www.cad-journal.net
Computer-Aided Design AND APPLICATIONS™

Aesthetic Analysis and Re-creation of Fine Arts Lines Based on Hough Transform in CAD Interactive Environment

Hua Zhang[1] and Xiongfei Min[2]

[1]Academy of Fine Arts, Weinan Normal University, Weinan, Shaanxi 714099, China, zhanghua@wnu.edu.cn
[2]School of Physical Education, Weinan Normal University, Weinan, Shaanxi 714099, China, minxiongfei@wnu.edu.cn

Corresponding author: Xiongfei Min, minxiongfei@wnu.edu.cn

Abstract. In artistic creation, a computer-aided design (CAD) interactive environment provides rich tools for graphic editing and drawing and has strong data management and analysis capabilities. In the field of image processing, the Hough transform, as a classical image processing method, can detect specific shapes in images efficiently. This article aims to explore the aesthetic analysis and re-creation method of lines in artworks based on Hough transform. First of all, by analyzing the aesthetic characteristics of lines in artworks, a set of objective and quantitative evaluation criteria is established, which provides a scientific basis for the aesthetic analysis of lines. Then, using Hough transform technology, the lines in artworks are accurately detected in a CAD interactive environment, which provides basic data for subsequent line re-creation. On this basis, a line re-creation method based on the Hough transform is proposed. By adjusting the geometric characteristics of lines and combining the artist's aesthetic concept, artistic works are generated that not only maintain the original style but also incorporate new ideas. The results show that this method can effectively extract the line information in artworks and generate artistic re-created works.

Keywords: CAD Interactive Environment; Hough Transform; Lines of Art Works; Aesthetic Analysis; Line Re-Creation
DOI: https://doi.org/10.14733/cadaps.2025.S2.14-26

1 INTRODUCTION

In the vast ocean of art, works of art attract the attention of countless people with their unique charm and profound connotations. Among them, lines, as one of the basic elements of artworks, not only bear the artist's thoughts but also constitute the key to the aesthetic feeling of the picture [1]. However, how to make an in-depth aesthetic analysis of the lines of artworks and recreate them on this basis has always been a hot topic in cross-research in the art field and computer vision technology. In the interactive CAD environment, artists can edit, modify, and create works of art more conveniently, which greatly improves the efficiency and quality of artistic creation. The accuracy of machined components is undoubtedly a key factor in precision manufacturing in all industries [2]. Researchers constantly update and optimize their processing equipment in order to capture and maintain the aesthetic characteristics of this art line. In the process of mechanical processing, environmental fluctuations and time factors often become the main challenges affecting the accuracy of artistic lines. Some scholars have paid special attention to the hot abrasive jet machining using fluidized bed systems at different abrasive temperatures. Aesthetic image content analysis is one of the important research directions in the field of emotion computing, and abstract image emotion recognition is a challenging and important branch of AICA [3]. Moreover, it can expand the application scenarios of abstract images and visual elements in daily life, and assist in the creative work of generative AI, which has important theoretical and practical significance. Abstract images are composed of low-level visual features such as colour, texture, and shape, and humans cannot recognize the objective subject they depict. In previous studies, traditional methods have struggled to bridge the emotional semantic gap, while neural network-based methods have been limited by the difficulty of training on small datasets. In addition, common aesthetic image emotion recognition methods often focus too much on high-level semantics and ignore the characteristics of abstract images themselves, lacking differentiation from large-scale AICA tasks in terms of thinking. The image style concept in style transfer tasks defines the low-level visual information contained in aesthetic images, which is semantically similar to abstract images [4]. Extract content images from the FI dataset using the original dataset as aesthetic style images, and perform style transfer based on MetaStyle for data augmentation. To classify abstract images based on emotions, it is necessary to establish a connection between low-level visual information of aesthetic images and human cognitive emotional semantics and to cross deeper emotional semantic gaps.

At present, the general public improves their cultural literacy and pursues spiritual satisfaction by visiting art exhibitions, art galleries, and other means. It is difficult to understand the thoughts and emotions conveyed by writers through their works and appreciate the style of artistic works without professional explanations [5]. For the general public, due to their lack of professional artistic literacy and solid painting knowledge foundation. People can only appreciate art through online means, such as digital museums, but lack professional guides. Therefore, computer technology is needed to assist amateur enthusiasts in understanding artistic works, thereby promoting the development of research on style classification of painting images. Some scholars focus on abstract image emotion recognition that integrates style features. Concepts related to style transfer tasks and methods for extracting image style features, as well as the application of style features in emotion recognition tasks [6]. At the same time, a summary of relevant work was conducted, and the shortcomings of existing traditional methods and new deep learning methods were analyzed. Finally, the inspiration source and work overview of the proposed solution were provided. It provides a complete introduction to the entire process of the proposed new solution for abstract image emotion recognition. Propose a new abstract image emotion recognition neural network model and introduce the design details of its various modules. Summarize the existing data augmentation methods and provide a detailed description of the new style transfer data augmentation method proposed in this paper. Firstly, the overall idea and module design criteria of ConvNeXt were introduced. Then, the implementation methods of key modules such as the inverse bottleneck residual block, stem module, and independent downsampling module were described. Moreover, different styles in the same period or region often influence each other, resulting in a certain degree of similarity [7]. Although some works have different choices of painting themes, they belong to the same painting style. Artists often incorporate historical and cultural elements from their place of origin into their artwork, thus the style of the artwork is often influenced by its place of origin and time. In the task of style classification of painting images, the content of painting images has a significant degree of randomness and may have painting images of the same subject matter [8].

The popularity of graphic flat design has never faded. The graphic flat design captures the public's attention with concise and concise graphic symbols, clear information hierarchy, and bold colours, and is favoured by designers. Whether in logo design, packaging design, poster design, or illustration design, graphics are one of the most important elements in design works. In order to better integrate graphic flat design into graphic design works and seek the perfect integration of function and form beauty, this article will deeply explore the origin, development process, and style characteristics of graphic flat design style [9]. Starting from three aspects of graphic design, graphic special effects design, and graphic colour, this study delves into how to transform graphic design from three-dimensional to flat, from concrete to abstract, how to choose colour tones, and how to match colours in graphic flattening design. From interface design to logo design and packaging design, graphic flat design has emerged in various design fields, which not only reflects people's aesthetic changes but also the transformation of contemporary designers' design thinking and design language. The flat design of graphics is highly praised and favoured by designers, which naturally has its advantages, but it does not mean that it is suitable for application in all designs. The systematic study of graphic flattening design methods will provide a theoretical basis for future research on graphic flattening design applications from the perspective of visual communication, which has academic and practical significance [10]. Summarize the principles that graphic flat design should follow in the field of visual communication from three aspects: functional principles, visual language principles, and audience emotional needs. Finally, selecting logo design, poster design, and packaging design from the perspective of visual communication as the focus of exploration, combined with graphic flattening design cases, the summarized methods and principles are applied and analyzed to make the theoretical research results of the article more convincing and credible.

The research significance of this article lies in: on the one hand, it provides a scientific basis for the aesthetic analysis of lines in artworks through objective and quantitative evaluation criteria of aesthetic characteristics; On the other hand, the line re-creation method based on Hough transform provides new technical support for artists and helps to promote the innovation of art creation.

In terms of research methods, this article adopts a combination of theoretical analysis and experimental research. First of all, through combing and summarizing the relevant literature, the theoretical framework of aesthetic analysis of lines in artworks is established. Then, in the interactive environment of CAD, Hough transform technology is used to detect and extract lines in artworks, and the effectiveness of evaluation criteria and re-creation method is verified by experiments.

In terms of expected results, I hope to provide a new method for the aesthetic analysis and re-creation of lines in artworks. Through an in-depth study of the aesthetic characteristics and re-creation technology of lines in artworks, we can provide more creative inspiration for artists and promote the diversified development of art creation.

(a) The article first emphasizes the importance of lines as the basic elements of art creation. Lines not only shape shapes but also carry emotions and styles.

(b)Hough transform can accurately detect lines and shapes in images, which provides an effective tool for line analysis of artworks.

(c) The interactivity of CAD technology provides a convenient creative platform for artists, which makes the editing, modification and re-creation of artistic works more efficient.

(d) Through the classification and recognition of the aesthetic features of lines, the constructed model has realized a deeper understanding of lines in artworks.

This article first introduces the research background, purpose and significance through the introduction, and then expounds on the importance of lines in artworks and the application of CAD technology in artistic creation. Then, a line re-creation method based on the Hough transform is proposed, and the effectiveness of the method is verified by experimental results and case analysis. Finally, the research results and contributions are summarized, and the future research direction is prospected. This article aims to provide new ideas for aesthetic analysis and re-creation of lines in artworks through CAD interactive environment and Hough transform technology.

2 RELATED WORK

Fractal art line segments, as a unique form of artistic expression, have the charm of filling space in non-traditional ways through fractal boundary polygons with self-similarity. In this process, line aesthetic analysis provides us with a new perspective on understanding the composition and visual effects of these shapes. It shows how isosceles right-angled triangles cleverly construct a magical world where fish contract uniformly at the boundaries. The lines not only form the boundaries of the graphics in the f tile but also give the graphics vitality and energy through their direction, density, and variation. Popa et al. [11] conducted in-depth research on the local star-like structure of f-tilings and listed four pattern shapes composed of kite or dart-shaped prototypes. The layout and variation of lines in graphics not only affect the overall visual effect of the graphics but also reflect the mathematical principles and aesthetic pursuits behind the graphics. It also introduces a method of integrating line aesthetic analysis to achieve shapes similar to Escher and explore the unique role of lines in it. Each pattern attracts our attention with its unique self-similarity and fractal boundaries. Next, a fast packaging algorithm was established to visualize the effect. This algorithm not only achieves efficient rendering of tiles but also enables us to observe and analyze the performance of lines more intuitively. It displays the generated graphics library, similar to Escher. These graphics not only showcase unique charm but also create a magical and rhythmic visual effect through the clever use of lines. In this process, line aesthetics analysis provides us with guiding principles for optimizing line layout and changes, enabling us to create graphics that better meet aesthetic requirements. In order to facilitate the creation of shapes similar to Escher, we further explored the one-to-one mapping relationship between squares, kites, and darts. This mapping relationship enables us to pre-design square templates and obtain all considered prototypes through simple transformations. The aesthetic analysis of lines plays a crucial role here, enabling us to have a deeper understanding of the important role of lines in graphic creation and explore more innovative and expressive creative techniques.

As a core field in the software industry, image processing not only continues to develop in the IT environment but also plays an indispensable role in industrial design. From the perspective of graphic analysis, this application can generate a series of fractal images with unique aesthetics. Pradhan and Dhupal [12] focus on a specially developed fractal generation model and use it as a case study to improve efficiency, further combining line aesthetics analysis to explore new directions in image processing. The increasing popularity of large-scale computing systems highlights the need for efficient computing power, especially when dealing with complex graphics and images. These images not only showcase the harmonious unity between mathematics and nature but also convey unique artistic charm through complex line structures and colour changes. The Mandelbrot set, as a complex mathematical set, generates images full of endless changes and beauty. Soori and Asmael [13] introduced the software structure and implementation of generating fractal images using Mandelbrot sets. Through a detailed analysis of the lines in the generated fractal image, we found that the direction, thickness, density, and interaction with other lines have a profound impact on the overall beauty of the image. This method not only improves computational efficiency but also significantly enhances the beauty of details and lines in generated images. From the perspectives of programming and processor level, the implementation details of this process were analyzed in depth, and the performance differences under different methods were compared. In the process of optimizing algorithms and generating images, the aesthetic factors of lines are fully considered, striving to make the generated images conform to mathematical principles and have high artistic value. This software not only has high flexibility and scalability but also significantly improves computational efficiency through parallel computing technology. At the same time, we also provide rich test packages for the generated environment to ensure the stability and reliability of the software.

In the classroom of art education, artificial intelligence and machine learning have gradually replaced traditional teaching methods, becoming a new driving force to stimulate students' creativity. Wenjing and Cai [14] analyzed the use of GTMA to evaluate the best art design based on artificial intelligence and machine learning. It is particularly noteworthy that the introduction of information technology enables designers to create more productive and expressive artworks with less time and energy. Machine learning and human emotions, these seemingly contradictory elements, exhibit astonishing harmony and interaction in art and design. This combination enables artworks to more accurately convey human emotions and emotions, bringing viewers a deeper artistic experience. In the process of creating interactive intelligent digital art, artificial intelligence and machine learning not only help designers more accurately capture and express the aesthetic characteristics of lines. It also provides designers with more diverse creative inspiration and possibilities through algorithms and data analysis. As one of the core elements of artistic design, lines contain rich emotional information and aesthetic value in their changes in direction, thickness, curvature, density, and other aspects. In this process, the aesthetic analysis of lines plays a crucial role. Xiang et al. [15] reviewed and summarized the existing high-quality and high-precision art and design methods in the field of art and design. Yu et al. [16] used graph theory matrix methods to quantitatively analyze and compare the extracted features, providing designers with an accessible alternative ranking system. We extracted various features related to aesthetic analysis of lines from existing literature, which not only cover the basic characteristics of lines, but also include advanced features such as layout, combination, and variation of lines in artistic works. This system not only helps designers quickly find the most suitable combination of line aesthetic features for their creative needs but also provides designers with more creative inspiration and ideas.

3 CAD INTERACTIVE ENVIRONMENT AND HOUGH TRANSFORM

3.1 CAD Interactive Environment

In the field of CAD, an interactive environment is a platform for information exchange and operation between users and computer systems. With its intuitive, efficient, and flexible characteristics, CAD interactive environment is widely used in architectural design, mechanical design, electronic design, artistic creation, and other fields. In artistic creation, a CAD interactive environment provides rich tools for graphic editing and drawing and has strong data management and analysis capabilities.

The main functions of a CAD interactive environment include drawing, editing, measuring, analyzing, and data management. Among them, the graphic drawing function allows users to draw various graphic elements directly on the screen, such as points, lines, surfaces, bodies, etc., through input devices such as mouse and keyboard. The editing function allows users to modify, move, rotate, and scale the drawn graphics. The measurement and analysis function can be used to measure the size, calculate the area, calculate the volume, and analyze the complex space. The data management function can store, query, retrieve, and output graphic data.

In artistic creation, the application of CAD interactive environment is mainly reflected in the following aspects: through CAD interactive environment, artists can more conveniently carry out creative ideas, sketch drawings and details modification. The interactive CAD environment provides rich graphic display and rendering functions, which enables artists to preview and adjust the effect of works in real time during the creative process. The interactive CAD environment supports the digital creation process, including digital sketch, digital rendering, digital output, and other links, which makes the works of art easier to save, spread, and display.

3.2 Hough Transform Theory

Hough transform is a feature detection technology widely used in image processing, and it is especially good at detecting geometric shapes such as lines and circles in images. Its basic principle is to map the points in the image space to the parameter space and detect the specific shape in the image by finding the peak points in the parameter space.

The basic principle of the Hough transform is to map points in image space to parameter space through a voting algorithm. Taking line detection as an example, the Hough transform maps every point in the image space to a line in the parameter space, and the parameters of this line (such as slope and intercept) represent all possible lines passing through this point in the image space. Then, the cumulative value of each point in the parameter space (that is, the number of votes) is counted. The higher the cumulative value, the more straight lines exist in the image space. Therefore, by finding the peak point in the parameter space, the straight line position in the image space can be determined.

The implementation steps of the Hough transform mainly include the following aspects:

Edge detection: Firstly, edge detection is performed on the input image to extract the edge information in the image.

Parameter space mapping: Map the edge points obtained by edge detection into the parameter space to form a parameter space image.

Peak detection: look for the peak points of accumulated values (votes) in the parameter space image, and these peak points correspond to the straight line positions in the image space.

Line extraction: According to the parameter information of the peak point, the corresponding line is extracted in the image space.

The advantage of the Hough transform is that it is robust to noise and partial occlusion in the image and can accurately detect shapes such as lines and circles in the image. However, the Hough transform also has some shortcomings, such as a large amount of calculation and poor detection effect for complex shapes. In addition, the parameter setting of the Hough transform will also have a great influence on the detection results, which need to be adjusted according to the specific application scenarios.

4 LINE RE-CREATION BASED ON HOUGH TRANSFORM

4.1 Line Reconstruction Algorithm

Through this hierarchical drawing process from large to small and from coarse to fine, the thickness and distribution of lines can be flexibly adjusted based on maintaining the original style, bringing brand-new visual effects and creative elements to the works. Figure 1 shows the intuitive process of this layered drawing. From the large strokes at the bottom to the medium strokes in the middle layer, and then to the small strokes in the upper layer, each layer carries different information and aesthetic values, which together constitute a complete work of art.

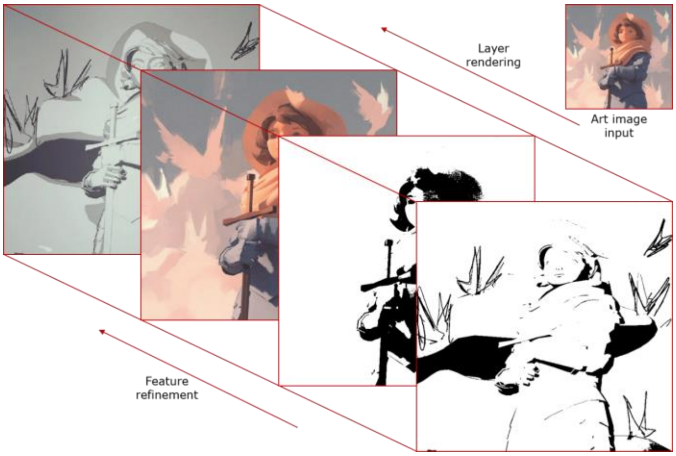

Figure 1: Layered rendering process.

Firstly, the artworks are preprocessed to improve the accuracy of subsequent line detection. Using a bilateral filter to denoise the image while preserving the edge information;

$$I_{\text{bilateral}} = \sqrt{I_{\text{intensity}}^2 + I_{\text{gradient}}^2} \tag{1}$$

Where $I_{\text{bilateral}}$ represents the image after bilateral filtering, $I_{\text{intensity}}$ represents the intensity of the image, and I_{gradient} represents the gradient of the image.

Next, the Hough transform is used to detect the lines in the image. Hough transform is an effective line detection method which can transform lines in an image into points in parameter space:

$$R=\sqrt{x^2+y^2} \tag{2}$$

$$\theta=\arctan\left(\frac{y}{x}\right) \tag{3}$$

Where x,y represents a point in the image, R represents the distance from the point to the origin, and θ represents the included angle between the point and x axis.

In order to improve the accuracy of line detection, it is necessary to optimize the detected line parameters. In this study, the RANSAC algorithm is used to optimize the line parameters to reduce the influence of noise on line detection:

$$\hat{x}=\frac{1}{n}\sum_{i=1}^{n}x_i \tag{4}$$

$$\hat{y}=\frac{1}{n}\sum_{i=1}^{n}y_i \tag{5}$$

$$\hat{A}=\frac{1}{n}\sum_{i=1}^{n}\left(x_i-\hat{x}\right)\ y_i-\hat{y} \tag{6}$$

$$\hat{B}=\frac{1}{n}\sum_{i=1}^{n}\ y_i-\hat{y} \tag{7}$$

Where $\left(\hat{x},\hat{y}\right)$ represents the center point of the line, A and B represent the slope and intercept of the line, and n represents the number of points participating in the optimization.

After the parameters are optimized, the lines are analyzed aesthetically. Evaluate the length, direction and curvature of lines. The formula is as follows:

$$L=\sqrt{\ \Delta x^{\ 2}+\ \Delta y^{\ 2}} \tag{8}$$

$$\theta=\arctan\left(\frac{\Delta y}{\Delta x}\right) \tag{9}$$

$$\kappa=\frac{1}{L}\arctan\left(\frac{\Delta y}{\Delta x}\right) \tag{10}$$

Where L represents the length of the line, θ represents the direction of the line, and κ represents the curvature of the line.

According to the aesthetic analysis results of lines, re-create lines to achieve better aesthetic effects;

$$C=a\cdot I+b \tag{11}$$

$$W=c\cdot I+d \tag{12}$$

Where C represents the colour of the line, W represents the width of the line, and a , b , c and d represents the adjustment parameters.

In the process of line re-creation, you can interact with users and make real-time adjustments according to users' needs. The formula is as follows:

$$I_{\text{after adjustment}}=I_{\text{original}}\cdot adjust \tag{13}$$

Where $I_{\text{after adjustment}}$ represents the adjusted image, I_{original} represents the original image and $adjust$ represents the adjustment factor.

After the line detection results are obtained, it is necessary to design a line reconstruction algorithm to recreate based on these lines. The algorithm mainly includes the following steps:

Line feature detection: key features such as length, direction and curvature are extracted from the detected lines. These characteristics will be the basis of the subsequent re-creation process.

Drop lines and grouping: According to the characteristics of lines, they are classified and grouped. Similar or similar lines can be combined to form a more complex line structure.

Line optimization and adjustment: According to the artist's creativity and aesthetic concept, the extracted lines are optimized and adjusted. This includes changing the length, direction, curvature, and other parameters of lines to generate new line combinations.

Line fusion and re-creation: fuse the optimized lines with the original works of art to generate new works of art. In the process of integration, it is necessary to maintain the original style and artistic conception and, at the same time, introduce new creative elements.

4.2 Re-Creation Strategy

Graphic flat design often uses bright colours, retro colours, and monochrome schemes in colour application. Bold colour choices and rich visual impact can effectively convey information to people. The use and combination of sans serif fonts, the shape of graphic symbols, and the control of the number of graphic symbols all affect the optimization of information hierarchy. The use of retro colours provides people with a softer emotional enjoyment and liberates the audience visually. Layout design is also of utmost importance in graphic flattening design. Due to the use of the simplest visual elements in graphic flattening design. The change in brightness of a single colour can help users understand the content and hierarchy of information more quickly, making their visual flow clear and distinct and rapidly improving the efficiency of information acquisition. In addition, the perfect combination of bright and warm tones makes the audience very comfortable and joyful. Bright colors have considerable visibility in both bright and dark backgrounds and can quickly capture people's attention. Therefore, in typesetting, it is also necessary to uphold a minimalist layout style, and in flat layout design, use the relationship between colour brightness and darkness. In addition, in flat design, it is common to see the art form of "leaving blank," which brings users a simple and neat visual enjoyment and can more clearly grasp the key information. The blank layout provides people with more breathing and imagination space, making the information itself more prominent and making the visual effect of the picture full of tension.

5 ALGORITHM IMPLEMENTATION AND VERIFICATION

The extracted lines are used for re-creation experiments to observe whether the generated works meet the expected aesthetic requirements.

Using Hough transform technology, the lines in the experimental samples are accurately detected and classified. By adjusting the parameters of the Hough transform, different types of lines, such as straight lines and curves, are successfully extracted, and they are classified and marked. Based on the line detection results of the Hough transform and the aesthetic evaluation model, this study carried out the line re-creation experiment. By adjusting the length, direction, curvature, and other parameters of lines, a line combination is generated that not only maintains the original style but also incorporates new ideas. Professional artists and audiences were invited to evaluate the effects of recreated works.

Figure 2 shows the effect comparison of the whole correction process in detail. From left to right: the initial image, the filtered image, and the final effect after visual error correction. Through comparison, we can clearly see that the corrected image effectively eliminates visual errors while retaining the artistic style and details of the original, making the picture clearer and more realistic.

(a) Initial image (b) Filter effect image (c) Correction effect image

Figure 2: Visual error correction effect diagram.

Figure 3 shows the statistical results of drop line accuracy based on the Hough transform. Our method can accurately identify the line types in the works and achieve high classification accuracy. This proves the validity of the Hough transforms inline detection of artworks.

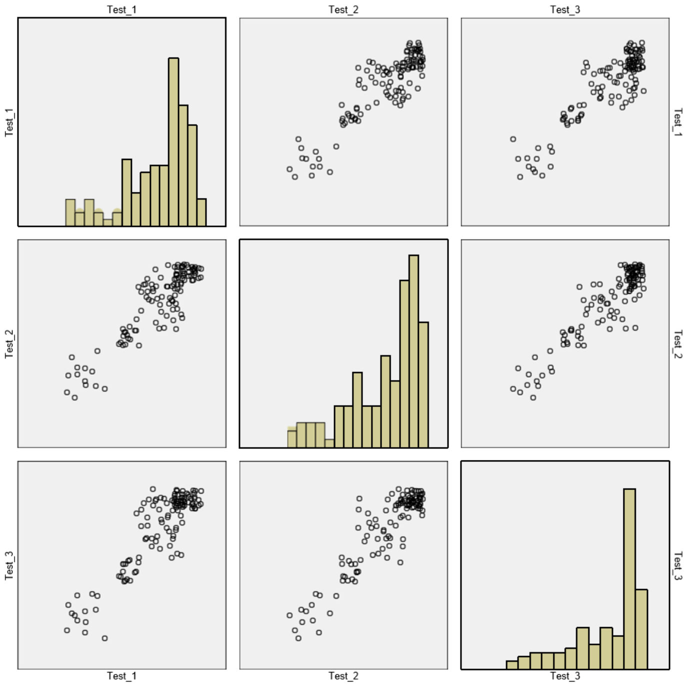

Figure 3: Classification accuracy of the model.

Figure 4 shows the classification recall of the model. Compared with the classification accuracy, the recall measures the recognition ability of the model to real positive cases. Our model achieves a high recall while maintaining a high accuracy, which further verifies the effectiveness of the model.

Figure 5 shows the output error of the model. The output error here refers to the deviation between the adjustment of line parameters and the expected goal in the process of re-creation. The output error of the model is small, which shows that our re-creation method can accurately achieve the expected artistic effect.

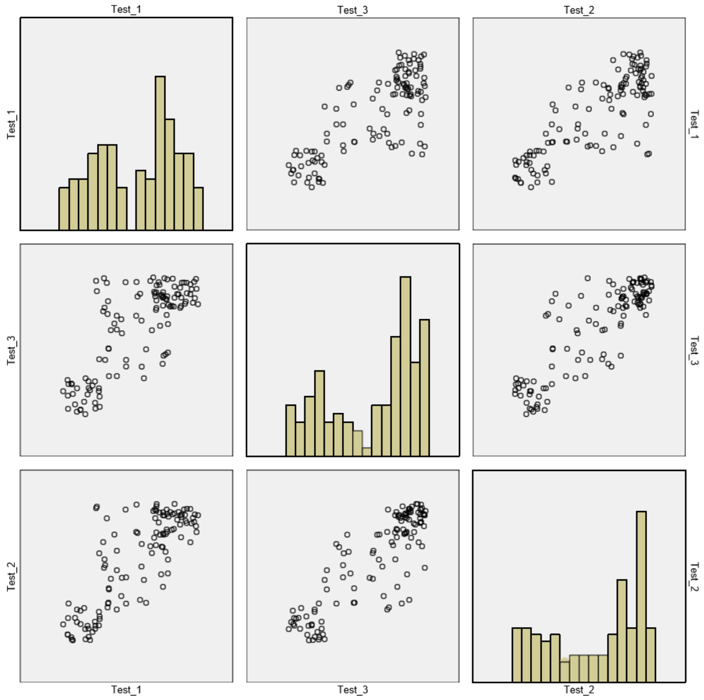

Figure 4: Classification recall of the model.

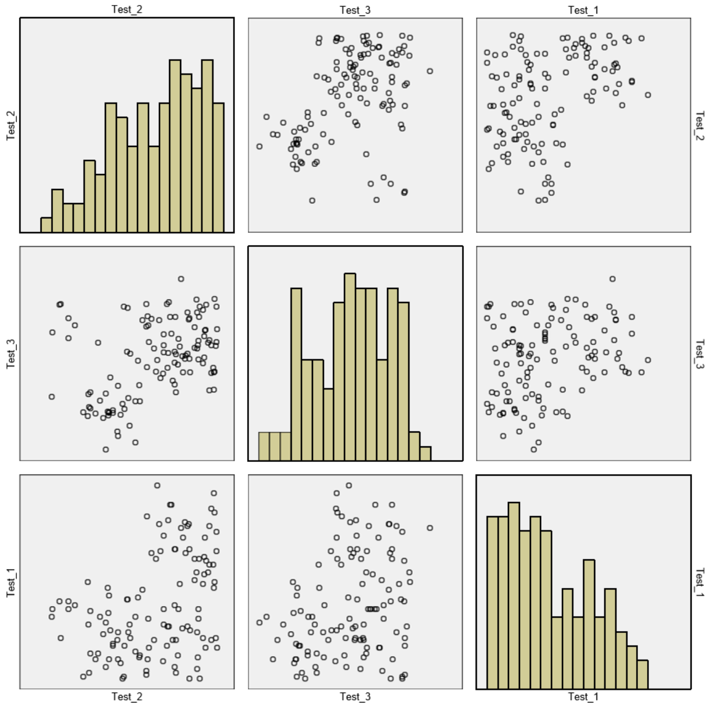

Figure 5: Output error of the model.

Figure 6 shows the audience's evaluation of the line aesthetics of artworks. Several audiences were invited to rate the recreated works, and they were evaluated from three aspects: the beauty of form, the beauty of structure and the beauty of dynamics. The audience's evaluation of re-created works is generally high, which proves that our method can generate artistic works that meet aesthetic requirements.

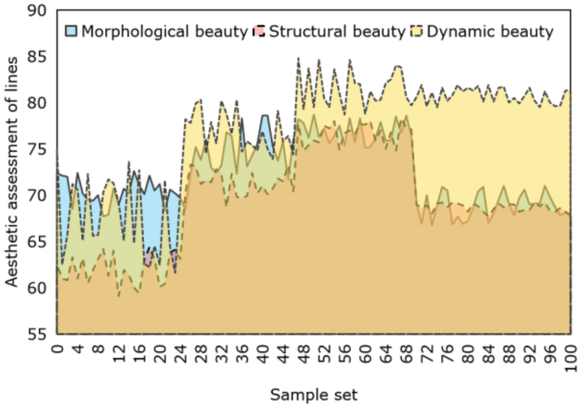

Figure 6: Aesthetic evaluation of lines in artworks.

In Figure 7, the rendering effect based on the Hough transform is compared with the existing rendering effect. As can be seen from the figure, the rendering effect based on the Hough transform introduces new creative elements while maintaining the original style, making the work more artistic and innovative. Compared with the existing rendering effects, our method can better preserve the aesthetic characteristics of the original lines and generate more vivid and natural artistic effects.

Figure 7: Comparison of rendering effects.

Through the above experiments and analysis, we can draw a conclusion that the aesthetic analysis and re-creation method of lines in artworks based on Hough transformation is an effective means of artistic innovation. It can not only accurately detect and analyze the aesthetic characteristics of lines in artworks, but also re-create them based on these characteristics, and generate artworks that not only maintain the original style but also incorporate new ideas.

6 CONCLUSIONS

This article has introduced a novel method that allows us to analyze and recreate the lines of artwork in CAD (computer-aided design) software. Then, based on these features, we can redesign and create new works of art that not only retain the original style but also add new creativity and aesthetics. This method is based on a technique called the Hough transform, which can help us accurately "see" and "grasp" the lines in artwork. Through a series of in-depth analyses and experiments, we have developed an algorithm that, like a magician, can "extract" key features of lines from artwork. What's even more magical is that our method can also "repair" potential visual problems in artworks, making the images clearer and more vivid, further enhancing the overall beauty of the artwork. Simply put, it's like an artist having a magical brush that not only replicates the beauty of the original work but also creates new and more beautiful works based on it. This method provides artists with a new and interesting way of creating. In the future, we will continue to optimize the algorithm and expand the application scope in order to make more breakthroughs in the fields of art creation and computer vision.

Hua Zhang, https://orcid.org/0009-0008-3754-9001
Xiongfei Min, https://orcid.org/0000-0003-2116-9238

REFERENCES

[1] Bai, S.; Zhou, L.; Yan, M.; Ji, X.; Tao, X.: Image cryptosystem for visually meaningful encryption based on fractal graph generating, IETE Technical Review, 38(1), 2021, 130-141. https://doi.org/10.1080/02564602.2020.1799875

[2] Chao, H.: The fractal artistic design based on interactive genetic algorithm, Computer-Aided Design and Applications, 17(S2), 2020, 35-45. https://doi.org/10.14733/cadaps.2020.S2.35-45

[3] Gdawiec, K.; Adewinbi, H.: Procedural generation of artistic patterns using a modified orbit trap method, Applied Sciences, 12(6), 2022, 2923. https://doi.org/10.3390/app12062923

[4] Jin, H.; Yang, J.: Using Computer-Aided Design Software in Teaching Environmental Art Design, Computer-Aided Design and Applications, 19(S1), 2021, 173-183. https://doi.org/10.14733/cadaps.2022.S1.173-183

[5] Kumari, S.; Gdawiec, K.; Nandal, A.; Kumar, N.; Chugh, R.: An application of viscosity approximation type iterative method in the generation of Mandelbrot and Julia fractals, Aequationes Mathematicae, 97(2), 2023, 257-278. https://doi.org/10.1007/s00010-022-00908-z

[6] Liu, F.; Yang, K.: Exploration of the teaching mode of contemporary art computer-aided design centered on creativity, Computer-Aided Design and Applications, 19(S1), 2021, 105-116. https://doi.org/10.14733/cadaps.2022.S1.105-116

[7] Nakamura, K.: Iterated inversion system: an algorithm for efficiently visualizing Kleinian groups and extending the possibilities of fractal art, Journal of Mathematics and the Arts, 15(2), 2021, 106-136. https://doi.org/10.1080/17513472.2021.1943998

[8] Ormaz, D.; Sarkar, A.: SIMPM - Upper-level ontology for manufacturing process plan network generation, Robotics and Computer-Integrated Manufacturing, 55(11), 2019, 183-198. https://doi.org/10.1016/j.rcim.2018.04.002

[9] Ouyang, P.; Chung, K.-W.; Nicolas, A.; Gdawiec, K.: Self-similar fractal drawings inspired by MC Escher's print Square Limit, ACM Transactions on Graphics (TOG), 40(3), 2021, 1-34. https://doi.org/10.1145/3456298

[10] Pelliccia, L.; Bojko, M.; Prielipp, R.: Applicability of 3D-factory simulation software for computer-aided participatory design for industrial workplaces and processes, Procedia CIRP, 99(1), 2021, 122-126. https://doi.org/10.1016/j.procir.2021.03.019

[11] Popa, B.; Selișteanu, D.; Lorincz, A.-E.: Possibilities of use for fractal techniques as parameters of graphic analysis, Fractal and Fractional, 6(11), 2022, 686. https://doi.org/10.3390/fractalfract6110686

[12] Pradhan, S.; Dhupal, D.: An integrated approach of simulation, modeling and computer-aided design of hot abrasive jet machining setup, Journal of Advanced Manufacturing Systems, 21(03), 2022, 427-472. https://doi.org/10.1142/S0219686722500123

[13] Soori, M.; Asmael, M.: Classification of research and applications of the computer-aided process planning in manufacturing systems, Independent Journal of Management & Production, 12(5), 2020, 1250-1281. https://doi.org/10.14807/ijmp.v12i5.1397

[14] Wenjing, X.; Cai, Z.: Assessing the best art design based on artificial intelligence and machine learning using GTMA, Soft Computing, 27(1), 2023, 149-156. https://doi.org/10.1007/s00500-022-07555-1

[15] Xiang, Z.; Zhou, K.-Q.; Guo, Y.: Gaussian mixture noised random fractals with adversarial learning for automated creation of visual objects, Fractals, 28(04), 2020, 2050068. https://doi.org/10.1142/S0218348X20500681

[16] Yu, C.; Altalbe, A.; Du, N.: Environmental landscape art design using dynamic nonlinear parameterization, Fractals, 30(02), 2022, 2240077. https://doi.org/10.1142/S0218348X22400771