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Intelligent Processing Technology for Painting Based on Fuzzy Logic Control System and Computer Image Recognition

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Abstract Traditional painting methods require a lot of time and energy, and their creative efficiency is low, making it difficult to meet the needs of modern and efficient life. With the development of technology, painting technology has been greatly improved, from manual painting to electronic painting, and now to intelligent processing technology for painting. Among these technologies, fuzzy logic control systems and computer image recognition technology play a crucial role. This paper analyzed a computer image recognition algorithm based on YOLOv3 (You Only Look Once version 3) algorithm, Mask R-CNN (Mask Region-based Convolutional Neural Network) algorithm and residual network network (ResNet) algorithm, as well as a fuzzy logic control system that can be used for automatic color filling, intelligent assisted painting and image enhancement, and analyzed the development of an intelligent painting tool by combining the fuzzy logic control system with computer image recognition technology. The experiment proved that the painting intelligent processing technology analyzed in this paper has better object recognition, object detection and object segmentation capabilities. The highest value of the creation process time of the painting works created using the painting intelligent processing technology analyzed in this paper was 499.92 minutes; the highest average line smoothness score was 133.484; the highest painting accuracy score was 138.36. In addition, most of the experimental participants gave positive feedback on the user experience. This technology can enhance the artistic value and aesthetic appeal of digital painting, providing artists with more creativity and inspiration. In summary, the intelligent painting processing technology based on computer vision and fuzzy logic control systems analyzed in this article could have a positive impact on the development of digital painting, and also provide new ideas and methods for research in related fields.

Index Terms Painting Art, Intelligent Processing Technology for Painting, Computer Image Recognition, Fuzzy Logic, System Design

I. Introduction

Painting is an art that requires a variety of skills and experience, and requires artists to have a deep understanding of details and expressiveness [1], [2]. As an art form, although hand-painted paintings have a profound cultural heritage in history, their creation process is cumbersome, time-consuming, and requires extremely high technical requirements of artists, making it difficult to adapt to the needs of modern society for rapid creation and efficient production. With the popularization of electronic painting and digital art tools, artistic creation has entered a new era.

In recent years, computer image recognition and artificial intelligence technologies have made significant progress in many fields. In painting creation, computer image recognition technology realizes automated auxiliary painting through precise image processing and analysis, reducing the workload of manual painting. Although painting assistance technology based on computer vision and intelligent algorithms has made some initial progress, there are still many challenges in how to deeply integrate these technologies with the needs of artistic creation.

To address this problem, this paper combines fuzzy logic control system with computer image recognition technology and applies it to intelligent painting. This solution not only uses image recognition and target detection technology to accurately analyze and locate painting objects, but also uses fuzzy logic control system to achieve real-time regulation of the creation process, so as to achieve more efficient creation effects and more artistic works. This innovative combination method has promoted the intelligent process of painting creation, and also provided new directions and possibilities for the development of future art creation tools.

II. Literature Review

II. A. Development of Painting Techniques and Methods

Painting techniques and methods have evolved from ancient manual painting to modern digital painting, continuously driving the progress and development of art[3]. At the end of the 20th century, with the development of computer technology and graphics, digital painting gradually emerged. Digital painting uses digital devices and painting software to achieve painting creation. Artists can use digital painting technology to realize their imagination of colors, shapes and materials, and create more unique and diverse works.

The rise of virtual reality and augmented reality technologies has brought new possibilities to painting technology[4]. For example, Michael F. Deering's research results show that the use of virtual reality technology for painting and animation creation can better simulate the real painting experience, allowing artists to create more naturally in a virtual environment. In addition, the use of virtual reality technology can greatly improve artists' creativity and creation speed, while also improving the expressiveness and integrity of their works[5]. In the field of graffiti, which is more inclined to modern painting art, Liu Hanjian evaluated the application of virtual reality graffiti and found that virtual reality technology can provide artists with a freer, more intuitive and more immersive creative experience[6]. Therefore, virtual reality technology can allow artists to experience new painting methods and a sense of space, and create more creative and expressive works.

II. B. Application of Computer Image Recognition Technology and Fuzzy Logic

Computer image recognition technology has brought painting art into the digital age, providing new possibilities for the dissemination and sharing of paintings. This technology can accurately determine the authenticity and author of the work by deeply analyzing the texture, color, and brushstroke features of the work, and comparing and matching it with the works of known artists, providing a guarantee for the stable development of the painting market. At the same time, computer image recognition technology processes and repairs the image features of damaged works, which can reproduce the original appearance and details of the painting, protect and inherit the precious artistic heritage. In addition, with the help of image recognition technology, paintings can be accurately classified and labeled, making them easier to organize and manage. Computer image recognition technology can also help artists, researchers, and enthusiasts discover works of interest through image search and similarity matching, expanding their artistic vision and knowledge breadth.

In computer image recognition, fuzzy logic can be used to deal with ambiguity and uncertainty in images. In addition, fuzzy logic describes and handles ambiguity by introducing fuzzy sets and fuzzy relations to achieve image recognition and classification. Therefore, in image recognition, fuzzy logic can be used as a useful tool and technology for dealing with image ambiguity and uncertainty.

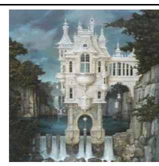
At present, there have been a lot of research and literature on the application of computer image recognition and other technologies in the field of art. For example, Zhang Hao accurately identified ethnic characteristics in paintings based on deep learning algorithms and realized automatic classification and labeling of ethnic paintings[7]. Darraji KFA's research shows that by adopting graphic digital technology, artists can use computer vision algorithms to identify the characteristics and style of their paintings. In addition, the application of image recognition technology is also conducive to promoting the digital development of painting art and plays an important role in protection, inheritance and research[8]. In the field of painting restoration, Zeng Yuan et al. used convolutional neural networks and nearest neighbor algorithm technology to perform digital restoration, restore the details and colors in ancient paintings, and restore the works to their original artistic state. These studies show that image processing technology has broad application prospects in ancient painting restoration[9]. Computer image recognition technology has brought new development opportunities and innovations to painting art through applications such as digitization, recognition, restoration, classification, and retrieval. Fuzzy logic can handle fuzziness and uncertainty problems in images and plays an important role in image recognition and classification. This paper analyzes a painting intelligent processing technology based on fuzzy logic control system and computer image recognition, which provides certain reference and inspiration for the research of painting scene recognition algorithm.

III. Design and Implementation of Intelligent Processing Technology for Painting

III. A. Computer Image Recognition Algorithm

Computer image recognition technology can achieve understanding and recognition of the information contained in images by processing and analyzing them. In the field of painting art, people need to analyze and identify painting works in order to better understand their creative intent and style characteristics. Traditional painting analysis often relies on the experience and perceptual cognition of human artists. Although this method has certain effects, it also has great subjectivity and uncertainty. In contrast, computer image recognition technology can achieve automated processing and analysis of images, greatly improving the objectivity and accuracy of analysis results. Especially in today's big data era, the number of paintings is so huge that it is difficult for humans to complete accurate identification and classification by hand, and computer image recognition technology can easily solve this problem [10]. Therefore, for the field of painting art, researching and applying computer image recognition technology is of great significance. In the intelligent processing technology of painting, computer image recognition technology can be used for automatic painting and color matching. Therefore, this article could study and select computer image recognition algorithms suitable for painting scenes to perceive and recognize painting objects, lines, colors, textures, etc.

Table 1: Collected partial data

Data sequence number	Painting scene images	Object category	Bounding box size (pixels per unit)
1		House	Width and height (132,186)
2		Arbor	Width and height (32,24)
3		House	Width and height (160,96)
4		Fruit	Width and height (48,70)
5		Swan	Width and height (32,56)
6		Flower	Width and height (200,80)
7		House	Width and height (40,100)
8		Flower	Width and height (240,90)

(1) Construction of datasets

The construction of a dataset is a prerequisite for conducting research on computer image recognition algorithms. When constructing a dataset, the objects in the painting scene are taken as the research object. A large number of painting scene images were collected from the network, and these images were annotated at the same time. The annotated content includes information such as bounding boxes, object categories, positions, sizes, etc. After the dataset construction was completed, statistics were conducted on the dataset to obtain a dataset containing various painting scene objects. The collected data is shown in Table 1.

(2) Design and implementation of object detection algorithms

The object detection algorithm is the first step in recognizing objects in painting scenes. This article uses deep learning algorithms to achieve object detection, which is the recognition of objects in painting scenes. Specifically, YOLOv3 algorithm was used, which is currently one of the more advanced object detection algorithms. YOLOv3 is the latest version of the YOLO algorithm series, and compared to previous versions, YOLOv3 achieves a better balance between accuracy and speed. The core idea of YOLOv3 algorithm is to model the target detection task as a regression problem. It divides the input image into a fixed size grid and predicts multiple bounding boxes and corresponding target probabilities in each grid unit. These bounding boxes represent the position and size of the target in the image, and the target probability represents whether the bounding box contains the target object. Meanwhile, YOLOv3 can also predict the category of each target. A YOLOv3 algorithm model is established to achieve object detection in painting scenes, and the following steps are followed:

a) The model architecture selection is to use the Darknet framework and PyTorch open-source tools to construct the YOLOv3 model. YOLOv3's network structure uses Darknet-53 as the backbone network, which is a deep residual network used to extract features from images. Darknet-53 has 53 convolutional layers, which can effectively capture the characteristics of different scales and abstraction levels. After Darknet-53, YOLOv3 obtains higher resolution feature maps through multiple convolutional and upsampling layers and is used to detect small targets.

b) Model configuration involves configuring the network structure and hyperparameters of the model after the model architecture is determined. Firstly, the size of the input image is set according to the actual requirements. Generally, the image scaling can be scaled to a fixed size to facilitate network processing. Secondly, the learning rate determines the update speed of the model parameters in the training process. A suitable initial learning rate is set according to the situation and adjusted according to the training process. The batch size determines the number of images used during each training session, and is adjusted based on hardware resources and memory limitations.

c) Model training: YOLOv3 usually uses multiple loss function to train the model. Common loss function include classification loss function and target detection loss function. Among them, YOLOv3 uses the cross entropy loss function in the classification loss function to calculate the prediction error of object category. Multiple target detection loss function are used to predict the object's bounding box, including target presence loss, bounding box coordinate loss and bounding box confidence loss. The target existence loss is used to judge whether there is an object in a grid cell. The commonly used target existence loss function is a binary cross entropy loss function. The boundary box coordinate loss is used to measure the difference between the predicted boundary box and the real boundary box. The common boundary box coordinate loss function is the square error loss function or Smooth L1 Loss. The confidence loss of the bounding box is used to measure the degree of overlap between the predicted bounding box and the actual bounding box, as well as whether the category of objects in the predicted bounding box is correct. Considering the above loss function comprehensively, this paper can build the total loss function of YOLOv3 model, as shown below [11]:

$$\text{Loss} = \text{lambda}_1 * \text{CE} + \text{lambda}_2 * \text{OBJ} + \text{lambda}_3 * \text{BBox} + \text{lambda}_4 * \text{Conf} \tag{1}$$

Among them, lambda_1, lambda_2, lambda_3 and lambda_4 are weight parameters used to balance different loss function.

d) Model training and optimization is to use labeled painting scene image dataset to train the model. In the training process, backpropagation is used to update the gradient to minimize the loss function. Data enhancement techniques are used to increase the diversity and number of data samples to improve the generalization of the model.

(3) Design and implementation of object segmentation algorithm

The object segmentation algorithm is based on object detection and provides more detailed analysis of the detected objects. This article uses the Mask R-CNN algorithm for object segmentation. Compared to traditional object segmentation algorithms, the Mask R-CNN algorithm can not only segment objects in images, but also accurately control the contours of objects. The Mask R-CNN algorithm is modeled to achieve object segmentation in a painting scene and the following steps are followed:

a) The establishment of the model architecture is based on the Mask R-CNN model architecture, which introduces segmentation heads on the basis of Faster R-CNN (Faster Region-Based Convolutional Neural Networks) and can simultaneously perform object detection and segmentation.

b) Configuration model network structure: Mask R-CNN model consists of backbone network, regional proposal network (RPN), object classful network and partition network. A pre-trained backbone network, ResNet, is selected as the feature extractor. This backbone network has been trained on large-scale image datasets and has good feature extraction capabilities. The hyper-parameters of the RPN network are set, including the size and ratio of the sliding window, the number of candidate regions generated, etc., in order to get a better candidate region generation effect. The number of layers and width of the object classification network, and the number of layers and channels of the segmentation network, etc. are determined.

c) The super parameters are set using learning rate scheduling methods, such as learning rate attenuation and hot restart, to improve the training effect of the model. The appropriate batch size is selected based on the limitations of computational resources and the training effect of the model. A larger batch size can accelerate training speed, but may require more memory and graphics memory. Depending on the size of the training set and the training convergence of the model, the appropriate number of training iterations is chosen, and L1 and L2 regularization are added to help prevent overfitting.

d) Definition of loss function: the loss function defined for model training includes classification loss, bounding box regression loss and segmentation mask loss of object detection. The loss function of RPN is used to generate candidate regions. Its loss function consists of two parts, namely, classification loss and boundary box regression loss, which can be expressed as:

$$L(RPN) = L(cls) + \lambda * L(reg) \tag{2}$$

Among them, L(cls) represents classification loss; L(reg) represents the bounding box regression loss; λ is the weight of the two parts of the loss.

The loss function of the segmentation network is used to generate the segmentation mask of the object. Its loss function is the cross entropy loss at the pixel level, which can be expressed as:

$$L(mask) = \frac{-1}{N} * \sum \log(y_{ij}) * m_{ij} + \log(1-y_{ij}) * (1-m_{ij}) \tag{3}$$

Among them, y_{ij} is the probability that the i-th pixel predicted by the network belongs to the j-th category, and m_{ij} is the label of the i-th pixel belonging to the j-th category in the real segmentation mask.

e) Model training involves using a prepared training dataset and inputting it into the Mask R-CNN model for training. Through the backpropagation, the parameters of the model are optimized, so that the model can learn the accurate object detection and segmentation ability.

In summary, Mask R-CNN is a deep learning model for object detection and segmentation, which can introduce segmentation heads on top of Faster R-CNN to achieve fine object segmentation. Its main idea is to additionally predict the mask of each object based on the detection phase. Therefore, Mask R-CNN can detect objects in the image and accurately separate the pixels of each object.

(4) Design and implementation of object recognition algorithm

Object recognition algorithm is an algorithm to classify objects based on object detection and segmentation. This paper uses object recognition algorithm based on convolutional neural network, specifically ResNet50 algorithm to classify objects. ResNet50 is a deep convolutional neural network based on ResNet architecture, which is commonly used for feature extraction. It consists of a convolutional neural network with a depth of 50 layers, including residual blocks and convolutional layers. The core idea of ResNet is to introduce residual connections, which enable information to be directly transmitted through the network by skipping one or more convolutional layers, thereby solving the problem of gradient vanishing or exploding during deep network training, making the network deeper and easier to train. The innovation of ResNet lies in the introduction of residual blocks, which include skip connections and batch normalization, and the construction of deep networks through the stacking of residual blocks. ResNet50 achieves deeper network structure and more accurate feature extraction capabilities through the stacking of multiple residual blocks and the introduction of a global average pooling layer. It has been widely used in computer vision tasks such as image classification, object detection, and image segmentation, and has achieved excellent performance in multiple fields. The ResNet50 algorithm is modeled for the task of object recognition and the following steps are followed:

a) The model architecture selection is to select ResNet50 as the backbone network for extracting image features [12]. ResNet50 is a classic convolutional neural network structure with good feature extraction ability.

b) The model configuration is based on the ResNet50 architecture, adding appropriate head networks for object classification. The head network consists of fully connected layers, pooling layers, and other structures, used to map extracted features to category probabilities. This article chooses to add a global average pooling layer and a fully connected layer to map features to category probabilities. The global average pooling operation averages the input features according to spatial dimensions to obtain a feature map. The specific calculation formula is as follows:

$$g_i = (1 / (W * H)) * \sum x_{ijk} \quad (4)$$

In Formula (4), g_i represents the value of the i-th channel of the global average pooled feature map, and x_{ijk} represents the elements of the i-th channel, j-th row, and k-th column of the input feature.

The probability that the fully connected layer maps the feature maps obtained after global average pooling to the output categories. The specific calculation formula is as follows:

$$y_i = \mathrm{sum}(w_i * g_i) + b_i \quad (5)$$

In Formula (5), y_i represents the i-th element of the output category probability; w_i represents the weight of the fully connected layer; b_i represents the bias term of the fully connected layer. Finally, the output of the fully connected layer is normalized using the softmax function to obtain probability predictions for each category.

c) Loss function selection: for object classification tasks, cross entropy loss function is selected as the objective function to measure the difference between the prediction results and the real category. The calculation formula of cross entropy loss function is as follows:

$$loss = -\mathrm{sum}(y_{true} * \log(y_{pred})) \quad (6)$$

In the formula, y_{true} represents the actual category label, and y_{pred} represents the predicted category probability.

d) Model training is the use of prepared datasets for model training. In the training process, the random gradient descent optimization algorithm is used to minimize the loss function. During the model training process, it is necessary to set some hyperparameters to control the training behavior. Appropriate batch sizes are selected to fully utilize the computational resources and ensure the convergence of training. Learning rate decay strategies are used to dynamically adjust the learning rate, including learning rate decay and learning rate scheduler. Finally, control of the degree of regularization is achieved in ResNet50 by setting the weight decay parameter in the optimizer to reduce the risk of overfitting the model.

III. B. Construction of Fuzzy Logic Control System

As a control system based on fuzzy set theory, fuzzy logic control system can process fuzzy and uncertain information, thus improving the robustness, stability and reliability of the control system [13], [14]. In intelligent painting processing technology, fuzzy logic control systems can be used for automatic color filling, intelligent assisted painting, and image enhancement. For example, a fuzzy logic control system can automatically fill colors through fuzzy classification and fuzzy reasoning. When the input image contains regional boundaries, the fuzzy logic control system can recognize these boundaries and automatically fill in colors. This can reduce the workload of painters and improve the accuracy and speed of painting. These functions can enable painters to complete their paintings more quickly and accurately [15], [16]. Therefore, this article could analyze and implement a control system based on fuzzy logic to assist in intelligent painting processing technology. The interface of the analyzed fuzzy logic control system is shown in Figure 1.

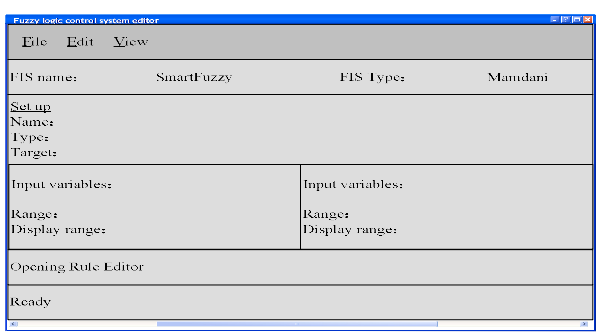


Figure 1: Fuzzy logic control system interface

(1) Determining the needs and goals: here is an example of the goal of generating landscape paintings with partial intelligence, such as automatic selection of painting colors and lines.

(2) Determining input and output variables: the input variables are the pixel values and image recognition results of the original image, while the output variables are painting decision and control signals, such as selecting painting colors, line thickness, etc.

(3) Image processing and feature extraction: by using computer image processing technology, the input image is processed and feature extraction is performed to extract the color distribution, edge information, etc. of the image as fuzzy input.

(4) Building a fuzzy logic control system: building a fuzzy logic control system includes components such as fuzzy inputs, fuzzy outputs and fuzzy rule base. In terms of fuzzy input, image processing technology is used to analyze the input image, extract key information such as colors, lines, and other features, and convert them into fuzzy variables for input. In terms of fuzzy output, artistic rules, painting techniques, etc. are introduced to transform them into fuzzy variables and fuse them with fuzzy input variables to generate painting decision and control signals. The fuzzy rule library is used to describe the relationship between input and output variables, and to generate drawing decisions and control signals through fuzzy reasoning.

(5) Carrying out fuzzy reasoning: through the fuzzy rule base and fuzzy reasoning mechanism, according to the value of the fuzzy input variable, the value of the fuzzy output variable is derived, that is, drawing decision and control signal.

(6) Integration of artistic rules and painting techniques: art rules and painting techniques are introduced into a fuzzy logic control system to generate more accurate painting decisions and control signals by fusing them with fuzzy input variables. Artistic rules are introduced to guide painting color selection and line drawing.

III. C. Development of Intelligent Painting Tools

Painting is a manifestation of culture and art, closely linked to the times and culture [17], [18]. In the digital era, the development of intelligent processing technology in painting could provide new ideas and means for art education, cultural inheritance, and artistic creation [19], [20]. This article could introduce intelligent painting processing technology based on fuzzy logic control system and computer image recognition. The fuzzy control system and drawing tools are implemented using Python language and fuzzy logic toolkit; the Web-based intelligent drawing tools are developed using JavaScript and with the help of HTML (Hypertext Markup Language), CSS (Cascading Style Sheets), and Canvas; the analyzed fuzzy logic control system is applied to the drawing process to realize intelligent drawing assistance and enhancement functions.

(1) Determining the functions of intelligent painting tools: the goals and needs of smart drawing tools include automatically adjusting brush size and color, automatically filling in blank areas, and providing suggestions based on the user's drawing style.

(2) Designing user interface: based on the functional requirements, a user-friendly interface is designed so that users can easily use the smart drawing tool. The interface and interaction logic of the drawing tool is realized based on the designed user interface using JavaScript, HTML and CSS. HTML is used to build the structure of the user interface; CSS is used for styling; JavaScript is used to realize the interaction logic and the processing of user operations. Considering the needs of different users, some appropriate setting options are provided so that users can personalize the settings according to their needs and preferences. Context menu options are provided based on the user's current action and context. This can help users operate more quickly and reduce unnecessary steps. Corresponding shortcut keys and gestures should also be provided for commonly used operations to facilitate users to quickly complete operations. For example, common operations such as undo/redo, save, and copy/paste can be achieved by defining shortcut keys or gestures. In addition, it provides real-time preview function, allowing users to see their painting effects in real-time. At the same time, timely feedback should be given to users, such as through prompts, status bars, or animations, to ensure that they know whether their actions have been successful. Finally, user assistance and instructions are provided to help users understand the usage of the tool. That is to provide some tips, tutorials, or options to link to online documents to help users solve problems and obtain more information.

(3) Connecting the fuzzy control system: the analyzed fuzzy control system is connected with the intelligent painting tool. Connecting the Python language and fuzzy logic toolkit with JavaScript, the input data of the drawing needs to be passed to the fuzzy control system for intelligent processing during the drawing process. For example, the user's drawing data is passed from the JavaScript front-end to the back-end Python fuzzy control system by sending requests and receiving responses, and the output of the fuzzy control system is passed back to the JavaScript front-end. Typical input data could include stroke position, speed, pressure, color and brush selection, and painting history and context.

(4) Data preprocessing: before transmitting input data to the fuzzy control system, some preprocessing operations are required. This includes data normalization, filtering, feature extraction, etc. The goal of preprocessing is to ensure the accuracy and consistency of input data, so that the fuzzy control system can process the data correctly.

(5) Calling the fuzzy control system: based on the preprocessed input data, the fuzzy control system is invoked to perform operations such as fuzzification, rule inference and defuzzification. Python language and fuzzy logic toolkit are used to implement the processes of fuzzification, rule inference and defuzzification for fuzzy control systems. Based on the user's drawing input data, appropriate parameters are calculated, including brush size, color, transparency, etc., and the results are returned to the front-end JavaScript.

(6) Implementing painting function: according to the user interface and requirements, the relevant functions of the painting tool are realized. In the front-end JavaScript, the parameters of the painting tool are adjusted according to the output of the fuzzy control system. According to the user's operation and drawing input data, drawing functions such as drawing lines and filling areas are realized.

In summary, this article provides new ideas and means for art education, cultural inheritance and artistic creation, and will continue to explore the realization and application of intelligent painting processing technology in the future [21], [22].

IV. Evaluation of the Effect of Intelligent Processing Technology in Painting

IV. A. Experimental Design

In order to evaluate the effectiveness and advantages of this study in improving the quality of paintings, the experiment included paintings of different themes, styles and complexities, divided into still life paintings, landscape paintings and portraits. The experiment invited 100 artists and painting enthusiasts to participate. The participants had professional painting techniques and aesthetic perception, and had similar levels of painting experience. The experiment used the creation process time, line smoothness and painting accuracy as evaluation indicators. The experimental participants were randomly divided into two groups. The experimental group used painting intelligent processing technology, and the control group used traditional painting methods. Each group of participants needs to complete the same painting task. The painting process of each participant was recorded, including the techniques used, tools and materials used, as well as detailed records of the painting steps. A panel of experts was invited to evaluate the painting works completed by participants using intelligent painting processing technology and traditional painting methods. The jury includes art experts, designers, and professionals in related fields. Drawings completed by the experimental participants using drawing intelligence processing technology and traditional drawing methods were collected, and jury ratings and judging comments were recorded. Statistical analysis methods were used to analyze the scoring data and compare the quality differences between the works completed by two groups of participants using different methods. At the same time, in order to evaluate the performance of painting intelligent processing technology based on fuzzy logic control system and computer image recognition, data sets were used to test the painting intelligent processing technology based on fuzzy logic control system and computer image recognition for many times, so as to evaluate the accuracy of object detection, object segmentation and object recognition.

IV. B. Data Evaluation of Painting Results

(1) Evaluation of creative process time

Long periods of time may lead to artists losing clarity in their conception and expression, making it difficult to concentrate and maintain coherence in their creations. In addition, prolonged periods of time may lead artists to excessively pursue details, falling into excessive rendering and embellishments, and resulting in a loss of simplicity and natural presentation in their works. At the same time, the prolonged creative process may lead artists into a dilemma of self doubt and constant adjustment, leading to the loss of their original uniqueness and liveliness. More importantly, excessive time may also cause artists to lose their inspiration and creativity, limiting their freedom to express themes and emotions. Therefore, moderate time management and mastery are crucial in painting creation, as they can help artists maintain the accuracy, personalization, and expressiveness of their creations, making their works more powerful in conveying the unique perspective and inner world. The creative process time of the control group and the experimental group was recorded, and the comparison results are shown in Figure 2. The horizontal axis represents the analysis indicators for different categories of painting works, while the vertical axis represents the creative process time spent.

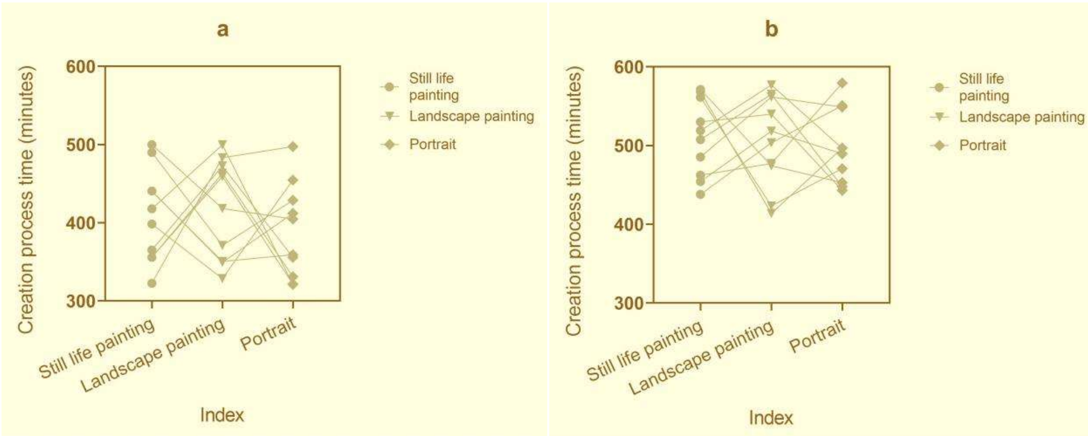


Figure 2: Creation process time data of the control group and experimental group

Figure 2 (a) Creation process time data of the experimental group
Figure 2 (b) Creation process time data of the control group

In Figure 2 (a), the creation process time data of the experimental group was described, with the highest creation process time value of 499.92 minutes for different categories of painting works. In Figure 2 (b), the creation process time data of the control group was described, with the highest creation process time of 579.48 minutes for different categories of painting works. The results indicated that the highest value of the creative process time in the experimental group was lower than the highest value of the creative process time in the control group, so the creative process time of painting works created using the intelligent processing technology analyzed in this article was shorter.

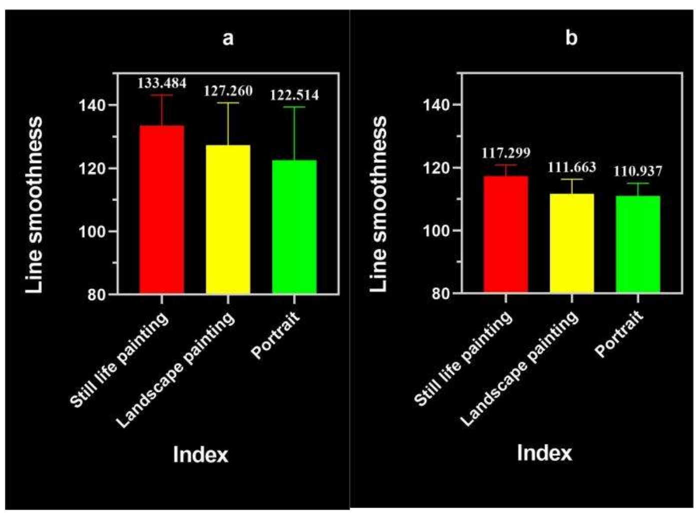


Figure 3: Line smoothness score data of the control and experimental groups

(2) Line smoothness evaluation

The smoothness of the lines directly affects the visual effect and viewing experience of the work. Smooth lines can give people a soft and smooth feeling, giving the work an elegant and harmonious aesthetic, and enhancing the artistic expression of the work. Secondly, the smoothness of the lines is closely related to the structure and proportion of the work. When the smoothness of the lines is high, it can better express the structure, proportion, and contour of the form, making the work more accurate and three-dimensional. Smooth lines can create a soft and comfortable atmosphere, allowing viewers to feel a gentle and harmonious emotion, and enhancing the infectivity of the work. Most importantly, the smoothness of the lines also reflects the artist's painting skills and exquisite level. By mastering the direction and rhythm of lines, artists can showcase their unique brushstrokes and painting styles, reflecting their personal creative style and artistic concepts. Therefore, artists should pay attention to the smoothness of lines in their painting creations. By mastering the curvature, length changes, and slope changes of lines, they can achieve a perfect fusion of visual beauty, structural authenticity, and emotional expression in their works, making them more full, vivid, and powerful in conveying the author's artistic ideas and emotional experience. A panel of experts was invited to rate all painting works, with a maximum score of 150 points. The line smoothness scores of the control group and the experimental group were recorded, and the comparison results are shown in Figure 3. The horizontal axis represents the analysis indicators for different categories of painting works, and the vertical axis represents the line smoothness scores.

Figure 3 (a) Line smoothness score data of the experimental group

Figure 3 (b) Line smoothness score data of the control group

In Figure 3 (a), the line smoothness score data of the experimental group was described, with the highest average line smoothness score of 133.484 for different categories of painting works. In Figure 3 (b), the line smoothness score data of the control group was described, with the highest average line smoothness score of 117.299 for different categories of painting works. The results indicated that the average line smoothness score of the experimental group was higher than the highest score of the control group, so the line smoothness of painting works created using the intelligent processing technology analyzed in this article was higher.

(3) Painting accuracy evaluation

The accuracy of painting has a profound impact on all aspects of a work. Accuracy directly affects the visual effect and realism of the work. Accurate painting can accurately express the form, proportion, and details of objects, giving works a realistic aesthetic and three-dimensional feeling, and giving people a strong visual impact. Secondly, the accuracy of painting is closely related to the expressive power and skill level of the work. By accurately grasping the contours, textures, and colors of objects, artists can more accurately express the emotions, atmosphere, and artistic conception of the theme, enhancing the expressive and infectious power of their works. In addition, the accuracy of painting also reflects the artist's attention to detail and processing ability. Accurate detail processing can make the work more delicate and exquisite, enhance the texture and layering of the picture, and enhance the viewing value and quality of the work. Most importantly, the accuracy of painting also reflects the artist's professional literacy and artistic pursuit. By continuously pursuing the accuracy and precision of painting, artists can enhance their skills and artistic taste, further deepening their understanding and mastery of painting art. Therefore, artists should focus on the pursuit of accuracy in their painting creations, continuously improving their understanding of the essence of things through observation, analysis, and practice, in order to achieve realistic and precise painting effects, making their works more powerful, dynamic, and infectious, and giving viewers a profound artistic experience and thinking. A panel of experts was invited to rate all painting works, with a maximum score of 150 points. The accuracy scores of the control group and the experimental group were recorded, and the comparison results are shown in Figure 4. The horizontal axis represents the analysis indicators for different categories of painting works, while the vertical axis represents the accuracy scores of painting.

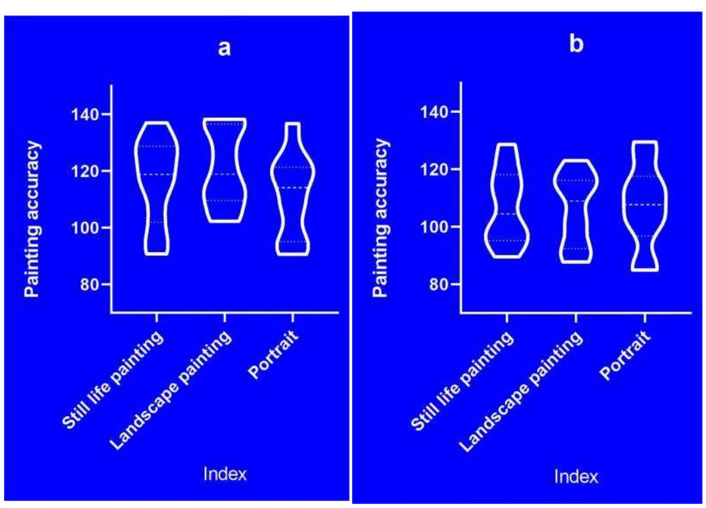


Figure 4: Painting accuracy score data of the control group and experimental group

Figure 4 (a) Painting accuracy score data of the experimental group

Figure 4 (b) Painting accuracy score data of the control group

In Figure 4 (a), the painting accuracy score data of the experimental group was described, with the highest painting accuracy score of 138.36 for different categories of painting works. In Figure 4 (b), the painting accuracy score data of the control group was described, with the highest painting accuracy score of 128.68 for different categories of painting works. The results indicated that the experimental group's painting accuracy score was higher than the control group's painting accuracy score, so the painting accuracy of the paintings created using the intelligent processing technology analyzed in this article was higher.

(4) Evaluation of innovation and artistry

Innovation and artistry are important factors in a painting, serving as the soul and characteristic of the work. Through innovative ideas and expressive techniques, artists can inject unique personality and style into their works, making them stand out and stand out. Secondly, innovation and artistry also affect the viewing experience and aesthetic value of works. Innovative painting forms and themes can arouse viewers' curiosity and thinking, and stimulate their interest and love for artistic works. At the same time, artistic expression and innovative expression methods can also bring aesthetic enjoyment and emotion to the audience, making the work resonate emotionally. In addition, innovation and artistry also have a significant impact on the communication and expressive power of a work. Through innovation and artistic techniques, artists can better transform their emotional and ideological experiences into the language and form of their works, making them more expressive and infectious, and touching the depths of the viewer's heart. A panel of experts was invited to rate all painting works, with a maximum score of 150 points. The innovation and artistry scores of the control group and the experimental group were recorded, and the comparison results are shown in Figure 5. The horizontal axis shows the innovation and artistry scores, while the vertical axis shows the analysis indicators for different categories of painting works.

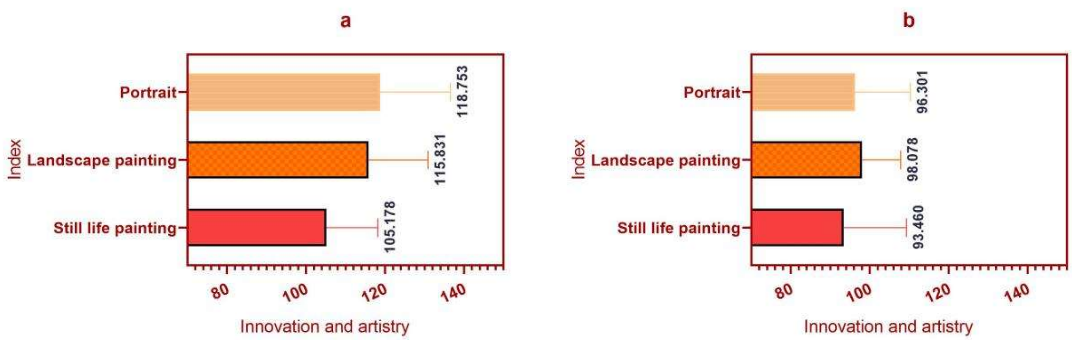


Figure 5: Innovation and artistry score data for the control and experimental groups

Figure 5 (a) Innovation and artistic score data of the experimental group

Figure 5 (b) Innovation and artistry score data of the control group

In Figure 5 (a), the innovation and artistry score data of the experimental group were described, with the highest average innovation and artistry score of 118.753 for different categories of painting works. In Figure 5 (b), the innovation and artistic score data of the control group were described, with the highest average innovation and artistic score of 98.078 for different categories of painting works. The results indicated that the experimental group's highest scores for innovation and artistry were higher than the control group's highest scores for innovation and artistry. Therefore, paintings created using the intelligent processing technology of painting analyzed in this article were more innovative and artistic.

(5) User experience assessment

User experience feedback can help improve the practicality and ease of use of intelligent painting processing technology. By understanding the user experience and needs for intelligent painting processing technology, optimization and improvement can be made based on user feedback and expectations, making the technology more tailored to the actual needs of users and providing a more user-friendly and convenient user experience. User experience assessment can also help improve the viewing and quality of intelligent painting processing technology. By observing and analyzing users' reactions and evaluations of intelligently processed painting works, the processing and painting effects of the technology can be further optimized, making the works more in line with users' aesthetic needs and tastes, and enhancing the viewing value and artistic expression of the works. In addition, user experience assessment can also help promote the innovation and development of intelligent painting processing technology. Through interaction and feedback with users, people can understand their expectations and needs for existing technology, provide valuable reference and guidance for the development direction and innovation of technology, and promote continuous progress and upgrading of technology. Fifty participants' evaluations of the ease of use and user interface of the intelligent processing technique of drawing based on fuzzy logic control system with computerized image recognition were collected. The recorded participants' evaluation of the degree of ease of use is shown in Table 2:

Table 2: Participants' evaluation of the degree of ease of use

Ease of use	Very easy	Easy	Moderate	Difficult	Very difficult
Number of people	10	9	18	8	5
Proportion (%)	20	18	36	16	10

As shown in Table 2, 10 participants believed that the painting intelligent processing technology analyzed in this article was very easy to use, accounting for a percentage of 20%; nine participants believed that the intelligent processing technology for painting analyzed in this article was easy to use, accounting for 18%; 18 participants believed that the ease of use of the painting intelligent processing technology analyzed in this article was average, accounting for 36%; 8 participants believed that the intelligent processing technology for painting analyzed in this article was difficult to use, accounting for 16% of the total; five participants believed that the intelligent processing technology for painting analyzed in this article was very difficult to use, accounting for 10% of the total.

The participants' evaluations of user interface satisfaction were recorded, as shown in Table 3:

Table 3: Participants' evaluation of user interface satisfaction

User interface satisfaction	Very satisfied	Satisfied	Neutral	Unsatisfied	Very unsatisfied
Number of people	8	16	12	8	6
Proportion (%)	16	32	24	16	12

As shown in Table 3, 8 participants were very satisfied with the user interface of the intelligent painting tool analyzed in this article, accounting for 16%; 16 participants were satisfied with the user interface of the intelligent painting tool analyzed in this article, accounting for 32%; 12 participants felt that the user interface of the intelligent painting tool analyzed in this article was average, accounting for 24%; 8 participants were dissatisfied with the user interface of the intelligent painting tool analyzed in this article, accounting for 16%; six participants were very dissatisfied with the user interface of the intelligent painting tool analyzed in this article, accounting for 12%. From this, it can be seen that the ease of use and user interface satisfaction of the painting intelligent processing technology analyzed in this article are high, with 74% and 72% of participants giving non negative evaluations, respectively.

(6) Technical feasibility assessment

The evaluation of technical feasibility includes the evaluation of object detection accuracy, object segmentation accuracy and object recognition accuracy of painting intelligent processing technology based on fuzzy logic control system and computer image recognition. This could affect the effectiveness and reliability of intelligent painting processing technology. By improving the accuracy of object recognition, people can more accurately capture the characteristics and details of painting objects, enhance the ability of intelligent processing systems to interpret and process different objects, make paintings more consistent with the characteristics and forms of actual objects, and improve the authenticity and appreciation of works. For example, in the painting task of the same ocean theme, the paintings of two contestants using intelligent processing technology and traditional painting methods are shown in Figure 6. Figure 6 (a) shows the paintings of the contestants using intelligent processing technology, and Figure [0-9] (b) shows the paintings of the contestants using traditional painting methods. It is evident that the ocean painted using intelligent processing technology is more realistic.

Figure 6 (a) The painting works of participants using intelligent painting processing technology

Figure 6 (b) Paintings of participants using traditional painting methods

Figure 6: Comparison of painting works between two participants using intelligent painting processing technology and traditional painting methods

The accuracy of object detection has a direct impact on the refinement of painting intelligent processing technology and the improvement of painting effects. By improving the accuracy of object detection, it is possible to capture the contours, edges, and textures of objects in a more precise manner, enabling intelligent processing systems to more accurately simulate and restore the delicate features of actual objects, enhance the texture and three-dimensional sense of painting, and enhance the aesthetic value and quality of painting. The data set was used to test the painting intelligent processing technology based on the fuzzy logic control system and computer image recognition for many times, and the model performance was evaluated using three indicators: mAP (mean Average Precision), object recognition accuracy and IoU (Intersection over Union). Among them, mAP is an important indicator to measure the accuracy of detection algorithms. IoU can segment objects accurately, and record multiple test results including mAP, object recognition accuracy and IoU, as shown in Table 4:

Table 4: Multiple test results of mAP, object recognition accuracy and IoU

Data sequence number	Accuracy of recognition detection (%)	Intersection over Union	Mean Average Precision (%)
1	94.31	0.82	72.75
2	86.27	0.79	73.84
3	92.17	0.77	66.04
4	87.65	0.78	68.85
5	89.78	0.88	74.00
6	88.42	0.86	73.31
7	86.75	0.72	70.31
8	89.95	0.74	72.77

As shown in Table 4, in the test results, the maximum value of mAP of painting intelligent processing technology was 74%; the maximum value of object recognition accuracy is was .31%, and the maximum value of IoU was 0.88. The value range of IoU was between 0 and 1, and a higher value indicated a more accurate predicted segmentation result. In general, IoU greater than 0.5 was considered a relatively accurate detection segmentation result. Therefore, the painting intelligent processing technology analyzed in this article has good object detection, segmentation, and recognition capabilities.

V. Conclusions

This article analyzed a painting intelligent processing technology based on fuzzy logic control system and computer image recognition, and evaluated and analyzed the effectiveness of painting intelligent processing technology based on fuzzy logic control system and computer image recognition in improving painting quality through design experiments. The experimental results indicated that the painting intelligent processing technology analyzed in this article has good computer image recognition ability, which can improve the quality and accuracy of painting. Compared to traditional hand drawn works, works drawn using this technology have higher painting accuracy and quality, which can effectively enhance the artistic value and beauty of painting. Therefore, the intelligent processing technology of painting based on fuzzy logic control system and computer image recognition has certain application prospects and practical value, which can bring new development opportunities for art design and digital culture industry.

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