International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 17 (2025) pp. 1-15
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https://doi.org/10.70917/ijcisim-2025-0275
Article

Application Strategies of Artificial Intelligence Painting Technology in Oil Painting Art Education

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Abstract: This paper constructs a mathematical model of oil painting generation, elaborates the algorithmic principles of painting analysis, color transformation and brush painting, and proposes an efficient oil painting generation algorithm. From the perspective of teaching practice, it analyzes the innovative application strategies of AI painting technology in teachers' lesson preparation and classroom teaching. The performance advantages of the proposed oil painting generation system are verified through experiments and system evaluation. Combined with teaching experiments, the actual effect of AI-assisted oil painting art education is evaluated. Under the same image segmentation conditions, compared with the traditional image segmentation-based regional stroke algorithm, the algorithm proposed in this paper significantly reduces the running time, shortening about 80% or more on average, up to 94.1%. In teaching practice, the experimental group outperforms the control group in both aesthetic expression and thinking development. The system obtained an average score of 78.91/100 in the SUS usability test, which belongs to B grade.

Keywords: artificial intelligence painting technology; oil painting art education; mathematical model; oil painting generation algorithm

1. Introduction

The art category of oil painting originates from the West and reflects the unique artistic style of the West [1]. Higher art education has played an important role in promoting the development of Chinese oil painting. Nowadays, China's oil painting art education has made remarkable progress, and the education mode has tended to mature, art education has entered a new period of development, which also puts forward higher educational goals and requirements for university oil painting art education [2-3]. Nowadays, many universities have opened oil painting art education related courses in their art colleges, which have cultivated many excellent art professionals. However, there are some shortcomings in oil painting education, including too much emphasis on the skill training of oil painting creation and neglecting the cultivation of students' humanistic qualities, too much emphasis on the standardized systematic teaching and neglecting the cultivation of students' aesthetic ability, etc. [4-5]. In addition, some colleges and universities adopt a single model teaching method, which is not conducive to the cultivation of students' creativity and artistic thinking ability. In the face of the current problems in university oil painting art education, art teachers in colleges and universities need to constantly develop educational ideas, focus on adopting a diversified education model, aiming at improving the overall quality and comprehensive quality of students, and realizing the innovative cultivation of artistic talents [6-7].

Since 2018, artificial intelligence technology has begun to be applied in large quantities in China, and it is mainly used in industries such as health care, education, transportation and machinery manufacturing [8]. Although the research of AI in the field of education has achieved initial success and produced important research results, it is still a blank in art and design education [9]. Artificial intelligence painting is mainly realized based on intelligent platforms and intelligent painting software, which use training data to learn painting techniques and styles and generate multiple types and styles of paintings [10].

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Intelligent painting technology during the application mainly analyzes and learns the relevant data by collecting metadata such as the author, the time of creation, and the techniques used to simulate the painting process [11-12]. During the application period designers can input specific instructions into the intelligent system or intelligent platform, and the platform, after interpreting the requirements and instructions, applies algorithms such as generative adversarial network and convolutional neural network to create works with innovative and artistic value while maintaining the original style [13-14]. Once the image generated by the system fails to meet the designer's requirements, the designer is able to continue to optimize the content of the painting using the intelligent system feedback and optimization module. The process mainly uses user feedback, expert review, and self-assessment to continuously improve their drawing skills and create higher quality works [15].

With the rapid development of social and economic development, the social demand for artistic talents is becoming increasingly diversified, which also puts forward higher requirements for the quality of oil painting art teaching talent training [16]. In order to better adapt to the development of the times and society, university oil painting art education needs to develop in a more diversified direction, so as to better enhance the effectiveness of art education. Intelligent painting technology is a new creation method combining art and technology, which shows great potential in the fields of art creation, design, entertainment, etc., and has a broad application prospect and development space [17].

Oil painting has a hundred years of history, and research on the reform of oil painting education has been carried out all over the world in recent years. Li, C, in order to enrich the content of the traditional oil painting classroom and stimulate the students' interest in learning art, the theory of ecology is integrated into the oil painting classroom, and this ecological oil painting teaching strategy not only depicts the beauty of nature, but also strengthens the students' environmental protection thinking, and plays an important role in the development of the students' aesthetics and personal qualities [18]. Wang, B compared the effects of distance learning and field trip on the development of students' innovative thinking in oil painting skills, and found that field trip can improve the completeness and flexibility of students' oil painting creation, and cultivate their innovative thinking in oil painting [19]. Wang, C pointed out that the sense of innovation is an important factor to promote the development of art, and therefore explored in depth the importance of intelligent painting. In the study, Wang, C pointed out that creative consciousness is an important factor to promote the development of art, and for this reason, he discussed in depth how to use the network cloud platform to cultivate students' creative thinking in oil painting creation under the background of the intelligent age, so as to improve the level of art education in colleges and universities [20]. Deng analyzed the problem of logical obstacles of thinking that existed in the learning process of the students, among which, logical thinking refers to the individual's cognitive process of forming a way of thinking by judging and reasoning, and the teaching system of oil painting in colleges and universities is reformed to strengthen students' creative thinking. The reform of oil painting teaching system in colleges and universities starts from strengthening the cultivation of students' creative thinking and stimulating students' motivation [21]. Ding designed a digital image technology course teaching system for oil painting teaching, which deeply integrates digital image technology with traditional painting teaching, realizes the digitalization change of traditional oil painting painting techniques, and adds novel contents for oil painting technique teaching [22]. Yi combined deep learning and artificial intelligence technology to construct an intelligent optimization teaching framework to improve the traditional optimization teaching mode in China. The intelligent framework can extract the characteristics including oil painting colors and brush strokes during painting, which makes its average accuracy of optimization classification reach 94.03%, and the oil painting teaching system designed based on the framework can assist students in adjusting their learning plans [23]. Ma et al. used broadband technology, MIMO technology, and decoupling technology to design two wearable smart antennas, the designed antennas have reflection coefficients lower than -6db and antenna efficiencies of more than 40% in the target operating frequency bands, which can be implanted into smart paintbrush devices to realize the automatic teaching of oil paintings [24]. Qi et al. depicted the contents of Van Gogh's oil painting “La Mousmé” by using the virtual reality technology, and integrated visual, auditory, and haptic elements into the user's virtual experience, which improves the user's depth experience of oil painting culture, colleges and universities can draw on this technology to understand and appreciate the analysis of oil paintings in oil painting art education [25].

As a pioneer in the development of artificial intelligence technology, foreign countries, in order to obtain a leading edge in digital technology, promote artificial intelligence generation technology as a priority goal, and incorporate digital teaching into the strategic layout of the country [26]. Artificial intelligence education research in foreign countries is more extensive in the direction of research, the use of information technology tools to adapt students to the process of artificial intelligence education, and to promote the sharing of information [27-28]. In art education, An developed an intelligent drawing system based on deep learning and ResNet-50 modeling, and designed a quasi-experiment for comparison in order to explore the effect of the system on the students' self-efficacy and sense of participation, and the teaching results confirmed the feasibility of the intelligent drawing system, which is of great significance to the development of art education [29]. Liu et al. explored the application of deep learning and AI technology in the art creation and education, and found that the use of intelligent art creation model has better performance in image quality evaluation in terms of clarity, detail performance, style consistency and color accuracy, etc. [30]. Kong designed an art teaching strategy based on AI technology, and in order to accurately assess the effectiveness of the application of AI in art teaching introduced a hierarchical analysis and grey clustering analysis the quantitative results of the application effectiveness are realistic that AI technology has a good potential for application in art teaching [31]. Li, J et al. integrated AI technology into the architectural painting module of art teaching, and the study pointed out that the intelligent algorithm was able to mark the important works that need to be paid attention to when teaching the art of architectural painting and achieved an accuracy rate of 97% in the training phase and 98% in the testing phase [32]. Gong utilizes virtual reality and artificial intelligence technology to carry out practical application value assessment in digital media art creation teaching, and the teaching experience of teachers and students in the teaching process is comprehensively enhanced, breaking the information barriers of traditional teaching concepts, which has good due value and practical significance [33]. Zhao et al. propose a regression learning-assisted integrated data representation model to optimize the data integration and representation by means of regression learning and calibration and evaluation to optimize data integration and representation, solve the problem of multi-source data integration in art teaching, and provide technical reference for interdisciplinary education [34].

From the previous analysis of the current status of foreign research, it can be seen that the foreign research is more technical development and the construction of the model related aspects of the research. For art education, artificial intelligence is more as a teaching method and teaching tool in the classroom, empowering teachers and students through specific artificial intelligence tools. The shortcoming is that the current application of artificial intelligence education is more in the application of science and technology disciplines, humanities and social sciences are less involved, especially the combination of artificial intelligence technology and oil painting art education is more scarce [35-36]. The prospect of the development of artificial intelligence technology in the field of education is considerable, but how to use artificial intelligence technology in the specific oil painting art teaching needs to be analyzed and explored through more teaching applications and practices.

This paper firstly analyzes the mechanism of art painting, and constructs a mathematical model including direction field model, color model, brush model and placement model. Based on computer image processing technology, the core algorithm of oil painting generation system is proposed. Explore the specific application of AI painting technology in the whole process of teaching, covering the differentiation strategies for the two core aspects of teacher preparation and classroom teaching. Verify the practical application value of AI painting technology through experimental data and system evaluation. Design an AI drawing technology-enabled teaching experiment to reveal the positive effects of AI-assisted teaching.

2. The design of oil painting art generation system based on computer image processing technology

2.1. Mathematical Modeling of Artistic Painting Drawing

2.1.1. Mapping process

The drawing of an art painting is the product of combining a person's/painter's subjectivity with objective things. When a beautiful scene enters a person's brain, the human brain will analyze the painting of the image just obtained from the objective world, first of all, it is to divide the image, divide the objects inside one by one, and then to determine the before and after relationship of the objects, and different people will get different division results and before and after blocking relationship according to their different cognition or importance to different objects in the scene, reflecting each person's individuality; after that, the brain will decide the sequence and primary and secondary relationship of each object drawn during the painting. Different people will get different segmentation results and before and after blocking relationships according to his/her different perception or emphasis on different objects in the scene, reflecting the individuality of each person, which then determines the sequence of each object and the primary and secondary relationships in painting, which only completes the first step of parsing; after that, the brain will be further subdivided to analyze the main structure of each object to determine the direction of the main structure of the painting, i.e., the position and direction of the brush, and then further think according to the direction of the main structure. According to some painters who have been engaged in the art industry for a long time and teachers who teach painting, the relationship between the brush direction of the other parts of a painting and the brush direction of the main structure close to it is very big, and the human brain gets the brush direction of the non-structural parts according to this relationship, which is the whole process of painting analysis.

Accordingly, there also exists a color change process, which is also a personalized process, which reflects a person's habit, mood, and perspective of looking at problems and the world, for example, some people like a picture to be dominated by cold colors, like blue, cyan, while some people are inclined to warm colors, like red, yellow, etc., which is closely related to the individual's personality and mood, and the human brain produces new colors based on the general color habit plus the prevailing The human brain produces new colors according to the general color habits plus the state of mind at that time, realizing the personalized color transformation from objective to subjective.

After the painting analysis and color transformation, people get an art painting in their own brain, know what color to use in any position of the canvas and what direction to paint, and then it is expressed through the brush stroke by stroke.

This completes the drawing of an art painting. By summarizing this process, this paper uses four models to simulate the process of generating art paintings, and the process of generating art paintings is shown in Figure 1.

Among them, the directional field model is to represent the process of painting resolution, the color model is to get the personalized color to provide pigment for painting, and the brush model and the placement model represent the process of really starting to paint onto the canvas.

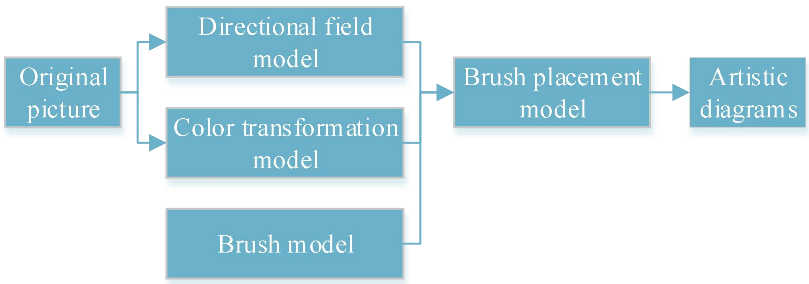

Figure 1. The process of generating artistic paintings.

2.1.2. Drawing the model

In order to further explain the process of generating art paintings and reach the final computer simulation, this paper abstracts it into a mathematical process as shown in Figure 2.

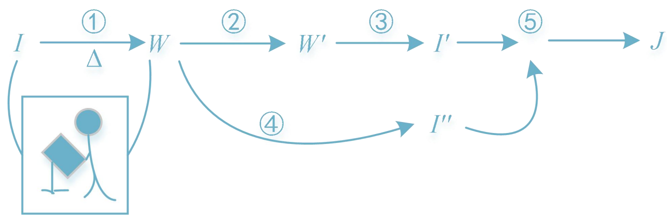

Figure 2. The mathematical process of generating artistic paintings.

This mathematical process, is mathematically depicted in Fig. 1, where 1, 2, and 3 denote directional field models, 4 denotes a color transformation model, and 5 denotes a brush placement model. For the brush model is a pre-defined underlying model, which is obtained by collecting samples of various brushes from a class of painters for analysis and processing. From here on, this section focuses on further mathematical analysis of the directional field model, the color transformation model, and the brush placement model.

(1) Directional field model

The directional field model is shown in Figure 3. The model is divided into 3 layers: object level segmentation of the image referred to as ("image layering"), main structure analysis, and direction diffusion.

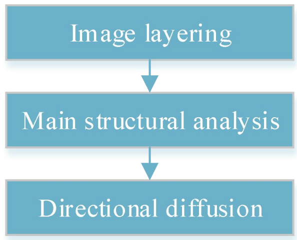

Figure 3. Direction field model.

1) Image Layering

A picture I consists of multiple layers, each layer consists of multiple objects and the former layer occludes the latter layer, each person has their own different interpretations of the same picture, so there is a certain amount of interaction here in the hope of achieving the maximum play of personalization, as in equation (1).

$$W = \pi(I) \tag{1}$$

The π denotes that a personalized picture consisting of multiple objects with occlusion relations is obtained through simple editing by the user according to his/her own point of view.

2) Main structure analysis

After obtaining different objects, each object is then analyzed to obtain the main structure of each object, as in equation (2).

$$W' = \arg\max P\left(I \mid W'\right) P\left(W'\right) \tag{2}$$

In this paper, we use the Bayesian formula to find the main structure of an object, where W' refers to the main structure of an object, and I denotes the diagram of an object segmented from the original diagram. The formula obtains the main structure part of an object by finding the maximum joint probability distribution, $P\left(W'\right)$ is the prior probability and $P\left(I \mid W'\right)$ is the likelihood probability.

3) Orientation diffusion

When the main structure part of the object is obtained, the direction of the brushes at any position of the main structure can be obtained, but it is not possible to determine for the other parts of the object, because the other parts are generally texture or noise or something like that, and according to the guidance of the professionals who have been engaged in the painting for a long time, the analysis concludes that the non-primary structure part is greatly influenced by the main structure part. So, this thesis defines a direction probability smoothing term $p\left(V_{\Lambda nsk} \mid V_{\Lambda sk}\right)$, and the direction of the non-primary structural part is obtained by finding the maximum probability as in equation (3).

$$p\left(V_{\Lambda nsk} \mid V_{\Lambda sk}\right) \propto \prod_{v \in \Lambda nsk} \exp\left\{ -\sum_{v \in \Lambda nsk} \sum_{u \in \partial v} e\left(\tau_v, \tau_u\right)^2 / \lambda_\theta \right\} \tag{3}$$

Λnsk denotes the non-primary structural part of the object;

Λsk denotes the main structural part of the object;

∂v denotes the 4-neighborhood or 8-neighborhood of position V;

$e\left(\tau_v, \tau_u\right)$ denotes the distance between the two directions, and the squared term denotes the energy, the smaller the energy the higher the probability, and also indicates the influence of the direction of the primary structure on the non-primary structure.

The required directional field is when the probability of the whole object is maximized, when the total energy is minimized. Therefore, this thesis constructs a diffusion model of the directional field according to the principle of energy diffusion to solve this problem.

(2) Color transformation model

Since each person has different color perception and preference, the transformation model in this paper is not static, with human interaction, but has a basic reference model, which is a statistical model obtained by counting the characteristics of thousands of existing oil paintings.

(3) Brush placement model

After having the directional field and color transformation model, it is necessary to start deciding the order of the brushes, because an unreasonable order will bring unsightly effects. For this reason, this paper defines an energy formula specifically for the order of brush placement for objects in the same layer, as in equation (4).

$$J_n = \arg\min \sum_{i=1}^{k} \left[\rho_{po_i} \left(I^*, J\left(m_i, l_{ij}, \theta_{ij}\right)\right) + \lambda_i \, \text{Bias}\left(I_i^*\right) \right] \tag{4}$$

where:

po_i denotes different objects;

m_i denotes the number of brushes;

l_{ij} denotes the type of brush;

θ_{ij} denotes the attributes of the brushes, such as color, length, and so on;

ρ_{po_i} denotes the distance between the result and the original image, here in this paper, we use histogram comparison to get it;

$Bias\left(I_i^*\right)$ This is the defined dithering parameter, the purpose is to be a richer picture.

Then, the final brush placement order is obtained by minimizing its energy. Similarly, by further expansion, layer by layer, we can get the result of all the layers and finally get the desired art painting.

2.2. Algorithm for oil painting generation

Receive the source image in real time and evaluate the nature of the image, i.e., color image vs. grayscale map, convert to grayscale map if color image and take sample points if grayscale map.

Color image is converted to grayscale map i.e.:

$$Q_1 = 0.30 * R + 0.59 * G + 0.12 * B \tag{5}$$

Q_1 represents the grayscale value of a grayscale map pixel point; R, G, and B represent the red, green, and blue channel color values of a color image pixel point.

$$Q_2 = \frac{30 * R + 150 * G + 77 * B + 255}{256}$$
$$Q_2 = (30 * R + 150 * G + 77 * B + 255) \gg 8 \tag{6}$$

Q_2 represents the grayscale value of the pixel point of the grayscale map; R, G, and B represent the red, green, and blue channel color values of the color image pixel point, and $\gg 8$ represents the shift to the right by 8 bits.

Raster based approach oriented grayscale map to obtain sample points with random offset. Divide the grayscale map into multiple rasters, each raster contains 7*7 pixels; take the vertices of each raster as the sampling points; generate random values between the range of 1-3, the sampling points in the horizontal position are offset by 3 times of the random value, and in the vertical position are offset by the random value. Horizontal position offset and vertical position offset calculation formula that is:

$$Offset_x = 3 * [Rand()\%3] \tag{7}$$

$$Offset_y = Rand()\%3 \tag{8}$$

$offset\_x$ represents the horizontal position offset; $offset\_y$ represents the vertical position offset; $Rand()\%3$ represents the remainder of the division of the random variable by 3, i.e., a random value in the range of 1-3.

The horizontal and vertical position offsets are added for the horizontal and vertical positions of the sampled points.

Using the grayscale value of the sampled point as a carrier, the horizontal and vertical edge operators are used to calculate the gradient of the sampled point's position. Matrix multiplication of horizontal edge operator and gray value of the sampled point is used to obtain horizontal edge intensity; similarly, vertical edge intensity is obtained. Where, the horizontalward edge operator and verticalward edge operator are both 3*3 Sobel operators, and:

$$T_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ 1 & 0 & 1 \end{bmatrix} T_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{9}$$

Based on the horizontal and vertical edge intensity of the sampling point, the gradient of the sampling point is calculated. The specific direction of the stroke is calculated by the gradient, and the vertical direction of the gradient is the direction of the stroke, i.e:

$$\alpha = \frac{\pi}{2} - \theta \tag{10}$$

The θ represents the sampling point gradient direction.

Taking the core of the sampling point location, the pixels in the 3*3 neighborhood are selected as the window, and the window edge intensity calculation is performed by the 45°ward edge operator and the 135°ward edge operator, i.e.:

$$c(x,y) = C_1 * I(x,y) + C_2 * I(x,y)$$
$$C_1 = \begin{bmatrix} 1 & -1 & -1 \\ -1 & 4 & -1 \\ -1 & -1 & 1 \end{bmatrix} C_2 = \begin{bmatrix} -1 & -1 & 1 \\ -1 & 4 & -1 \\ 1 & -1 & -1 \end{bmatrix} \tag{11}$$

C_1 represents 45° toward edge operator; C_2 represents 135° toward edge operator; $I(x,y)$ represents the window pixel point; $c(x,y)$ represents the window edge intensity.

Specify the stroke radius by pre-storing a table of edge intensity versus radius relationships.

Take the pixel value of the corresponding position of the sampling point on the source image as the brush pixel value.

Draw the sample point based on the stroke direction, radius, and pixel value, and set drawing annotations for all positions to identify the specific drawing status of the corresponding position.

Changes the drawing annotation.

3. Strategies of Artificial Intelligence Painting Technology Empowering Oil Painting Art Education

In oil painting art education, the application of AI painting technology needs to run through the whole process of teaching, especially for the two core aspects of teacher preparation and classroom teaching to design a differentiated strategy to achieve the deep integration of technical tools and educational goals.

3.1. Strategic innovations at the stage of teachers' lesson planning

(1) Dynamic generation of materials, empowering resource acquisition. Under the traditional model, teachers are often faced with a single art material, which limits the curriculum design of aesthetic education teachers and the development of students' artistic cognition. Generative AI painting technology can dynamically generate diversified, high-quality art materials, covering a wide range of art styles from classical to modern, providing teachers with unlimited and flexible resource support. Based on Dewey's theory of "experiential education", these diversified materials can help students deeply understand the differences between different art styles through visual interaction, and enhance their artistic perception and cognitive integration ability. For example, teachers can use generative AI drawing tools to generate works of different art genres to enrich the teaching content and meet students' individual needs, thus stimulating students' creativity and artistic understanding more efficiently.

(2) Optimize the process of lesson planning and empower the efficiency of lesson planning. Traditional aesthetic education teaching preparation takes a long time, especially in the collection of cross-cultural art or complex art styles, which is prone to inefficiency and lack of flexibility. Generative Artificial Intelligence painting technology can simplify the lesson preparation process and improve the efficiency of lesson preparation by automatically generating diversified art materials that match the teaching objectives.

3.2. Strategic innovations in the classroom teaching phase

(1) Free creation of works to empower students' inspiration. Traditional inspirational teaching is often

difficult to inspire students due to insufficient resources and low student participation. Generative AI painting technology helps students observe the changes of works at any time through intuitive creation tools, deepening their understanding of art creation and stimulating creative inspiration. For example, in the “Oil Painting Design” course, students can use generative AI drawing tools to generate preliminary illustrations, and adjust and optimize them according to different style requirements. This process not only cultivates students' artistic expression and creative thinking, but also saves the cost of teaching materials.

(2) Enhance classroom interaction and empower cooperative co-creation. In traditional aesthetic education teaching, the interactivity of classroom teaching and students' teamwork ability are weak, and the communication between teachers and students mostly stays on simple work display and discussion, lacking diversified interactive links and collaborative creation. Generative AI painting technology provides new possibilities for interactive teaching. Teachers can use the tool to generate diversified design solutions, and students analyze the impact of color matching and layout on the atmosphere of the oil painting through the tool, actively participate in artistic creation and enhance aesthetic perception. On this basis, the teamwork task further develops students' communication and collaborative creative skills, and enhances their understanding and application of artistic styles. This teaching mode combining artificial intelligence and teamwork not only promotes the improvement of students' artistic practice ability, but also fits the concept of modern preschool education focusing on interaction and team learning, which can promote the overall development of students' comprehensive quality.

(3) Personalized teaching evaluation, empowering independent learning. The traditional teaching evaluation of aesthetic education focuses on post-course corrections and lacks real-time and personalized feedback in the classroom, limiting students' ability to understand their own learning progress in a timely manner, thus affecting the enhancement of students' independent learning ability. Generative AI tools provide teachers with personalized feedback support by accurately analyzing the composition, color and other elements of students' works.

4. Application Analysis of Artificial Intelligence Painting Technology Enabling Oil Painting Art Education

4.1. Analysis of the effect of oil painting generation

Ten groups of images (numbered A1 to A10) were selected for the experiment. Images were generated respectively by using the regional stroke algorithm based on image segmentation and the algorithm proposed in this paper. Each group of experiments was conducted at the same image segmentation level. The comparison results of the relevant experimental data are shown in Table 1. Under the same image segmentation conditions, compared with the traditional regional stroke algorithm based on image segmentation, the algorithm proposed in this paper significantly reduces the running time, with an average reduction of more than 80% and a maximum reduction of 94.1%. Meanwhile, the stroke flexibility of the algorithms in this paper has significantly improved, generally reaching a "good" level, while the comparison algorithms are mostly "average" or "poor".

Table 1. Comparison results of experimental data.

Image	Image size	Region stroke algorithm based on image segmentation		The proposed	
		Running time(s)	Stroke flexibility	Running time(s)	Stroke flexibility
A1	128×256	9.237	Generally	0.548	Good
A2	256×256	11.464	Generally	0.924	Good
A3	300×300	13.637	Generally	1.548	Good
A4	300×360	15.052	Poor	2.011	Good
A5	384×616	18.226	Poor	2.937	Good
A6	640×360	19.035	Poor	3.162	Good
A7	1200×675	34.115	Poor	5.491	Good
A8	1080×1080	48.626	Poor	5.973	Good

A9	1200×1080	79.153	Poor	7.251	Good
A10	1920×1080	91.606	Poor	7.912	Good

4.2. System Performance Evaluation and Optimization

In this paper, the oil painting generation system performance evaluation scheme adopts a hierarchical testing architecture to validate the model computational efficiency, image generation quality and system response performance. The evaluation scheme focuses on three core dimensions: the model computational efficiency evaluation focuses on the reasoning speed and resource consumption of different batch sizes, and seeks for the performance balance point by adjusting the number of parameters and computational accuracy; the image generation quality evaluation builds an objective evaluation system based on the FID scores and the CLIP scores; and the system response performance evaluation includes the request processing latency, the queuing time of the tasks, and the efficiency of the resource scheduling. The data collection module records CPU utilization, GPU utilization and memory usage to construct performance evaluation benchmarks; quantitative model testing evaluates the performance of INT8 and FP16 precision configurations; concurrent performance testing evaluates the load balancing capability; resource scheduling evaluation verifies the scheduling strategy of GPU resource pools; and system stability is verified through long-term operation testing.

4.2.1. Analysis of indicators for systematic assessment

The system performance evaluation adopts a multi-dimensional quantitative analysis method, establishes an evaluation system from three dimensions: computational efficiency, generation quality and service performance, and reveals the room for improvement and optimization direction of the system performance through benchmarking and optimization comparisons of key indicators. The performance test data comprehensively reflects the performance level of the system at all levels, and the comparison results of the system performance evaluation indexes are shown in Table 2. The system optimization significantly improves the computational efficiency, the inference speed is reduced from 3.4 seconds to 0.76 seconds, the GPU memory occupation is greatly reduced, the image generation quality is improved, the FID and CLIP scores are improved by 42.86% and 54.24% respectively, the concurrent processing capacity is improved by 477.78%, and the service success rate is maintained at a high level. The optimization results laid a performance foundation for the application of oil painting generation system.

Table 2. Comparison results of system performance evaluation indicators.

Evaluation indicator	Reference value	Optimized value	Improvement percentage(%)
Reasoning speed(s/page)	3.4	0.76	77.65
CPU memory usage(GB)	12.3	3.9	68.29
FID score	30.1	17.2	42.86
CLIP score	0.59	0.91	54.24
Average response time(s)	4.1	1.2	70.73
CPU utilization(%)	58	93	60.34
Concurrent processing capacity (req/s)	9	52	477.78
Service success rate(%)	97.6	100	2.40

4.2.2. Optimization Strategy and Effectiveness Verification

Based on the bottlenecks identified in the performance evaluation, an all-round optimization plan is formulated. The optimization strategy covers three dimensions: structural optimization at the model level, resource scheduling optimization at the system level, and quality enhancement at the service level. The comparison results of the system optimization strategies are shown in Table 3, and the various optimization measures have achieved significant results in practical applications. The system performance test data shows that the model parameters are compressed by 57.41% while the processing efficiency is improved by 253.66%, the improvement of the cache hit rate optimizes the data access efficiency, the shortening of the fault recovery time and the improvement of the system stability meets the standard, and the improvement of the resource utilization efficiency and the peak number of concurrencies proves that the system can effectively cope with high loads and provide protection for the large-scale deployment of software.

Table 3. Comparative results of system optimization strategy effects.

Optimization project	Initial value	Optimized value	Performance gain(%)
Model parameter size(GB)	16.2	6.9	57.41
Batch throughput(page/s)	0.41	1.45	253.66
Cache hit rate(%)	46	93	102.17
Fault recovery time(ms)	971	8	99.18
Average processing delay(s)	5.3	0.9	83.02
System stability(%)	98.6	100	1.40
Resource utilization efficiency(%)	60	95	58.33
Peak concurrent number(users)	79	371	369.62

4.3. Analysis of Artificial Intelligence Drawing Technology Enabling Teaching Practices

This paper adopts a two-factor mixed experimental design, focusing on the effects of teaching methods (artificial intelligence painting technology-assisted teaching and conventional teaching) and teachers' teaching experience (more than five years or less than two years of teaching experience) on the effectiveness of teaching oil painting art.

Four classes of first-year students majoring in oil painting at a university in a certain city were selected for the teaching study. The students in the four classes received AI-assisted teaching from teachers with short teaching experience (experimental group 1), AI-assisted teaching from teachers with long teaching experience (experimental group 2), regular teaching from teachers with short teaching experience (control group 1), and regular teaching from teachers with long teaching experience (control group 2), respectively. The content of the lesson was “symmetry”, and the goal of the lesson was to help students understand the meaning of “symmetry” in art and apply the knowledge to art practice. The study aimed to test two main hypotheses through the performance of students in the four classes with different teaching ages and teaching methods: first, AI-assisted teaching has a significant impact on students compared to conventional methods; second, the implementation of AI-assisted teaching is influenced by teachers' experience in teaching.

Students' classroom performance was evaluated on-site by experts, and was rated in terms of aesthetic expression, interest in learning, thinking development, and pleasurable feelings on a scale of 1 to 10. The higher the score, the better the performance. The assignments of the four groups of students, on the other hand, were graded by five teachers after random coding in seven aspects, namely, point-of-view understanding, point-of-view extension, vivid image, harmonious and moving, novel and creative, free flow and values, with scores also ranging from 1 to 10.

4.3.1. Student performance in the classroom

Experts' evaluation of the classroom performance of the four groups of students is shown in Table 4. By analyzing the scores of the four groups of students in the classroom in the four aspects of aesthetic expression, learning interest, thinking development and pleasurable feelings, we found that the experimental group performed better than the control group in both aesthetic expression and thinking development. Among them, there is a significant difference between the scores of the experimental group of teachers with short teaching experience and the control group on thinking development ($t=5.112$, $p=0.021$), and there is a significant difference between the scores of the experimental group of teachers with long teaching experience and the control group on aesthetic expression ($t=6.038$, $p=0.002$). In addition, the experimental group of teachers with long teaching experience was better than the control group in both pleasurable feelings and learning interest. By analyzing the classroom performance of the experimental and control groups, it can be seen that AI-assisted teaching has a significant effect on promoting students' aesthetic expression and thinking development compared to conventional teaching, but how the teaching methodology and the teaching experience work together in teaching and learning needs to be further analyzed.

Table 4. Evaluation of students' classroom performance in four groups.

		AI assisted teaching	Conventional teaching
Aesthetic expression	Short teaching years	8.1	4.6
	Long teaching years	5.9	2.8
Pleasant feeling	Short teaching years	8.5	8.8
	Long teaching years	9.3	7.6
Learning interest	Short teaching years	7.1	7.5
	Long teaching years	7.8	7.0
Thought development	Short teaching years	7.8	5.7
	Long teaching years	6.5	6.5

4.3.2. Student performance on assignments

The results of the analysis of the effects of different teaching methods and teaching age on viewpoint comprehension and viewpoint extension are shown in Tables 5 and 6, respectively. The present study analyzed the ANOVA on the scores of the students' work in four classes in seven aspects, namely, viewpoint understanding, viewpoint extension, vivid image, harmonious and moving, novel and creative, free flow and values, and the main effect of teaching method on viewpoint understanding was highly significant ($F=40.284, p<0.01$), and the mean of the experimental group (7.26/7.04) was significantly higher than that of the control group (4.98/5.71), and the interaction effect between teaching method and teaching age was significant ($F=6.138, p=0.01$). And the interaction effect between teaching method and teaching age was significant ($F=6.138, p=0.019$). In the perspective extension dimension, the main effect of teaching method was extremely significant ($F=261.375, p<0.01$), and the mean of the experimental group (6.94/6.01) was much higher than that of the control group (3.02/3.27), with a significant interaction effect ($F=5.227, p=0.028$). The results of the experiment showed that, first, regardless of the teacher's teaching experience, students who received AI-assisted instruction outperformed those who received conventional instruction in viewpoint comprehension and viewpoint extension, where the differences were highly significant. Second, in both classes receiving regular instruction, students of teachers with long teaching experience performed better on viewpoint comprehension and extension than students of teachers with short teaching experience, suggesting that teaching experience plays a greater role in regular instruction. However, the opposite was true for the two classes that received AI-assisted instruction, suggesting that teaching experience was not a determining factor in the effectiveness of AI-assisted instruction, which demonstrates the versatility of AI-assisted instruction. Third, the experimental group performed better on the dimension of aesthetic factors than the control group, but the difference was not significant, which indicates that there is a certain mediating effect of aesthetic factors on students' development.

Table 5. The impact on point of view understanding.

	Teaching experience	Mean value	Standard deviation	Quantity	F(1,124)	Significance
Conventional teaching	Short teaching years	4.98	1.937	39		
	Long teaching years	5.71	1.623	40		
AI assisted teaching	Short teaching years	7.26	1.026	40		
	Long teaching years	7.04	1.518	41		
Teaching method main effect					40.284	0.000
Teaching experience main effect					0.098	0.692
Teaching method×Teaching experience					6.138	0.019

Table 6. The impact of viewpoint extension.

	Teaching experience	Mean value	Standard deviation	Quantity	F(1,124)	Significance
Conventional teaching	Short teaching years	3.02	1.475	39		
	Long teaching years	3.27	1.162	40		
AI assisted teaching	Short teaching years	6.94	1.147	40		
	Long teaching years	6.01	1.623	41		
Teaching method main effect					261.375	0.000
Teaching experience main effect					3.018	0.162
Teaching method×Teaching experience					5.227	0.028

4.3.3. Student satisfaction

In order to validate the interactive performance and user satisfaction of the system in this paper in real-world usage scenarios, the completed ASQ task questionnaires and the final system usability scale were collected from 81 students in the experimental class after they completed six typical task processes.

The ASQ contains three questions, scoring each question from 1 to 7, with lower scores indicating higher satisfaction and better ease of use, and the overall score being the arithmetic mean of the three item scores. User scores of 1 to 3 are considered satisfactory, and it is determined that the upper limit of the confidence interval is greater than 3 when modification of the program needs to be considered, and the results of the ASQ data are shown in Table 7. The average ASQ scores for the six typical tasks were below the threshold, and none of the 95% confidence intervals crossed the threshold. The difference between the lowest score, F5, and the highest score, F6, was only 0.41, indicating a balanced experience across sessions.

Table 7. ASQ data results.

Process	Average score (/7)	Confidence interval (95%)	Whether the satisfaction threshold is exceeded (>3)
F1	1.69	[1.42,2.06]	No
F2	2.01	[1.71,2.52]	No
F3	1.98	[1.58,2.36]	No
F4	1.76	[1.47,2.09]	No
F5	2.06	[1.82,2.55]	No
F6	1.65	[1.37,1.98]	No
F7	1.72	[1.42,2.35]	No

The SUS test results are shown in Table 8. The system obtained an average score of 78.91/100 in the SUS usability test, which belongs to grade B (Excellent Experience) according to the usability scoring scale. This score indicates that the system performs well in terms of functional integration, operation guidance, and learning feedback, and the subject users are positive about the system's interaction rhythm, task logic and learning support structure.

Table 8. Results of SUS test.

Number of people	Total number	Average value	Standard deviation	Minimum value	Maximum value
81	6392	78.91	9.28	65	100

5. Conclusion

In this paper, an oil painting generation system is constructed to deeply explore the integration path of artificial intelligence painting technology in oil painting art education.

Under the same image segmentation conditions, compared with the traditional oil painting generation algorithm, the algorithm proposed in this paper significantly reduces the running time, shortening more than 80% on average, up to 94.1%. At the same time, the flexibility of the strokes of the generated oil paintings is significantly improved, generally reaching the “good” level, while the comparison algorithms are mostly ‘fair’ or “poor”. After system optimization, the model parameters are compressed by 57.41% while the processing efficiency is improved by 253.66%, the improvement of cache hit rate optimizes the data access efficiency, the shortening of the failure recovery time and the improvement of the system stability meet the standard, the improvement of the resource utilization efficiency and the number of peak concurrency proves that the system can effectively cope with the high load, which provides a guarantee for the large-scale deployment of the software.

In teaching practice, the experimental group outperformed the control group in both aesthetic expression and thinking development. There was a significant difference between the scores of the experimental and control groups of teachers with short teaching experience on thinking development ($t=5.112$, $p=0.021$), and between the scores of the experimental and control groups of teachers with long teaching experience on aesthetic expression ($t=6.038$, $p=0.002$). The main effect of teaching method on point-of-view comprehension was highly significant ($F=40.284, p<0.01$), with the mean of the experimental group (7.26/7.04) being significantly higher than that of the control group (4.98/5.71), and there was a significant interaction effect of teaching method with teaching age ($F=6.138, p=0.019$). In the perspective extension dimension, the main effect of teaching method was extremely significant ($F=261.375, p<0.01$), with the mean of the experimental group (6.94/6.01) far exceeding that of the control group (3.02/3.27), and the interaction effect was significant ($F=5.227, p=0.028$). The mean ASQ scores for the six typical tasks were below threshold, and none of the 95% confidence intervals crossed the threshold. The system received an average score of 78.91/100 on the SUS usability test, which is a B grade.

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