand the connotation of the creation of landscape oil painting and how the painter establishes an emotional connection with the audience through the picture [20]-[22].

This paper firstly describes in detail the design process of the composition-based image aesthetic quality evaluation algorithm, as well as the realization steps. At the same time, the idea of multiple linear regression is introduced, combining the two to construct the image composition evaluation method based on multiple linear regression. Then the composition optimization model is designed, and the content-based image scaling algorithm is adopted as the optimization algorithm to establish the composition optimization model of landscape oil painting images. Subsequently, for the further application of the evaluation method, the correlation analysis of the various influencing factors of oil painting composition is carried out to obtain the most important influencing factors affecting the composition of oil paintings. Finally, similar algorithm comparison experiments and composition optimization application experiments are carried out to test the reliability of the composition evaluation method and composition optimization method proposed in this paper.

II. Image composition evaluation method based on multiple linear regression

II. A. Composition-based algorithm for evaluating the aesthetic quality of images

Composition has always been an important indicator in the evaluation of image aesthetics, at present, the more popular composition method: three-part composition, central composition, horizontal line composition, symmetrical composition and so on. Among them, the three-part composition method and the horizontal line composition method are the basis. In this paper, the three-part composition method and the horizontal line composition method are used as a dimension of the evaluation of the aesthetic quality of images.

There are many algorithms in the research of image aesthetic evaluation based on three-dimensional composition and horizontal line composition, without exception, these algorithms are based on the detection of the saliency region of the image, and then segmentation, calculation, evaluation and reorganization of the image.

The saliency region of an image refers to the part of the region that the human eye is most interested in, i.e., the region that can best arouse the user's interest and best reflect the content of the image. The saliency region detection of an image refers to extracting the saliency region of an image, which is widely used in the fields of image segmentation, image classification, image recognition, edge detection and so on.

The mainstream algorithms for saliency region detection have the following four categories:

(1) LC algorithm. Its core formula is shown in equation (1):

$$SalS(I_k) = \sum_{\forall I_i \in I} \| I_k - I_i \| \tag{1}$$

The algorithm takes the sum of the Euclidean distance between each pixel and other pixels as the saliency value of the pixel point, and uses gray scale pixel values to complete the calculation to derive, and in the calculation of the histogram optimization algorithm time complexity.

(2) FT algorithm: a saliency region detection algorithm using color features that appeared in 2009, using the mean value of the Lab space of the image minus the current pixel value to obtain the saliency map algorithm, the core formula of the algorithm is shown in equation (2):

$$S(x, y) = \| I_u - I_{\text{whc}}(x, y) \| \tag{2}$$

where I_u represents the mean value of the image Lab space and $I_{\text{whc}}(x, y)$ represents the Gaussian fuzzy value of the original image. HC algorithm is developed on this algorithm.

(3) AC algorithm: it utilizes a similar image pyramid algorithm, making differences with standard images at different latitudes and then accumulating them for normalization.

(4) HC algorithm: HC algorithm is based on LC to increase the processing of color information, and the color image from the RGB space into Lab and then processed, in the performance of the algorithm, HC algorithm uses the number of colors from each channel 255 mapping is reduced to 12, so that the algorithm's processing speed will be much faster, and the color is quantified after the saliency region extraction of the effect of a small impact.

In a wide range of saliency region detection algorithms, this paper selected the basis of the HC algorithm, in the HC algorithm to get the saliency region, and then on the saliency region image using maximum entropy binarization segmentation, to obtain the binarized image and the original image fusion to extract the saliency region in the image of the content of the image information.

After obtaining the salient region of the image, the composition can be completed by judging the position of the salient region in the whole image.

The closer the image composition is to the four composition points of the one-point composition method, the more reasonable the image composition is, the higher the score should be, and vice versa, the lower the score is. The formula for the three-point composition is equation (3):

$$E_{point} = e^{-\frac{d^2(S)}{2\sigma}} \tag{3}$$

where $d(S)$ indicates the minimum distance between the center of the region of significance and the four composition points of the trichotomous composition method, and the value of σ is 0.17.

After a large number of experiments, for the same size of the image, with the above formula can reflect the quality of the image trichotomous composition, but for the size of the disparity of the image, $d(S)$ a parameter can not fully reflect the quality of the image trichotomous composition, the image trichotomous composition quality is not only related to the size of the salient region from the distance of the four points of the composition but also with the overall size of the image has a relationship with the overall size of the image, as a simple example. A 1024 * 1024 image and a 128 * 128 image, the same calculation to get the saliency region from the four intersecting points of the minimum distance of 30, then 1024 * 1024 image from the composition is more in line with the three-part composition method. Therefore, the algorithm implementation added this improvement, the calculated $d(S)$ and the overall size of the image for division, the larger the gap between the saliency region from the four composition points relatively farther away, the worse the quality of three-dimensional composition, and vice versa, the closer the distance, three-dimensional composition of the quality of the better. That is, the σ parameter in the algorithm should be set as a dynamic adaptive parameter, after a large number of experimental observations and calculations, there is equation (4):

$$\sigma = S(I) * 0.17 \tag{4}$$

$S(I)$ denotes the average of the width and height of the image. The final evaluation formula for the three-part composition method is equation (5):

$$E_{point} = e^{-\frac{d^2(S)}{2\sigma_s}}, \sigma_s = 0.17 * S(I) \tag{5}$$

The basic idea of scoring based on the horizontal line composition method is: use the Hough transform to detect lines in the image, determine the length and angle of the line to detect the presence of an important straight line in the image, and if there is an important straight line according to the location of the important straight line and the baseline in the horizontal line composition method to score the image, the closer the baseline the higher the score, and vice versa, the lower the score.

Similarly, after calculating the minimum distance between the important straight line and the baseline, it is also necessary to consider the impact of the image size on the evaluation of the horizontal line composition, and the final evaluation formula of the horizontal line composition method is equation (6):

$$E_{line} = e^{-\frac{d^2(l)}{2\sigma_1}}, \sigma_l = 0.17 * S(I) \tag{6}$$

The image composition was scored as a weighted average of the three-part composition and the horizontal line composition for the final score, calculated as equation (7):

$$E_M = R_p E_{point} + R_l E_{line} \tag{7}$$

According to the labeled experimental learning, R_p is 1/3 and R_l is 2/3. If no important straight line is detected in the image then R_p is 1 and R_l is 0, i.e., the horizontal line composition method is directly ignored.

In image composition, depth of field is one of the important indexes for evaluating the good and bad image works, and shallow depth of field composition is also a common painting technique. The so-called shallow depth of field composition is a compositional method that strengthens the main features of the image by deflating the background. According to the compositional characteristics of depth-of-field images, the evaluation algorithm of depth-of-field composition is proposed as equation (8):

$$E_D = \log_2\left(|B_A - B_s| + 1\right) + 0.5 \tag{8}$$

where B_A is the clarity evaluation value of the image saliency region, B_s is the clarity evaluation value of the whole image, after a large number of experiments to prove that the evaluation results of this algorithm are basically consistent with the real human visual experience, so this APP adopts this depth of field evaluation algorithm.

The visual balance of an image is also a very important index for evaluating image works, visual balance is a kind of feeling that an image brings to people's psychology, and there are many factors affecting the visual balance, mainly including the size of the main body of the image should be reasonable, and the distribution of the center of gravity of the image should be balanced.

In this paper, we propose a visual balance algorithm based on the state of the important subject of the image is located near the center of the image, and the formula of the algorithm is equation (9):

$$E_V = \omega_{VB} E_{VB} + \omega_{VS} E_{VS} \tag{9}$$

where E_{VS} and E_{VB} represent the subject proportion score and subject position score, respectively, ω_{VS} and ω_{VB} represent the proportion of the subject proportion score and the subject position score, and the experimental results take the value of each of them is 0.5. The experimental results are basically consistent with the visual perception of human beings.

Comprehensive analysis of the experimental results of the above algorithms, the formula of the composition-based image aesthetic quality evaluation algorithm is equation (10):

$$E = \frac{1}{3} E_M + \frac{1}{3} E_D + \frac{1}{3} E_V \tag{10}$$

That is, the composition score, depth of field score, and visual balance score are weighted and averaged, and the weight of each item is learned based on a large number of labeled experiments in the Photo.net Date image library.

II. B.Image quality evaluation based on multiple linear regression analysis

II. B. 1) Analytical methods

The Pearson correlation coefficient is usually used when examining the correlation between objective and subjective quality assessment indicators. This is a relatively simple measure of correlation and its expression is equation (11):

$$R_{XY} = \frac{\sum_{j=1}^{N} (X_j - \overline{X})(Y_j - \overline{Y})}{\sqrt{\sum_{j=1}^{N} (X_j - \overline{X})^2} \sqrt{\sum_{j=1}^{N} (Y_j - \overline{Y})^2}} \tag{11}$$

N denotes the number of measurement images, $N = 280$ in the experiment. The $\overline{X}$ and $\overline{Y}$ denote the mean values of the objective quality evaluation index vector sample group X and the MDS vector sample group Y, respectively.The Pearson correlation coefficient is the value on the interval $[-1,1]$, and the closer the absolute value of 1 is, the better the correlation is between the sample groups.

Another type of correlation coefficient, the Spearman rank correlation coefficient, is also considered in the experiment. This correlation coefficient measures the order correlation between two groups of sequentially paired samples. The reason for considering the rank correlation coefficient is that the rating value Y given by the subjective quality evaluation method (MOS) is in the form of a rank.The Spearman rank correlation coefficient is also one of the criteria used by VQEG to measure the objective quality evaluation index of the video, whether it can reflect the subjective quality evaluation index well.The formula for the Spearman rank correlation coefficient is shown in equation (12):

$$\theta = 1 - \frac{6\sum_{i=1}^{N} d_i^2}{N(N^2 - 1)} \tag{12}$$

where $d_i = R_{X_i} - R_{Y_i}$, R_{X_i} and R_{Y_i} denote the rank of X_i and Y_i in the respective vector samples, respectively. Spearman's correlation coefficient is also a value on the interval $[-1,1]$, and like Pearson's correlation coefficient, the closer the absolute value is to 1, the better the correlation between the corresponding sample groups. As with the Pearson correlation coefficient, the closer the absolute value is to 1, the better the correlation is between the corresponding sample groups.

II. B. 2) The idea of multiple linear regression

The stepwise regression method in multiple linear regression analysis is used, and the idea is that when considering the vector of values of the subjective quality evaluation method, MOS, denoted as Y, and when performing a linear regression on the known set of evaluated values of the objective quality evaluation method, $X_1, X_2, \cdots, X_{21}$, the largest contribution to the known explanatory variance (i.e., biased explanatory variance) is selected stepwise from the variables $X_1, X_2, \cdots, X_{21}$, the variable with the largest contribution to the known explanatory variance (i.e., biased explanatory variance) is gradually selected into the regression equation, where

X_j is the vector of quality predictive values of the objective quality evaluation method j for all experimental images. And the discrimination of the size of the contribution of the biased explanatory variance is based on the value of the corresponding F statistic F_j. The X_j with the largest value of F_j f_j enters the equation first. The last independent variable X_i to enter the equation also has to satisfy: the probability of significance of f_i, p, is not greater than the selected significance level α.

III. Composition Optimization Model for Landscape Oil Painting Images

III. A. Optimization models

To optimize the composition of an image, two aspects need to be taken into account: on the one hand, it is consistent with the principle of the "rule of thirds" composition. On the other hand, while optimizing, the original information of the image can be kept as much as possible, and as little distortion as possible. In order to achieve the above requirements, an optimization model is established, which needs to satisfy the energy function as in equation (13):

$$E(I_r) = \lambda E_e(I_r) + (1-\lambda)E_s(I_r, I_0) \tag{13}$$

In Eq. (13) E_e denotes the compositional aesthetic scoring of the optimized image I_r. E_s denotes the similarity between the original image I_0 and the optimized image I_r. λ is the parameter of the trade-off, which measures the weight between the compositional aesthetic scoring and the similarity. For simplicity, set $\lambda = 0.5$. When the above metric $E(I_r)$ reaches its maximum value, the image optimization result is considered optimal at this point in time, when the distortion of the image is within the tolerable range, and the image composition has been optimized.

III. B. Composition optimization

From the model above as well as the metric of image similarity and the aesthetic composition metric the objective function of the optimized image can be derived as in equation (14):

$$I_r = \arg\max_I E(I) \tag{14}$$

In terms of image composition optimization, the existing algorithms mainly use the cropping method and then the image is scaled and repositioned. Using Seam Carving (content-based image scaling algorithm) method to optimize the image, in addition the optimized image needs to meet the following requirements:

(1) The resolution of the image cannot be changed, i.e. the cropping operation does not meet the requirements.

(2) It is not possible to scale the subject, which would make the subject blurred. Therefore a heuristic algorithm is used to find the optimal image.

Seam Carving is used to change the size of the image by continuously removing or inserting an octet of pathways (called Seam) from one side of the image to the other side of the image, which is the octet of pathways with the lowest energy value in the image, while the pixels on the subject must have the highest energy value. The Seam Carving algorithm is continuously used to insert on one side of the salient region while removing the same number of Seams on the other side. Therefore it is necessary to decide how many Seams will be selected to get the optimal compositionally optimized image.

An efficient heuristic algorithm is used to find the optimal image for the original image I_o, since the "thirds" and the "thirds" are fixed, it is easy to determine in which direction the subject is moving to optimize the scoring of the composition. So by deleting Seams between the targets and inserting Seams on the other side, the subjects will get closer and closer to the "point of thirds" or "line of thirds" position. For images with multiple subjects in the foreground, it is necessary to define the front and back of the image. One side of the target area was once the front side and the other side was the back side. Delete Seams from the front side and insert Seams from the back side.

Initially, the optimal position of the subject is known as well as the distance to the ex officio position, which is the largest Seams that may be removed.Then, using dynamic programming to generate Seams to be removed, $E(I)$ will initially be increasing due to the increase in the compositional aesthetic scoring, even though the similarity is decreasing. When the rate of similarity decrease begins to exceed the rate of compositional aesthetic scoring increase, $E(I)$ reaches its maximum value.

IV. Refinement of the modeling approach and performance testing

In order to make the image composition evaluation method based on multiple linear regression more objective for scoring and calculating composition, this chapter develops the correlation analysis between the factors affecting oil painting composition, and incorporates the analysis results into the scope of consideration for scoring calculation. At the same time, a consistency comparison experiment is designed to test the effectiveness of the evaluation method. The application experiment of composition optimization is carried out to assess the feasibility of the composition optimization model.

IV. A. Evaluation of impact factors

Combined with the above analysis, this paper proposes six important influence factors of landscape oil painting composition: (A_1) scale proportion, (A_2) reality level, (A_3) compositional primary and secondary, (A_4) elemental richness, (A_5) sense of coordination of layout and (A_6) kinetic relationship. The correlation analysis of A_1~A_6 influencing factors, using bivariate correlation analysis to get the significance coefficient, if the significance is less than 0.05, then it means that there is a significant relationship between the two, the correlation analysis results of the six influencing factors are shown in Table 1. The results show that there is a significant relationship between the two factors A_3 compositional mastery and A_5 sense of layout coordination and the change of the standard value of the SBE (P<0.05), A_1 scale proportion, A_2 virtual and real levels, A_4 elemental richness, and A_6 dynamic relationship do not have a significant relationship (P>0.05).

Table 1: Correlation between various influencing factors and SBE standard value

Impact Factor	Correlation coefficient	P	Conclusion
A_1	0.256	0.308	There is no significant relationship
A_2	0.043	0.870	There is no significant relationship
A_3	0.570	0.014	There is a significant relationship
A_4	0.103	0.687	There is no significant relationship
A_5	0.525	0.027	There is a significant relationship
A_6	0.278	0.263	There is no significant relationship

In order to investigate whether the (A_3) compositional primary and secondary factors and (A_5) layout coordination factor are associated with other influencing factors, linear regression was conducted with (A_3) compositional primary and secondary factors as the dependent variable and (A_6) kinetic relationship factor as the independent variable. At the same time, (A_5) layout coordination factor as the dependent variable, (A_1) scale proportion, (A_4) element richness as the independent variables in turn for linear regression, regression analysis results are shown in Table 2.

Table 2: The performance of regression coefficient between influencing factors

Impact Factor		(A_3) and (A_6)	(A_5) and (A_1)	(A_5) and (A_4)
Normalized coefficient	B	0.767	0.612	0.738
	Standard error	0.342	0.221	0.304
Standardization coefficient Beta		0.491	0.571	0.522
t		2.248	2.775	2.445
Significance		0.038	0.015	0.028
B's 95.0% confidence interval	Lower limit	0.044	0.145	0.099
	Upper limit	1.489	1.079	1.382

From the results of the analysis, the relationship between the influence factors is shown in equations (15) and (16):

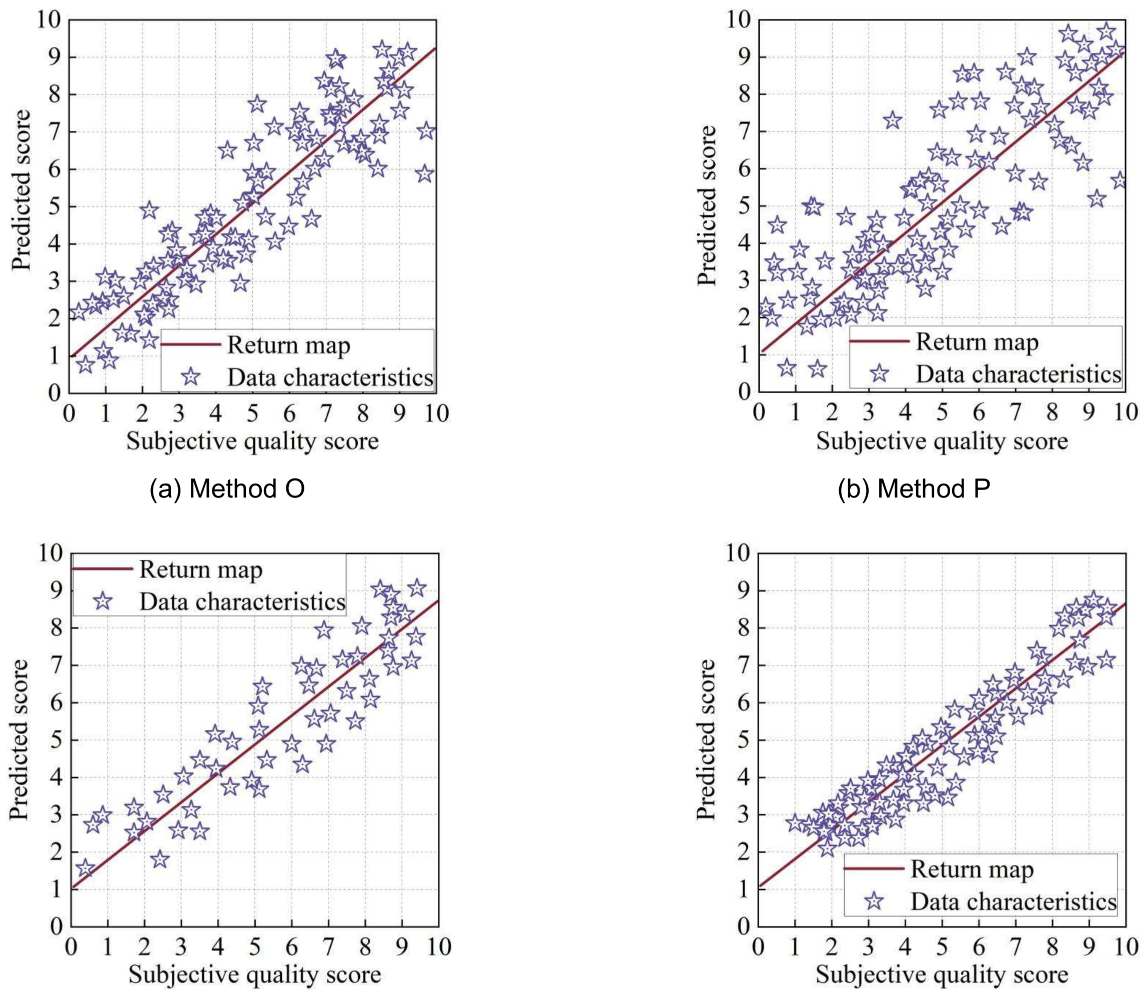
$$A_3 = 0.491A_6 \tag{15}$$

$$A_5 = 0.571A_1 = 0.522A_4 \tag{16}$$

From equations (15)-(16), it can be seen that in the influence factor of oil painting composition, there is a prevalent law of A_1:A_4=0.914, i.e., the ratio of scale proportion to the influence factor of elemental richness is 0.914, which indicates that the influence of elemental richness of oil painting composition is slightly higher than that of scale proportion.

IV. B. Consistency test

In order to verify the consistency between the experimental results of the evaluation method proposed in this paper with multiple linear regression analysis and the subjective perception scores, this paper conducts comparative experiments with three different non-reference-based evaluation models (O, P, and Q), respectively. In the consistency experiments, the data will be divided into two parts, 80% of the samples in the oil painting database are randomly selected to participate in the training, and the remaining 20% of the samples are used as the test set to evaluate the performance of the methods. Figure 1 shows the scatter plot of one of the 100 sets of experiments for one of the training test experiments.



(a) Method O

(b) Method P

(c) Method Q

(d) Textual Method

Figure 1: Consistent experimental results of different methods

Observing Figure 1, among the four image composition evaluation methods, since this paper adopts the multiple linear regression analysis method style evaluation method, the results obtained are more convergent and the regression effect is optimal. While the scoring data of other methods show different degrees of dispersion characteristics, the regression effect is poor.

IV. C. Composition optimization experiment

This section conducts experiments on the application of the image composition optimization model for landscape oil paintings. The original oil paintings (Xa, Ya, Za) of students X, Y, and Z in the art classroom of a university are selected, and the image composition evaluation method based on multivariate linear regression is used to evaluate the compositional performance. Combined with the evaluation results, the composition optimization model was used for optimization. The optimized images (Xb, Yb, Zb) were enhanced with sharpness, contrast and saturation corresponding to the composition optimization. The evaluation results of the three oil paintings in terms of saturation (ES), contrast (EC), sharpness (ER) and composition (EM) are shown in Fig. 2.

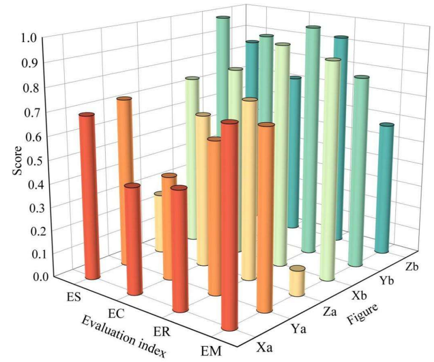
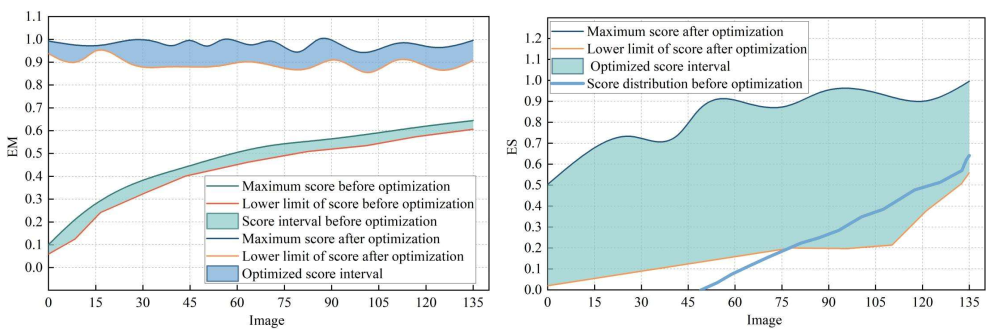


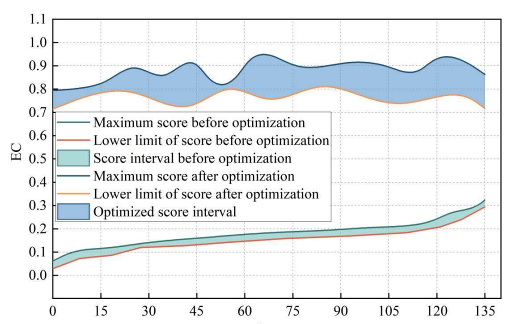
Figure 2: Evaluation results before and after image enhancement

From the experimental results, it can be seen that in terms of visual observation, the optimized image composition is more reasonable, and the visual effects in various aspects are better than the original image. In the quantitative evaluation results, the evaluation results of the optimized image in all aspects are significantly improved compared with the original image. The rating of Z's oil painting composition increased from 0.26 before the optimization to 0.849 after the optimization.The calculation of oil painting composition performance by using multiple linear regression analysis can provide effective guidance for the optimization of oil painting composition.

In order to quantitatively analyze the effectiveness of the optimization algorithm, all the optimized oil painting images in the classroom were reevaluated, and the evaluation results before and after the image optimization are shown in Fig. 3. Figs. 3(a)-(c) show the evaluation experimental results before and after the optimization of composition (EM), saturation (ES) and contrast (EC), respectively. Where the horizontal coordinate is the image number and the vertical coordinate is the evaluation score value.



(a) EM score change (b) ES score change



(c) EC score change

Figure 3: Evaluation results before and after image optimization

The experimental results show that, except for a small number of images, the evaluation results of all kinds of oil painting images after being optimized have been improved to a certain extent. Among them, in the evaluation of (EM) composition, it is even from the lowest 0.07 before optimization, rising to nearly full score after optimization.

Therefore, the composition evaluation method and composition optimization model in this paper are effective and feasible in the evaluation and optimization of image composition.

V. Conclusion

In this paper, we use multiple linear regression analysis as the calculation and evaluation method for the composition quality performance of oil paintings, and design a composition optimization model based on Seam Carving algorithm. Guided by the calculation of the evaluation of oil painting composition by multiple linear regression analysis method, the composition optimization model is able to optimize the most appropriate composition based on the compositional performance of the original image. The proposed image composition evaluation method based on multiple linear regression has strong convergence ability, good regression effect, and passes the consistency test. The method can accurately guide the composition optimization model to optimize the composition of oil paintings, and in the actual optimization application, the highest performance of oil painting composition optimization increases from 0.26 before optimization to 0.849 after optimization. After expanding the experimental scope, the model still maintains stable optimization performance, and the composition evaluation of optimized oil painting images increases from 0.07 to 0.99. The designed oil painting composition evaluation method based on the regression algorithm increases from 0.07 to 0.99. The designed oil painting composition evaluation method based on regression algorithm is both stable and feasible, and can effectively assist the teaching of oil painting composition in fine art landscapes.

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