International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 5369-5379

https://doi.org/10.70517/ijhsa464376

Machine Learning Correlation Analysis of Visual Elements and Aesthetic Ambience in Jiangnan Gardens

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Abstract As one of the representatives of Chinese traditional culture, Jiangnan garden is known for its unique landscape design and deep cultural connotation. Jiangnan gardens are not only the embodiment of garden art, but also incorporate elements such as natural landscape and humanistic history, forming a unique aesthetic mood. This study proposes a visual recognition model based on the improved YOLOv4 algorithm for recognizing key elements in the design of Jiangnan gardens and exploring the correlation between these elements and the aesthetic context of the gardens. First, the study constructs a rich dataset of Jiangnan garden elements through image acquisition and data enhancement techniques, which provides sufficient samples for training the target detection model. Subsequently, the model was optimized for the YOLOv4 model with a lightweight YOLOv4-tiny network, and the recognition accuracy and computational speed of the model were improved by introducing mosaic data enhancement, CSPNet structure, and cosine annealing learning rate. The experimental results show that the improved YOLOv4 model improves 5.19% in accuracy and 19.82% in detection speed compared to YOLOv4. Further Pearson correlation analysis and logistic regression modeling show that the sky and water elements have a significant impact on the aesthetic mood of Jiangnan gardens, with correlation coefficients exceeding 0.5, suggesting that the expansive skyline and water quality environment play a central role in enhancing the aesthetic perception of the gardens. This study quantifies the correlation between the elements of Jiangnan gardens and the aesthetic mood through the visual recognition technique, which provides new ideas for garden design.

Index Terms Jiangnan garden, YOLOv4, visual recognition, aesthetic context, Pearson correlation coefficient, logistic regression

I. Introduction

Jiangnan garden is one of the treasures of traditional Chinese garden art, which is famous for its beautiful environment, fine layout and unique design concept [1]. The characteristics of Jiangnan gardens include water, architecture, plants, sculpture and cultural connotations in many aspects [2]. One of the main features of Jiangnan gardens is water features. There are many rivers in the Jiangnan region, so many gardens use water elements [3]. Water is the soul of Jiangnan gardens, which brings vitality and vigor to the gardens. Common water features include ponds, streams, fountains and water curtains [4]. Water features are usually combined with stone bridges and corridors and pavilions in the gardens to form a unique landscape, and they can also serve to purify the air and cool down the temperature [5]. Another feature of Jiangnan gardens is architecture [6]. Garden architecture includes various forms such as pavilions, terraces, buildings and pavilions, which are usually exquisite and ornate, incorporating traditional Chinese architectural aesthetics [7], [8].

Contextual beauty is the core aesthetics of Jiangnan garden design, the so-called garden context is the designer's sentiments, it will be human emotional thought into the garden design, so that people through the garden design elements in the form of association to make its garden connotation can be expressed, so that people touch the feelings and resonance [9]-[12]. This is a kind of establishment in the heart on the basis of the realm of the "heart of things", it is an aesthetic spiritual effect [13]. Jiangnan garden design is based on architecture, such as bridges, pavilions and pavilions, the high degree of integration of architecture, landscape, flowers and trees, in the orderly spatial organization and the details of the design of different, so as to achieve an aesthetic realm [14]-[16]. At the same time, the garden nature and people for a high degree of integration, and then with the help of poems and paintings of the title, and ultimately make it reach "solidified poetry, three-dimensional painting" such a realm [17], [18]. This perfect combination of poetry and painting and external environmental beauty, forming a unique Jiangnan garden design of the beauty of the mood [19].

The purpose of this study is to explore how to carry out intelligent recognition of design elements of Jiangnan gardens by improving the YOLOv4 algorithm and combining it with visual recognition technology, and to analyze how these design elements affect the aesthetic context of the gardens. Specifically, this paper firstly constructs a rich dataset of Jiangnan garden design elements, which provides sufficient data support for subsequent training and model optimization; secondly, the YOLOv4 algorithm is optimized to better meet the actual needs of garden design in terms of recognition accuracy and computational speed; lastly, the correlation between the design elements of Jiangnan gardens and the aesthetic mood is systematically explored through the Pearson's correlation coefficient and logistic regression analysis; and the correlation between the design elements and the aesthetic mood of gardens is also analyzed. Finally, through the Pearson correlation coefficient and logistic regression analysis, the correlation between the elements of Jiangnan garden design and the aesthetic mood is systematically explored, which provides a theoretical basis and technical support for the aesthetic improvement of garden design.

II. The relevance of Jiangnan garden design elements and aesthetic mood

II. A. Characteristics of Jiangnan garden design elements

II. A. 1) Spatial characteristics

Jiangnan garden design includes external environmental treatment and internal space planning, the former is intended to effectively utilize the external elements of the garden, the latter can be rationally configured garden internal space design. Spatial attributes and the environment is closely related to the Jiangnan garden in accordance with the environmental characteristics can be divided into natural landscape garden and artificial landscape garden, the two types of garden space design techniques are very different. The internal environment of Jiangnan gardens also pursues the beauty of nature as a whole. The exquisite art of gardening creates a rich variety of environmental features and humanistic themes for the gardens, resulting in the formation of various subdivisions of the gardens as well as regional spatial differences. The internal environment of the Natural Landscape Garden is superior, dominated by natural vegetation and waters, with roads, squares and buildings scattered in between. Because the overall space of the natural landscape garden is open, the environment tends to be quiet and natural, so it is not easy for serious interference to occur between different sub-districts, and the zoning method is only to set up roads, water, vegetation, plazas, and other landscape elements to imply separation between different areas. However, the dispersed landscape of the large area in the natural landscape garden may cause the theme to be unknown, which needs to be controlled and harmonized. The surrounding environment can also exist as a background, and the site together constitute a “near far” multi-layered spatial structure, so as to enhance the spatial sense of the Jiangnan garden design, all show the aesthetic mood of the Jiangnan garden design.

II. A. 2) Time characteristics

The rotation and revolution of the Earth shape the cycles of the four seasons and the alternation of day and night, profoundly influencing the regularity of climate and sunlight. These natural rhythms serve as the cornerstone for the survival and reproduction of all living beings, guiding plants to adhere to their growth cycles, animals to migrate and forage according to seasons, and humans to arrange their lives in harmony with natural rhythms. Jiangnan garden design exemplifies a keen perception and ingenious application of these temporal characteristics.

In terms of natural landscapes, Jiangnan gardens exhibit distinct features that change with the seasons. In spring, everything comes back to life, with tender green shoots and blooming flowers intermingling, and the gentle spring rain creating a fresh and lively atmosphere. In summer, the gardens are shaded by lush green trees and adorned with blooming lotuses. Designers utilize the combination of water bodies and plants to form natural ventilation systems, while cicadas chirping and frogs croaking weave together a summer symphony, making the gardens an ideal retreat for escaping the heat and enjoying leisure time. As autumn arrives, trees don golden hues, and fallen leaves carpet the ground. The gurgling streams, rustling plane trees, and the chirping of autumn insects collectively compose a serene and distant autumn scene. In winter, although the gardens may lack some of the vibrancy of other seasons, the snow-covered pines and bamboos in the tranquil silence create a pure and lofty ambiance.

Regarding artificial landscapes, Jiangnan gardens enrich their cultural connotations and imbue them with temporal significance by hosting events such as lantern festivals and flower exhibitions during important traditional festivals like the Spring Festival and Mid-Autumn Festival. Meanwhile, architectural structures, sculptures, and other artistic forms within the gardens also bear profound temporal imprints, witnessing the historical evolution and development of the gardens. Designers prioritize the preservation of historical traces and temporal features when restoring and protecting these cultural heritages.

More importantly, the temporal characteristics in Jiangnan garden design are not merely reflected in the periodic changes of natural and artificial landscapes but are also deeply integrated into the aesthetic ambiance of the gardens. Designers skillfully employ temporal elements to create a transcendent aesthetic experience, allowing visitors to perceive the beauty of time's flow and nature's rhythms while experiencing the cultural connotations and historical heritage embedded within the gardens. This fusion of temporal characteristics and aesthetic ambiance not only enriches the cultural connotations and aesthetic values of the gardens but also provides valuable insights and references for modern garden design.

II. A. 3) Human character

Direct design utilizes intuitive things in the garden to express the humanistic connotation of the landscape. Usually includes three categories: visual text class, refers to the landscape related to the name of the garden name, plaques and couplets. Live interpretation class, refers to the local characteristics of the music and music and so on. Visitor activities, referring to a variety of cultural traditions of folk activities. To convey the landscape connotation of the garden to the user, setting simple and visible text is obviously the most direct method. Adding visual text in the garden is a traditional design technique in Jiangnan gardens. Gardens can add elements directly to the garden name, such as the bird of Liu Lang Wen Ying, the bell of Nan Ping Evening Bell, the rain of Lakeside Eyes and Rain, the wind of Qu Yuan Feng He, the bamboo leaves of the garden and so on. These garden names exist in the form of stone tablets and gate names, which clearly explain the landscape characteristics of the garden. The important landscape of the garden can be used near the buildings and structures of the plaque, planted to emphasize, such as the Humble Administrator's Garden to listen to the Pavilion, listen to the rain, listen to the pine winds at the Liouyuan Garden of the Qingfeng Pool Museum, Linquan Jingshuo Pavilion, Jia Qingxiyu fast snow Pavilion, Slim West Lake Oriole Pavilion, Canglang Pavilion, inscription poem, “wind Huang class flute, when the water is the sound of the piano,” and so on. Traditional visual text can not only play a role in the landscape title, but also increase the poetic mood, is an important part of the humanistic connotation of the Jiangnan Garden, the Jiangnan Garden adds an aesthetic mood.

II. B.Construction of the data set

II. B. 1) Description of Jiangnan garden design elements

In order to ensure the recognition accuracy of the lightweight target detection model generated based on the improved YOLOv4 algorithm, the study constructs a dataset adapted to the model according to the actual needs of the Jiangnan garden design design. The dataset is utilized with a large number of rich Jiangnan garden design samples, which are correctly labeled to provide sufficient basis for small target recognition training. The image can be used as the key single small target recognition, detection content. The study selects the more representative elements of Jiangnan garden design to construct the dataset.

II. B. 2) Image Acquisition, Preprocessing

The collection of relevant high-resolution images of Jiangnan garden design elements needs to be taken by digital cameras, and some difficult-to-obtain images need to be collected through books and the Internet, and the images need to be clearly labeled with specific sources. Through the combination of field shooting and Internet collection, the study realizes the diversity of complex Jiangnan garden design elements images, so as to ensure the abundance and accuracy of model training and target recognition. Considering the complexity of the dataset involving the types of Jiangnan garden design elements, in order to ensure the objectivity of the dataset, high degree of similarity, low image clarity, and difficult to quickly distinguish between the image samples are deleted in the pre-processing process.

II. B. 3) Image data enhancement

Different types of Jiangnan garden designs occur at very different frequencies, resulting in an imbalance in the amount of data among the elemental image samples in the dataset. The study implements image data enhancement for different types of image data to balance the number of image samples in the dataset. The study adopts enhancement forms such as flipping, rotating, scaling, cropping, shifting, etc., and introduces image data training methods such as Cut Mix, SAT, etc., to expand the training data volume for the dataset. For more high-quality low-generalization dataset, using drop block regularization to learn recognition features, relying on class label smoothing processing for dataset generalization processing, to improve the quality of image data of Jiangnan garden design elements, to facilitate the accurate completion of multi-attribute detection of fine-grained images in the more complex Jiangnan garden design elements.

II. C.Improving the visual recognition model of YOLOv4

The traditional method of recognizing Jiangnan garden elements is based on contour features, and the edge detection operator is often used to extract the contour of strawberries to achieve the purpose of recognizing the Jiangnan garden elements. Based on the shape features of Jiangnan garden elements, the Hough transform algorithm is used to accomplish the recognition of Jiangnan garden elements. After the rapid progress of deep learning target detection algorithms, Jiangnan garden element recognition also applies such target detection algorithms. Due to the recognition of Jiangnan garden elements in the process of recognition of fewer types of targets, the object itself is small and requires a fast recognition process, so the network model needs to be lightweight, and increase the recognition accuracy of small targets.YOLO series of YOLOv4-tiny network model is a lightweight version of YOLOv4, its parameters are only one-tenth of the YOLOv4 network, the amount of computation is thus reduced, and the detection speed is greatly accelerated and faster than YOLOv4. is greatly accelerated and faster than YOLOV4, YOLOV5 and other networks. Therefore, this paper takes the YOLOv4-Tiny network model as a benchmark and improves the network to establish a new network model, so as to satisfy the purpose of recognizing the elements of Jiangnan gardens.

II. C. 1) Overall model structure

The YOLOv4-tiny network model uses the principle of regression-based one-stage target detection algorithm, which can save the time required for model identification, and the main structures are: input, backbone network (Backbone), neck network (Neck), and output [20], [21]. The input side mainly utilizes the online data enhancement algorithm, Mosaic Data Enhancement (Mosaic). The backbone network is the detection network, which adopts the CSPNet structure, which integrates the feature maps at both the input and output ends of the network to deal with the variability of the gradient, and the gradient change is integrated into the whole feature map, which reduces the loss caused by the disappearance of the gradient, reduces the amount of computation required for the training process, improves the accuracy, and has good versatility. The neck network draws on the feature pyramid network (FPN), the principle of which is to increase the size of the feature map by up-sampling the input image and detecting multiple feature maps at different scales, which enhances the learning of feature information by the network [22], [23]. The loss function used at the output is the complete cross-parallel ratio loss function and the learning rate cosine annealing decay method.

(1) Data Enhancement

The Mosaic data enhancement concept is derived from the CutMix method CutMix method randomly selects a part of the image to be cut, and in the area cut off, the same area of other data in the dataset is then selected to be filled in to complete the data enhancement. The formula for the CutMix method is shown below:

$$\bar{x} = M \odot x_A + (1-M) \odot x_B \tag{1}$$

$$\bar{y} = \lambda y_A + (1-\lambda) \odot y_B \tag{2}$$

where $M \in \{0,1\}^{W \times H}$, $W \times H$ is the width and height of the image, which represents the size of the image; M is the binary mask matrix between 0 and 1, and the value of the part of the region that is clipped off is 0, and the value of the part of the region that is kept is 1. B is the bounding box of the clipped region, and $B = (r_x, r_y, r_w, r_h), (r_x, r_y)$ are the coordinates of the center point of the bounding box, and r_w, r_h are the frame and the height of the bounding box, and so there are:

$$r_x \sim Unif(0, W) \tag{3}$$

$$r_y \sim Unif(0, H) \tag{4}$$

$$r_w \sim W\sqrt{1-\lambda} \tag{5}$$

$$r_h \sim H\sqrt{1-\lambda} \tag{6}$$

Mosaic method randomly selects 10 pictures in the previous dataset, performs operations such as flipping, shrinking, and changing the color of the selected pictures, and splices the pictures after the operations, Mosaic method enriches the dataset, makes the robustness of the network strengthened, and reduces the use of GPU graphics memory.

(2) CSP structure

CSPNet is designed from the aspect of network structure, which balances the detection accuracy and speed of the network, saves computational resources, and enhances the learning ability of CNN.CSPNet divides the input into two parts, one part is computed through the module, and the other part is directly connected to concat.

(3) Cosine annealing learning rate

Learning rate is one of the hyperparameters in the network model that affects the performance of the model. During the model training process, the network constantly searches for the minimum value of the loss function, but in the process the network can easily fall into the local optimal solution, which makes the training results biased and worse. Cosine annealing learning rate is different from the traditional learning rate, the method uses the cosine function to make the learning rate decrease, with the increase of the number of iterations, the learning rate is the first to fall sharply, and then rise sharply, and constantly repeat the process. This sharp fluctuation allows the network to move away from the local optimal solution and thus find a new optimal solution.

II. C. 2) Backbone network improvements

Due to the small number of target species that need to be recognized for the recognition of Jiangnan garden design elements, if the detection speed of the network needs to be increased, the CSPNet structure in YOLOv4-tiny can be lightened and improved for the CSPNet structure in YOLOv4-tiny. In this paper, the number of CBLs inside the CSPNet structure in the backbone network is reduced by two layers, which in turn speeds up the detection speed of the network model, and the improved structuBackbone network improvementsre is named CPSNet_2, where 2 is the reduction of two convolutional layers. In order to compare the complexity of CSPNet_2 with CSPNet, floating point operations (FLOPs) are taken to evaluate the amount of computation in the network, which is given by:

$$FLOPs = \sum_{i=1}^{N} L_i^2 \times K_i^2 \times C_{i-1} \times C_i \tag{7}$$

where N is the number of convolutional layers, L_i is the size of the convolution of the i th layer of the output feature, K_i is the number of convolutional kernels, and C_i and C_{i-1} are the number of output and input channels, respectively.

II. C. 3) Neck network improvements

YOLOv4-tiny fuses two sizes of feature maps for detection through FPN network, respectively: 42×42 and 28×28 size, which enhances the learning ability of the network. Since the Jiangnan garden design elements have the characteristic of small shape, adding larger size feature maps for detection can effectively improve the network's recognition accuracy of strawberries. In this paper, a layer of FPN network is added to the neck structure of the designed network, and three different sizes of feature maps are used for detection, respectively: 82×82, 42×42, 28×28, and 82×82 size feature maps are added in order to effectively enhance the network's ability to learn the details, and the overall structure of the network is shown in Fig. 1 after improvement.

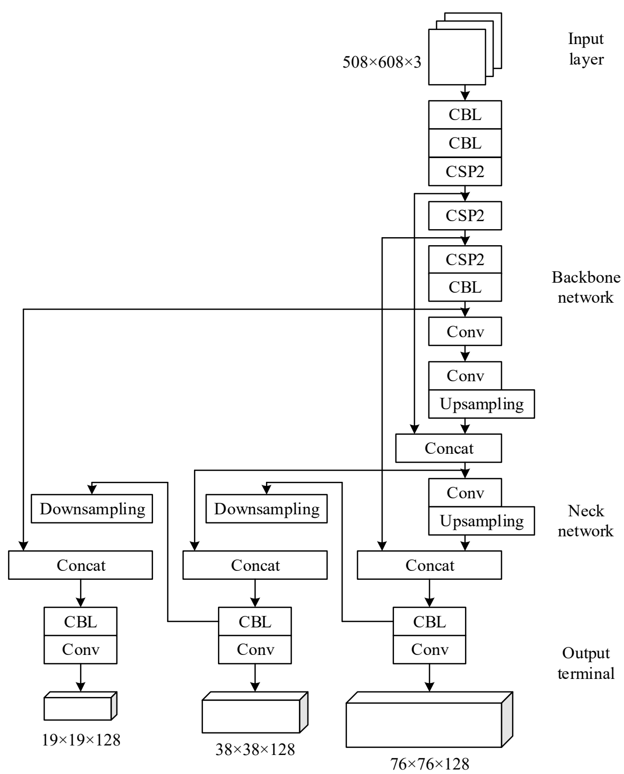


Figure 1: Improve the structure of the network

II. C. 4) Loss function improvement

In the training of target detection network, the loss function is needed to measure the effect of network training, and the intersection and parallel ratio loss function (IoU) is one of the most commonly used loss functions, such as: IoU Loss, GIoU Loss, DIoU Loss, CIoU Loss, EIoU Loss, etc., and in this paper, we use the EIoU Loss loss function for the training of network model. The mathematical model of EIoU Loss loss function is:

$$EIoU = IoU - \frac{\rho^2(b,b_g)}{c^2} - \frac{\rho^2(b,b_w)}{c_w^2} - \frac{\rho^2(b,b_h)}{c_h^2} \tag{8}$$

$$EIoUloss = 1 - IoU + \frac{\rho^2(b,b_g)}{(c_w^2 + c_h^2)} + \frac{\rho^2(w,w_g)}{c_w^2} + \frac{\rho^2(h,h_g)}{c_h^2} \tag{9}$$

where c_w, c_h are the width and height of the smallest outer rectangle between the prediction box and the real box, w, w_g is the width of the prediction box and the real box, and h, h_g is the height of the prediction box and the real box. EIoU splits the influence factor parameter v of the CIoU measure of aspect ratio, and calculates the width and height of the predicted and real frames respectively, which makes the network convergence speed up again and the accuracy gained, so the EIoULoss loss function is used for the training of the network model.

II. D.Relevance Inquiry Program

In order to accurately quantify the correlation between garden design elements and aesthetic context, based on the visual identification model mentioned above, Pearson's correlation coefficient and logistic regression are applied to systematically explore the interrelationship between garden design elements and aesthetic context.

II. D. 1) Pearson's correlation coefficient

The Pearson correlation coefficient r is used to describe the degree of linear correlation between two variables, and the larger the absolute value of r, the stronger the degree of linear correlation between the two variables. There are two sets of features $\{x_1, x_2, \cdots, x_i, \cdots, x_n\}$ and $\{y_1, y_2, \cdots, y_i, \cdots, y_n\}$, then the correlation coefficient r is given by:

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2}} \tag{10}$$

where, x and $\overline{y}$ are the means of the samples within the two feature sets, respectively, and r takes the value [-1, 1].

II. D. 2) Logistic regression

Logistic regression (LR) is a multivariate statistical analysis method to study the relationship between the dependent and independent variables, belonging to probabilistic nonlinear regression, which is a generalized linear model for dichotomous data. Due to the value characteristics of the dependent variable data (generally set to take 0 or 1), the model is actually the introduction of a logistic transformation function, Sigmoid, on the basis of general linear regression, and thus logistic regression is considered to be a linear regression model normalized by the Sigmoid function.

For the dichotomous dependent variable Y and explanatory variable X, let the probability p be:

$$p = P(Y=1 \mid X=x) = 1 - P(Y=0 \mid X=x) \tag{11}$$

With the help of the transformation of the Sigmoid function, the Logistic regression model at this point is:

$$p = \frac{\exp(\alpha + \beta' X)}{1 + \exp(\alpha + \beta' X)} \tag{12}$$

After transformation, the logarithmic occurrence ratio $\ln\frac{p}{1-p}$ is:

$$\ln\frac{p}{1-p} = \alpha + \beta' X \tag{13}$$

The sign of each component $(\beta_1, \beta_2 \cdots \beta p)'$ of the β vector determines whether the incidence ratio $\frac{p}{1-p}$ will rise or fall as the explanatory variable X is increased at a rate determined by $|\beta_i|$ is determined.

III. Example test analysis

III. A. Model validation analysis

III. A. 1) Performance assessment indicators

For the Jiangnan garden design elements, it belongs to the binary classification problem, for which all the detection samples can be categorized into four classes, which are TP, FP, TN and FN.

TP represents that the sample is a positive sample and the detection result is also a positive sample.

FP represents that this sample is a positive sample and the detection result is a negative sample.

TN means that the sample is actually negative and the test result is negative.

FN represents that the actual sample is negative and the detection result is positive.

The evaluation indexes chosen in the recognition of Jiangnan garden design elements are the leakage detection rate and the average value precision. When the lower the leakage detection rate and the higher the average value accuracy, it represents the better performance of the algorithm. Meanwhile, since this paper is a real-time detection and recognition algorithm, the average image recognition time is also added as a supplementary evaluation index.

The leakage rate (MR) is shown in equation (14), and the value represents the proportion of positive samples missed by the model to all positive samples:

$$MR = \frac{FN}{TP + FN} \tag{14}$$

The mean accuracy mAP is calculated as shown in equation (15):

$$mAP = \frac{\sum_{c=1}^{c} AP(c)}{C} \tag{15}$$

where C is the category. The AP calculation is shown in equation (16):

$$AP = \int_0^1 p(r)dr \tag{16}$$

where p is the accuracy, representing the proportion of correctly categorized samples among all samples, and r is the recall, representing the proportion of positive samples detected by the model among all positive samples:

$$Precision = \frac{TP}{TP + FP} \tag{17}$$

$$Recall = \frac{TP}{TP + FN} \tag{18}$$

III. A. 2) Experimental results

This experiment is conducted based on pytorch deep learning platform with Ubuntu 18.08 as the operating system, AMD Ryzen 53100X as the CPU and NVIDIA GTX 1080SUPER 12G as the GPU.In this chapter, the initialization of the network model follows the normal distribution to initialize the weights of convolutional layers for all networks. The initial value of the scale scaling factor for the normalization layer is 0.1 and the offset is 0. In the training phase of the Jiangnan garden model, the Adam optimizer with a weight decay coefficient of 0.0002 is chosen, and the training batch size is 32, and the network is trained using learning rate decay. The initial learning rate was set to 10-5 for a total of 200 iterations, and then the learning rate was adjusted to 10-6 to continue for 300 iterations. The improved YOLOv4 algorithm was trained according to the parameter settings above, and the loss variation curve of the training process is shown in Figure 2. It can be clearly seen that the improved YOLOv4 algorithm obviously performs more prominently than the YOLOv4 algorithm, and can maximize the recognition of the Jiangnan garden design elements in the image.

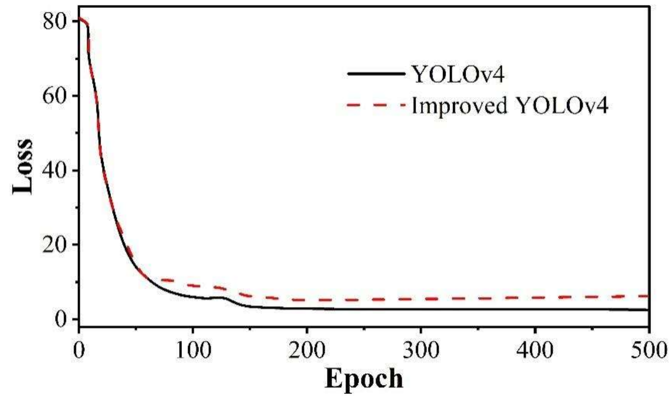
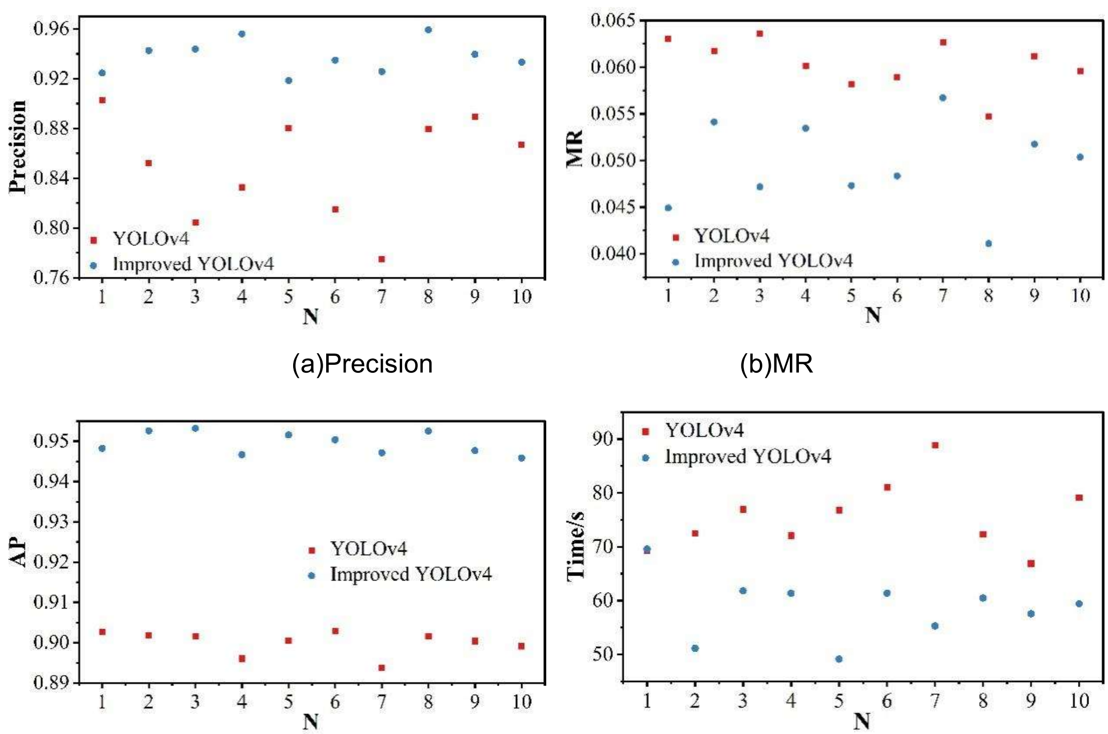


Figure 2: The loss variation curve during the training process

In order to prove the effect of the improved YOLOv4-based algorithm, 10 images are selected from the previous dataset as training objects, and the original YOLOv4 algorithm and the improved YOLOv4 algorithm are trained, and the accuracy, average precision value, leakage detection rate, and picture detection time are selected as the performance evaluation indexes, and the experimental results are shown in Fig. 3, in which (a) to (d) denote the selection of accuracy, average precision value, leakage detection rate, and picture detection time, respectively. , average precision value, leakage detection rate, and picture detection time, respectively. The experimental results show that the improved YOLOv4 is 5.19% better than YOLOv4 in terms of average accuracy. In terms of overall average accuracy value, the improved YOLOv4 improves 1.87% compared to YOLOv4. In terms of runtime, the improved YOLOv4 Jiangnan garden design element recognition time is reduced by 13.52ms, and the speed is improved by about 19.82%. It can be seen that the improved YOLOv4 image algorithm improves the network structure and reduces the network complexity by adjusting the feature extraction method, which improves the detection accuracy and performance of the algorithm, and at the same time shortens the number of its network parameters and speeds up the operation speed, which proves that the improved YOLOv4 algorithm has a high priority on the field of Jiangnan garden design element recognition.



(a)Precision (b)MR

(c)AP (d)Time

Figure 3: Experimental result

III. B. Relevance validation analysis

III. B. 1) Selection of Jiangnan garden design elements

Based on the garden space and natural landscape elements, the garden environment is divided into two major landscape levels: natural and humanistic, and with the help of the above visual identification obviously, the top 10 core garden visual elements with the highest frequency of occurrence are extracted, which are Sky X1, Mountain X2, Water X3, Vegetation X4, Pavilion X5, Waterscape X6, Bridge X7, Architecture X8, Vignettes X9, and Roads X10, respectively.

III. B. 2) Obtaining Aesthetic Context Indicator Data

A questionnaire was used to collect data on aesthetic mood indicators, and local tourists were invited to participate as volunteers in field observation and evaluation. During the experimental process, participants made direct evaluations in the field based on the correspondence between the images and the actual garden scenes. The evaluation method utilized the Semantic Difference Scale (SD) analysis technique to select a series of adjectives that can reflect the aesthetic mood of the garden, covering multiple dimensions such as psycho-emotional perception, visual spatial environment, and the richness of landscape elements, i.e., Comfort Y1, Pleasure Y2, Relaxation Y3, Sense of Security Y4, Attractiveness Y5, Sense of Aesthetics Y6, Sense of Naturalness Y7, Layered Sense Y8, Spatial Sense Y9, and Rhythm Y10, which are 10 groups of indicators. Y10 a total of 10 groups of indicators. Visitors observe each image in detail and give a seven-level evaluation, with the rating range set to a symmetrical -3~3. The questionnaire results show that the composition of the visitor group presents a balanced gender, with the main body of young people aged 18~35, students and retired people as the main educational background composition, and geographically significantly concentrated in the residents of Jiangsu and Zhejiang.

III. B. 3) Analysis of results

In this study, Pearson correlation analysis was applied to systematically quantify the potential association between aesthetic mood indicators and garden elements, and the results of the correlation analysis are shown in Figure 4. It can be concluded that the elements of sky X1 and water body X3 play a central role in enhancing the aesthetic mood of gardens, and their correlation coefficients are all greater than 0.5. This indicates that a broad skyline and good weather conditions and water quality environment are crucial for enhancing the aesthetic mood of Jiangnan gardens.

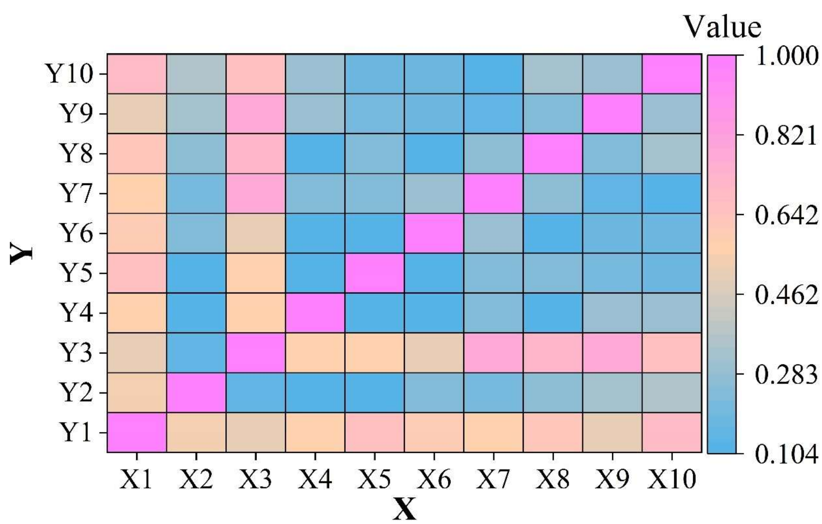
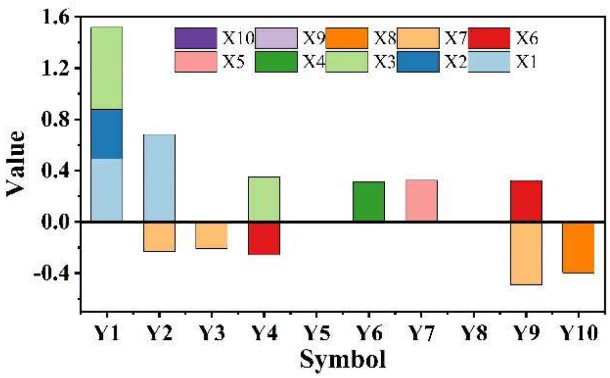


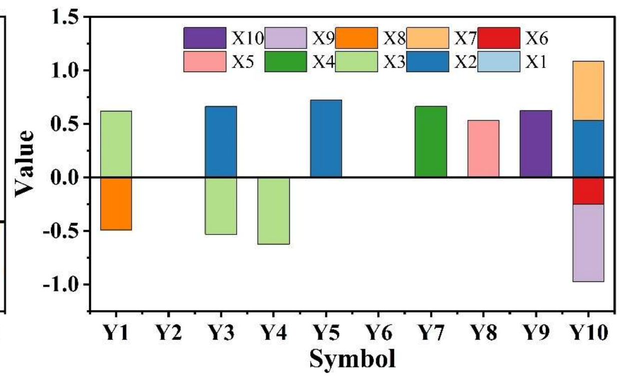
Figure 4: Results of correlation analysis

With the help of logistic regression, the aesthetic mood of garden elements in different regions is evaluated and analyzed, in which the different garden regions are specifically Wuxi Plum Garden, Suzhou Retreating Garden, Huzhou City Yiyuan, and the results of the evaluation of the relevance of the aesthetic mood of the garden elements are shown in Fig. 5, in which (a) to (c) are Wuxi Plum Garden, Suzhou Retreating Garden, Huzhou City Yiyuan, and the standardized regression coefficients are shown by the columns in the figure, which intuitively maps the influence of the elements of garden elements in each region on the aesthetic mood. The results show that Wuxi Meiyuan focuses on the harmonious symbiosis of air X1, mountain X2, and water X3, and the regression coefficients of X1, X2, and X3 are significantly larger than those of the other garden design elements, and the other Suzhou Retreating

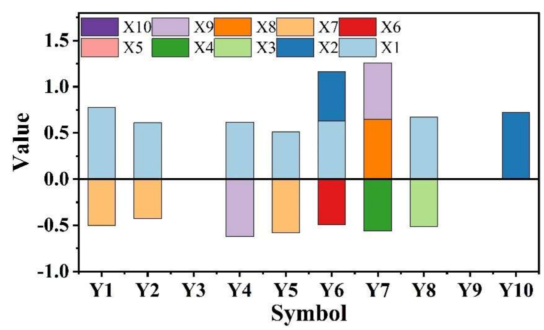
Scholar's Garden and Huzhou Yiyuan are similarly characterized, based on the data in the figure. This study further clearly defines the correlation between garden design elements and aesthetic mood, so that the Jiangnan Garden Design Institute fits the user's aesthetics and needs.



(a)Meiyuan, Wuxi City



(b)Tuisi Garden, Suzhou City



(c)Yiyuan, Huzhou City

Figure 5: Correlation evaluation results

IV. Conclusion

The improved YOLOv4 visual recognition algorithm in this paper significantly improves the recognition ability of the design elements of Jiangnan gardens, especially in the recognition of small targets and fast detection. The experimental results show that the improved YOLOv4 has significant improvement in both accuracy and speed. Specifically, the improved model improves 5.19% in accuracy over the original YOLOv4 and shortens the image detection time by 13.52ms, an improvement of about 19.82%. In addition, the correlation analysis between the recognition results of garden elements based on the improved YOLOv4 algorithm and the aesthetic mood of the garden shows that the natural elements such as the sky and the water body play an important role in the enhancement of the aesthetic mood. The correlation coefficients are all greater than 0.5, indicating that these two elements have a key influence in shaping the unique aesthetic atmosphere of Jiangnan gardens. The logistic regression analysis further reveals the intrinsic relationship between design elements and aesthetic mood in different garden areas. For example, in the gardens of Wuxi Plum Garden, Suzhou Retreat Garden, and Huzhou Yiyuan, the influence of elements such as air, mountain, and water on aesthetic perception is more prominent. Therefore, the study of the correlation between garden design elements and aesthetic mood based on visual recognition technology not only provides a scientific basis for the design and protection of Jiangnan gardens, but also provides a feasible technical solution for the intelligentization and digitization of garden design in the future.

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