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Computer-Aided Design AND APPLICATIONS

The Application of Computer Vision and CAD Technology in the Interactive Platform for Calligraphy Art

Hongbo Pan[1], Shunjie Pan[2] and Bo Pang[3]

[1]College of Teacher Education, Xinyang Normal University, Xinyang 464000, China, panpoe@xynu.edu.cn
[2]School of Software, Henan University, Kaifeng 475004, China, shunjiep@163.com
[3]School of Computer and Information Technology, Xinyang Normal University, Xinyang 464000, China, nothinghere2019@163.com

Corresponding author: Hongbo Pan, panpoe@xynu.edu.cn

Abstract. Computer vision is playing an increasingly important role in the analysis of calligraphy art. On the platform of artistic calligraphy development, visual CAD technology can build unique advantages for copying interactive platforms. This article proposes a precise analysis algorithm guidance for stroke features in CAD calligraphy technology. The complexity of artistic features in calligraphy works was algorithmically replicated using CAD technology. This method can provide detailed structural guidance for each stroke feature of artistic calligraphy. It can improve by 24% compared to traditional methods. This provides a good foundation for monitoring the characteristics of calligraphy under complex conditions. In addition, the SFA algorithm also has good algorithm stability in image rendering. It emphasizes a high level of performance, operational time, and stability while maintaining a high level of image rendering. The algorithm in this article can play a crucial role in replicating calligraphy art. Technical assistance can be provided on interactive platforms for calligraphy art and on calligraphy experience creation in a 3D calligraphy environment.

Keywords: Computer Vision; CAD; Calligraphy Art; Copying; Interactive Platform
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1 INTRODUCTION

The application of traditional calligraphy art forms in design makes the text arrangement more flexible. Here, designers are not limited to the consistency and accuracy of strokes but pay more attention to the aesthetic ideas presented in their visual presentation [1]. As a style of traditional cultural art, its unique brushstrokes are reflected in its external form, internal charm and artistic conception, and the interplay of virtual and real strokes. It is not only to combine traditional culture with modern design but also to explore the connotation of traditional culture, enhance the freshness of the visual experience, and make traditional culture more vibrant [2]. The feasibility of exploring calligraphy visual elements in font design through CAD lies in understanding the specific characteristics of calligraphy concepts and visual elements such as brushwork, typography, composition, and ink technique. Organize the characteristics of the calligraphy style and develop an understanding of the current application status of the calligraphy style behind the logo based on the characteristics of the calligraphy style [3]. Based on the principles of symbolic aesthetics, information communication layer, visual perception, and listing innovative cases of modern designers at home and abroad, the design principles of standardization, artistry, communication, and innovation are summarized. On this basis, the focus is on discussing how calligraphy visual elements can be combined with modern font design under the development of the times. In the investigation of visual communication design, problems were found in the application of logos, packaging, and signs. In the subsequent design practice, calligraphy visual elements were extracted, followed corresponding theories, and combined with practice for mutual verification of design creation. Convey corresponding design information, so that calligraphy art can express hidden meanings in the deep layers of national culture. Furthermore, the use of calligraphy elements in creative design is aimed at summarizing design methods. Its expressive techniques fully reflect the traditional aesthetic and artistic ideas of China, which are the sources of inspiration for contemporary designers. [4]

Font design is very important in visual communication design, which can be roughly divided into creative font design and typesetting font design. Among them, the application of calligraphy font design is relatively widespread. Based on the different characteristics of the calligraphy, design analysis can be carried out to understand the characteristics of the calligraphy, which can better express the content, style, and emotions of the design, thus achieving design for people. Typesetting font design refers to the commonly used font design for reading books, newspapers, web pages, etc. Creative font design refers to a more eye-catching and innovative title font design used for logos, bookbinding design, advertising design, web design, VI design, and other purposes [5]. On the other hand, CAD technology enables high-precision reproduction and customized creation of original works by utilizing vector representations and parametric stroke adjustments. This allows for effortless editing, modifying, and combining calligraphy strokes, leading to personalized calligraphy creations [6]. In the field of visual interaction in calligraphy art, traditional handwritten digitization methods such as image-based optical character recognition or systems using dedicated stylus and smart boards are used. The design of the smart pen prototype fully considers practicality and portability. It includes a regular ballpoint pen ink chamber, allowing writers to write smoothly like using a traditional brush. To address this issue, it proposes a compact intelligent digital pen, aiming to combine calligraphy art with modern technology to achieve a more natural and economical visual interaction experience. This intelligent digital pen not only recognizes common 36 alphanumeric characters, but more importantly, it can capture and recognize the unique, delicate, and expressive strokes and lines in calligraphy art [7]. Although they have achieved certain results, their high cost and dependence on specific devices have limited their popularity and application. Unlike traditional methods that only use inertial data, our system captures three-dimensional data of the writer's hand movement through built-in inertial force sensors, thereby more accurately restoring the dynamic and morphological beauty of calligraphy art. The entire device is cleverly integrated into a plastic bucket structure, which is both lightweight and easy to carry. After training and verification, the ViT network performed the best in calligraphy art character recognition tasks, with a verification accuracy of 99.05%. This result not only demonstrates the potential of our intelligent digital pen in the field of visual interaction in calligraphy art but also provides strong support for subsequent research and application [8].

To explore new possibilities in the field of visual interaction in calligraphy art. In the wave of digitization, we realize that many calligraphy art archives are still stuck in the paper stage due to historical reasons, which is not conducive to preservation or widespread dissemination. In the experiment, it was found that the recognition rate of the model remained stable between 93% and 98%, and its performance was not inferior to the current state-of-the-art models. It hopes to provide an efficient and economical solution for the digital protection and visual interaction of calligraphy art through this study [9]. And can achieve efficient handwritten text recognition with limited computing resources. This means that even without high-performance computing hardware, our model can run stably, providing a broader application space for the digitization and visual interaction of calligraphy art. In order to achieve this goal, a large amount of Khmer calligraphy and handwriting data collected from previous experiments were utilized, and in-depth analysis was conducted using state-of-the-art technology. More importantly, due to the compact design of our model, the computational power requirements typically associated with deep learning have been significantly alleviated. Firstly, by accurately recognizing handwritten texts, we can better preserve and inherit historical documents of calligraphy art, allowing more people to appreciate these precious artistic treasures [10]. The visual interaction of calligraphy art will usher in a broader development prospect. Secondly, we can further explore the visual expression and interactive experience of calligraphy art, providing calligraphy art enthusiasts with more diverse and interesting interactive methods. In the future, the application of calligraphy in visual image design will still be the mainstream form. Based on the theory of calligraphy aesthetics and the multifaceted nature of calligraphy beauty, this study aims to address the aforementioned issues. Creatively summarize the four-step method of applying calligraphy form beauty in visual image design and apply it in practice. Based on the analysis of the relationship between calligraphy form beauty and style, extract aesthetic elements that can highlight the characteristics of calligraphy form beauty, and build the connection between form beauty and visual image design. By analyzing the application of calligraphy form beauty in classic visual image design [11]. Innovatively propose a bridge connecting the beauty of calligraphy form and visual image design, allowing the application of calligraphy form beauty in visual image design to inject more expansion space. Theoretical and technical research on the application of calligraphy form beauty in visual image design. Summarizing the aesthetic characteristics and compositional characteristics of calligraphy form beauty from the inside out, from the surface to the inside, and deeply summarizing the beauty of the "first form" and "second form" of calligraphy. Research on calligraphy and visual image design mostly starts from one aspect of calligraphy form, and there are relatively few theoretical achievements on the application of calligraphy form beauty systems in visual image design [12]. Lastly, based on practical requirements and application contexts, we'll develop an interactive platform for calligraphy art analysis and reproduction, validating its efficacy and practicality through rigorous experimentation.

Through our research, we aspire to address some of the challenges encountered in the preservation and promotion of calligraphy art, fostering its widespread adoption in modern society. Additionally, we hope our findings can offer valuable insights for the preservation of other cultural and artistic domains.

This article initially presents the evolving application of computer vision and CAD technology in the realm of calligraphy art. Following this, it provides an extensive breakdown of the design concepts, system algorithm execution, case studies, and practical uses of the interactive platform designed for calligraphy art analysis and replication. In conclusion, the article highlights its primary accomplishments and contributions, acknowledges any research flaws or constraints, and outlines potential future research paths by summarizing and anticipating future trends.

2 RELATED WORK

In the field of visual interaction in calligraphy art, and the robustness of convolutional neural networks (CNN) in recognizing and understanding calligraphy works, Liu and Yang [13] proposed a cost function that integrates adaptive sensitivity and robustness terms. This discriminative ability enhances inter-class distance, which corresponds to the biological definition of simple cells in the visual system, which is the ability to recognize fundamental differences between different objects. Firstly, the sensitivity term plays an important role in the cost function, particularly focusing. In the art of calligraphy, even subtle differences in brushstrokes may represent completely different styles or meanings. This innovation not only focuses on the basic accuracy of image recognition but also emphasizes the complexity and subtlety of simulating the human visual system in the perception of calligraphy art. The design of the robustness term is precisely to address these challenges by developing more stable CNN structures to cope with various interferences and interferences. To achieve this goal, Ott et al. [14] use a gradient descent algorithm to adaptively adjust as well as network parameters. Through the collaborative work of two optimizers, the accuracy and robustness of the model can be dynamically balanced during the training process. This adaptive adjustment mechanism enables our model to better adapt to the complexity and diversity of visual interaction in calligraphy art. The robustness term is equally crucial in the cost function. In the art of calligraphy, due to differences in personal style, paper quality, lighting conditions, and other factors, calligraphy works may undergo certain degrees of deformation or distortion.

In the field of calligraphy art analysis, although many classification algorithms based on Convolutional Neural Networks (CNN) have been proposed, these algorithms often face common challenges in practical applications, such as filter size selection, data preparation quality, dataset constraints, and noise interference. In the art of calligraphy, the thickness, length, shape, and other characteristics of strokes are crucial for classification. Shen et al. [15] combined knowledge in the field of calligraphy art to calculate the size of the effective receptive field. These challenges are particularly important for the precise classification of calligraphy art, as calligraphy art has rich details and subtle artistic styles. These data not only increase the computational burden on the network but may also lead to misleading results. Secondly, we value the quality of data preparation. In the analysis of calligraphy art, data often contains a large amount of redundant information and variables unrelated to the target variable. By calculating the ERF, we can better understand the effective range of the network in capturing these features, and thus choose a more suitable filter size. This will help the network extract calligraphy art features more accurately and improve classification accuracy. In the analysis of calligraphy art, it is often difficult to obtain high-quality datasets, which limits the performance of classification algorithms. Wang and Chen [16] explored more data augmentation methods tailored to the characteristics of calligraphy art, such as simulating the writing styles of different calligraphers, simulating the texture and creases of paper, and so on.

In the field of calligraphy art analysis, human-computer interaction also pursues natural and convenient methods. In the microcontroller, we integrate deep learning algorithms to perform real-time inference and recognition of calligraphy art elements expressed by users through finger writing. And send these distance data in real-time to the low-power microcontroller STM32F401 for processing. Yahya et al. [17] proposed a sensor array. To verify the effectiveness and accuracy of the system, we collected rich data from 21 subjects (including 12 males and 9 females), covering various writing styles, speeds, and calligraphy art levels. The system utilizes ToF sensors to capture the distance changes between the writer's fingers and the surface, as they move at specific time intervals within a specific writing area (such as 9.5 x 15 centimeters). In the context of informatization, digital technology has changed the traditional way of design creation, and visual image design language with digital features has become the dominant style. The excessive use of many visual elements has impacted the expression of traditional Chinese cultural connotations in visual image design. In the late 1990s, designers were more adept at using computer software for design, using a large amount of unified design materials and dazzling rendering effects. A large number of works with technical stacking features have emerged in visual image design [18].

3 CALLIGRAPHY ART ANALYSIS AND COPYING INTERACTIVE PLATFORM DESIGN

3.1 Overview of Platform Design

In order to realize these functions, the platform will adopt advanced computer vision and CAD technology and combine the professional knowledge of calligraphy art to build an interactive environment integrating analysis, copying, creation, and communication.

3.2 Platform Function Design

The calligraphy art recognition and analysis module uses computer vision technology to preprocess, extract features and identify styles of the input calligraphy works. First of all, through image preprocessing technology, the noise and interference factors in the image are removed, and the key feature information such as stroke trajectory, speed and strength of calligraphy works are extracted.

Finally, based on deep learning technology, the extracted features are trained and learned, and the style of calligraphy works is automatically recognized.

The application module of CAD technology carries out digital reconstruction and parametric adjustment on the recognized calligraphy strokes. Firstly, according to the extracted stroke feature information, the corresponding stroke trajectory is drawn by CAD software. Then, through the parametric adjustment function, the thickness, length and curvature of strokes can be finely adjusted to achieve high-precision copying of the original. In addition, the module also supports the combination and editing of multiple strokes to meet the personalized creative needs of users. Figure 1 shows an application example of CAD technology in calligraphy copying.

Figure 1: Application example of CAD technology in calligraphy copying.

The real-time feedback and guidance module of the copying process captures the stroke trajectory and strength information of users in the copying process in real time, compares it with the original, and gives corresponding feedback and guidance. When users copy, the platform will calculate the difference between the user's strokes and the original strokes in real time and give corresponding suggestions according to the difference. In this way, users can know their own copying situation in time and make targeted improvements according to the feedback. The real-time feedback indicators of the copying process are shown in Table 1.

Index	*Describe*
Stroke accuracy	The overlap between the user's stroke trajectory and the original stroke trajectory
Consistency of strength	The similarity between the user's stroke intensity and the original stroke intensity
Structural integrity	The similarity between the structure of user-copied works and the original structure

Table 1: Real-time feedback indicators of the copying process.

The calligraphy exhibition and communication module provides an online platform for calligraphy exhibition and communication, and users can upload their own copied works or creative works to the platform to share and communicate with other users. The platform also provides social functions such as likes, comments, and forwards to facilitate user interaction.

In order to realize the above functional design, the platform will adopt advanced computer vision and CAD technology. The platform will use the deep learning framework to build a calligraphy art recognition and analysis model, Using CAD software library to realize the digital reconstruction of calligraphy strokes. Real-time capture and feedback of the copying process are realized through sensors and image processing technology And using Web development technology to build an online calligraphy exhibition platform.

4 SFA ALGORITHM AND REALIZATION OF CAD TECHNOLOGY

4.1 SFA Algorithm

The SFA algorithm serves as the foundation for calligraphy art analysis, extracting crucial feature information through processing and analyzing calligraphy work images. These characteristics, such as stroke trajectory, stroke speed, stroke strength, and structural layout, collectively shape the distinctive style and allure of calligraphy pieces. Initially, calligraphy images undergo preprocessing, encompassing denoising, binarization, edge detection, and other procedures. These preprocessing steps eliminate interfering information from the image, enhancing the precision. The stroke trajectory of calligraphy works is extracted from the preprocessed image, typically achieved through contour detection, curve fitting, and similar techniques. The extracted stroke trajectory reveals the writer's unique writing habits and styles. Figure 2 illustrates the principle of stroke feature detection.

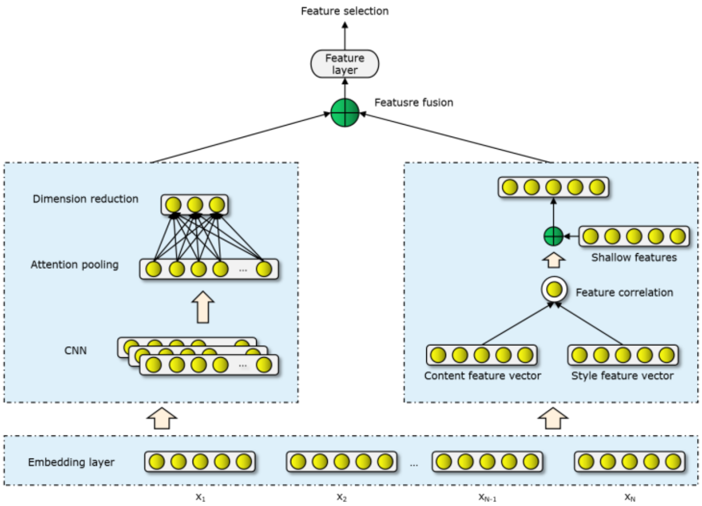

Figure 2: Principle of stroke feature detection.

CNN into SFA can achieve more accurate feature detection and classification of calligraphy images. First of all, we need to build an image data set containing a variety of calligraphy styles and strokes. This data set should contain enough samples so that CNN can learn the diversity of calligraphy images. So as to gradually extract the deep features of calligraphy images. After the training is completed, the CNN model is used to classify the features of calligraphy images. By inputting calligraphy images, the CNN model will automatically extract the key features in the images and map them into corresponding categories. Figure 3 illustrates the SFA optimization process utilizing CNN.

For a calligraphic creation, let us define $p(i)$ it as the probability histogram representation of the image, while i signifies the grayscale intensity within it. Furthermore, we introduce $0 \le i \le L$ a constant with a value of 1. The histogram's potential function can then be formulated in the manner described below:

$$P_H(k) = \frac{1}{P_{\max}} \sum_{i=0}^{L} \frac{P(i)}{1+\alpha(i-k)^2} \quad (1)$$

$$P_{\max} = \max\left\{ \sum_{i=0}^{L} \frac{P(i)}{1+\alpha(i-k)^2} \right\} \quad (2)$$

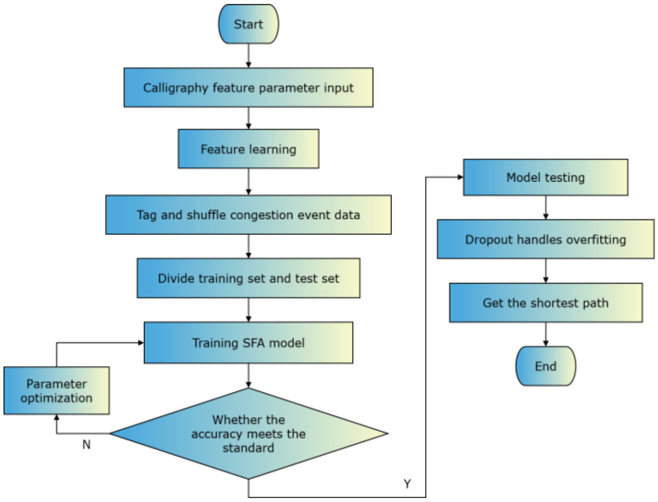

Figure 3: SFA optimization process.

In this context, α serves as a distinctive parameter. Now, considering the digital representation of a calligraphic artwork, we have the following image array:

$$I=\left[f(x,y)\right]_{m\times n} \tag{3}$$

Among them

$$\begin{cases} x\in\{0,1,2,3,\ldots,m-1\} \\ y\in\{0,1,2,3,\ldots,n-1\} \end{cases} \tag{4}$$

At a specific position within the image array (x,y), $f(x,y)\in\{0,1,2,3,\ldots,G-1\}$ represents the grayscale intensity of the pixel. Additionally, G denotes the maximum grayscale value present in the image I. The histogram depiction of the image I is subsequently formulated as follows:

$$h(i)=\sum_{x=0}^{m-1}\sum_{y=0}^{n-1}\delta\left(f(x,y)-i\right) \qquad i\in\{0,1,2,3,\ldots,G-1\} \tag{5}$$

Herein, the functions $\delta(0)=1$, $\delta(i\neq 0)=0$, and $h(i)$ respectively indicate the count of pixels within the image I that exhibit the grayscale value i.

By analyzing the change in stroke trajectory, we can further extract information on stroke speed and strength. This information can be obtained by calculating the length, curvature, acceleration and other parameters of the trajectory. The analysis of speed and strength can reveal the writer's emotions and state in the process of writing. In addition to the characteristics of strokes, the structural layout of calligraphy works is also one of its important characteristics.

4.2 Realization of CAD Technology

To mitigate the impact of noise, a smoothing operation is applied via convolution with an image function. One commonly employed smoothing method is the Gaussian smoothing function, which is defined as:

$$G(x,y,\sigma)=\frac{1}{2\pi\sigma^2}\exp\left(\frac{x^2+y^2}{2\sigma^2}\right) \tag{6}$$

As the adjustable parameter σ decreases, spatial positioning precision improves, yet suppression of high-frequency noise diminishes. To achieve a superior photo ensemble $V(p)$, patch filtering is executed utilizing the subsequent equation:

$$\left|V^*(p')\right|(1-g^*(p)) < \sum_{p \in U(p)} (1-g^*(p)) \tag{7}$$

Here, $U(p)$ designates the collection of patches that fail to satisfy the prescribed visual information criteria.

$$\Phi(p) = \begin{cases} 1, & p \in M \\ 0, & p \notin M \end{cases} \tag{8}$$

Direct application of this approach, however, tends to oversaturate the background, blending the subject and background indiscriminately. To address this, the present paper introduces a threshold to impose reasonable constraints. Consequently, during histogram computation, thresholds are assigned to grayscale pixels for statistical purposes:

$$p(\alpha_i) = \begin{cases} \dfrac{p}{h} & h_i > p \\ \dfrac{h_i}{h} & h_i < p \end{cases} \tag{9}$$

This equation $p(\alpha_i)$ signifies the likelihood of encountering a pixel with a grayscale value of i, while h stands for the aggregate count of pixels. α_i, on the other hand, represents the grayscale value assigned to the background.

During the calligraphy copying process, CAD technology facilitates real-time capture of the user's stroke data for comparison with the original. This comparative analysis enables the system to provide immediate feedback and suggestions for improvement, assisting users in mastering the original's brushstroke qualities and compositional structure. After copying is completed, CAD technology can also assess the quality of copied works. By comparing the differences between the original and the copied works in stroke trajectory, structural layout and so on, the system can give objective assessments and suggestions. Users can optimize the copied works according to these comments and suggestions.

4.3 Visual Elements of Text

Text is an important tool for people's communication and the most direct attribute of visual reception of signs. It can fully present the name of the design object. Some signs use text as the main graphic, but due to the regional limitations of the text, such signs. The visual elements of a logo include four aspects: main graphic design, text design, colour system design, and combination expression design. Regardless of the combination form of these textual symbols, they are essentially graphic applications of text and belong to the category of graphic design. This type of material can be in various forms such as concrete graphics, abstract graphics, Chinese characters, English letters, etc. In logo design, there are textual logos, Chinese logos, English logos, and prefix logos. It is a symbol of the elements that shape the visual image and personality of the design object. The design method determines the stability of the form and dissemination effect of the entire visual image expression. When designing the main graphics, in order to convey the image concept of the core idea of the design, it is first necessary to determine the element materials of the graphic design. The logo is the dominant factor in visual image design and also the centre of unified form for all visual elements. In the minds of the target audience, the logo represents the overall appearance of the organization being operated.

For users, this combination means that they can get more accurate and efficient calligraphy analysis and copying services. Whether for beginners or experienced lovers of calligraphy, the platform can provide personalized learning programs according to their needs. Through the analysis of the SFA algorithm and the reconstruction of CAD technology, users can deeply understand the essence of calligraphy art and constantly hone their skills in the process of copying.

5 ANALYSIS OF EXPERIMENTAL RESULTS

To thoroughly validate the SFA introduced in this article within the interactive platform for calligraphy art analysis and copying, a comprehensive set, not just the precision of the algorithm in detecting calligraphy features but also its performance in image rendering and quality evaluation of replicated calligraphy pieces.

Initially, decomposition experiments were performed on both classical and modern calligraphy images. As demonstrated in Figure 4, the SFA algorithm precisely extracts vital features like stroke trajectory and structural design of calligraphy works. This not only establishes a substantial database for future calligraphy analysis but also offers a precise benchmark for calligraphy replication.

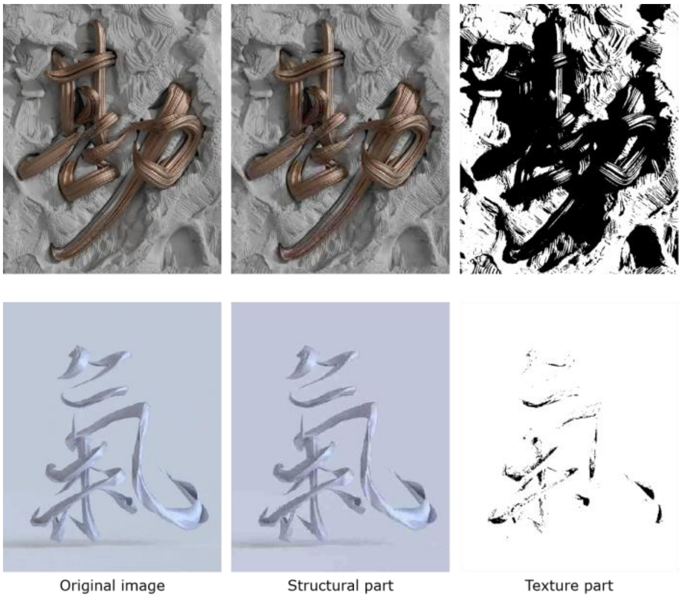

Figure 4: Calligraphy image decomposition.

To evaluate the precision of the SFA algorithm in detecting calligraphy features, a comparison was made with the conventional image rendering processing algorithm. As shown in Figure 5, the SFA algorithm has achieved remarkable advantages in precision testing. Compared with the control scheme, the accuracy of the SFA algorithm is improved by 24.87%, and it can detect the feature information of calligraphy strokes well.

To assess the image rendering capabilities of the SFA algorithm, a comparative analysis was conducted against the Contourlet transform algorithm and the Gravitational Potential Energy Clustering (GPEC) algorithm. Utilizing six distinct images, as depicted in Figure 6, the findings revealed that, although the GPEC algorithm's performance bears similarities to the SFA, its image rendering quality is occasionally inferior to the Contourlet transform due to divergence issues stemming from incorrect learning. The SFA algorithm has better stability and generalization ability while maintaining high PSNR.

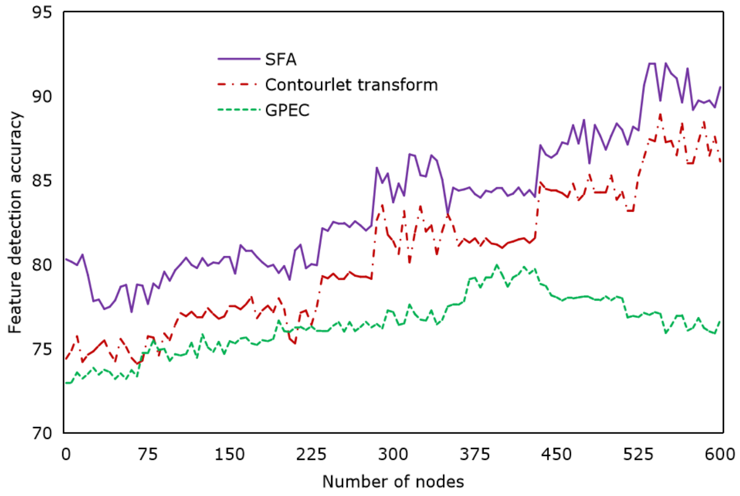

Figure 5: Accuracy of feature detection.

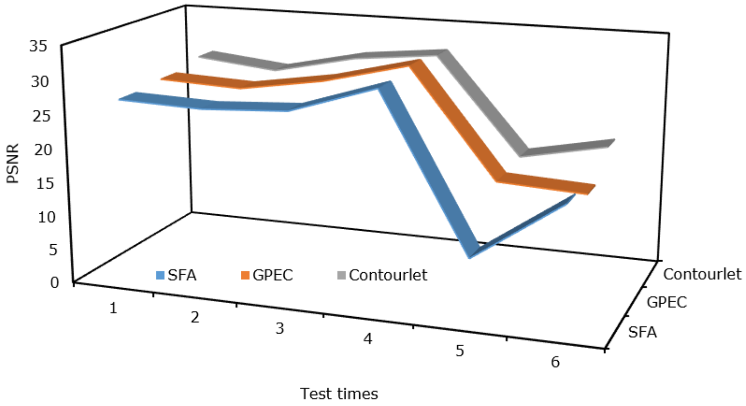

Figure 6: PSNR of image rendering.

To evaluate the practical efficiency of the SFA algorithm, a comparison of running times was conducted across three algorithms under various iterations. As illustrated in Figure 7, as iteration counts rise, the execution time for all three methods increases, albeit not exponentially, suggesting a gradual decrease in the computational demands per iteration. Among the algorithms, GPEC demonstrates the longest execution time and highest complexity due to its requirement for relearning in every iteration. It's less complex as its clustering iterations decrease over time. By the 32nd iteration, the SFA's execution time surpasses that of the Contourlet transform, highlighting its suitability for high-precision, multi-iteration image rendering tasks.

Finally, the quality of calligraphy copying works is assessed by using the interactive platform of calligraphy art analysis and copying. As shown in Figure 8, the calligraphy feature information extracted by the SFA algorithm provides an accurate reference for the copied works, which makes the copied works highly similar to the original works in terms of stroke trajectory and structural layout. Furthermore, the real-time feedback and adjustment function of the platform also helps users to continuously optimize the copied works.

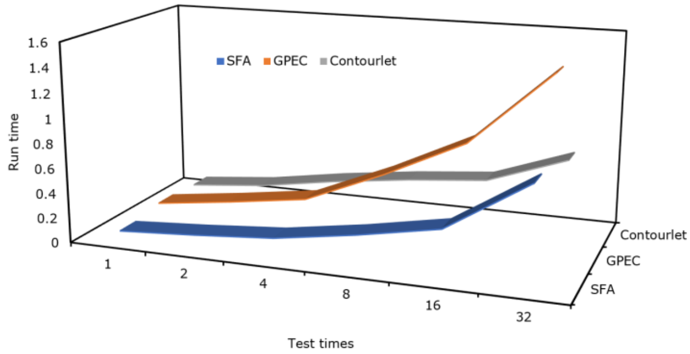

Figure 7: Image rendering running time of different algorithms.

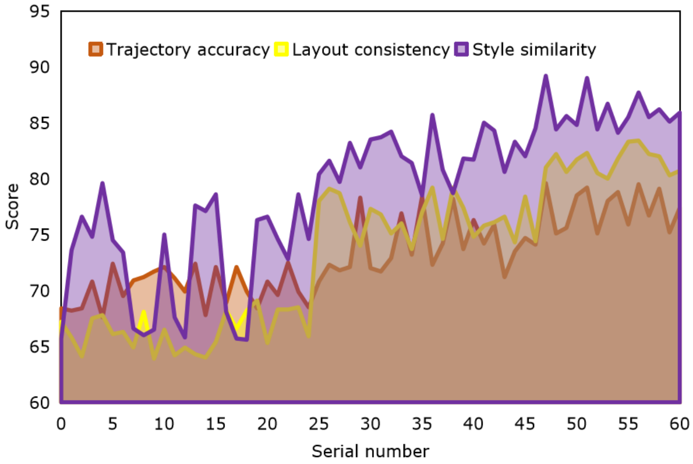

Figure 8: Quality assessment of calligraphy copying works.

6 DISCUSSION

This article discusses the key technologies in the interactive platform of calligraphy art analysis and copying, especially the realization of SFA and CAD technology. Through a series of experiments, we can not only clearly see the accuracy and efficiency of the SFA algorithm in calligraphy feature detection, but also feel the strong support of CAD technology in calligraphy copying and creation.

As the core of calligraphy art analysis, the accuracy and stability of the SFA algorithm are very important for the function of the whole platform. From the experimental results, the SFA algorithm performs well in extracting the characteristics of calligraphy strokes and analyzing the structural layout and has obvious advantages compared with traditional algorithms. This not only benefits from the ingenious algorithm design but also benefits from the profound understanding and grasp of calligraphy art. However, we also realize that any algorithm has its limitations, and the SFA algorithm also faces some challenges. When handling intricate or indistinct calligraphy images, the algorithm may struggle to comprehensively and precisely capture all features. Consequently, future investigations must refine the algorithm and enhance its versatility.

The use of CAD technology in calligraphy copying and creation provides convenience for calligraphy lovers. Through CAD technology, users can reconstruct and edit calligraphy works accurately, and achieve a copy effect that is highly similar to the original. Furthermore, the real-time feedback and adjustment function of CAD technology also enables users to find and correct their mistakes in time and continuously improve the copying level. However, although CAD technology is powerful, it cannot completely replace the creative process of people. The charm of calligraphy art lies in its unique charm and personality, which can not be completely copied by any technology. Therefore, when using CAD technology to copy calligraphy, we need to be cautious to avoid relying too much on technology and losing the essence of art.

The interactive platform dedicated to calligraphy art analysis and replication offers a revolutionary learning approach. By utilizing this platform, users have the opportunity to methodically acquire and grasp the fundamentals of calligraphy, comprehend distinct traits of various calligraphers, and elevate their appreciation for aesthetics and creativity. The platform also provides more possibilities for the inheritance of calligraphy art. For example, preserving and displaying calligraphy works through digital technology can let more people know the charm of calligraphy art; Through online teaching and communication, more calligraphy lovers can get professional guidance and help.

7 CONCLUSIONS

When exploring an interactive platform for analyzing and copying calligraphy art, we focus on the key technology of SFA and its implementation in computer-aided design (CAD). Calligraphy enthusiasts can receive real-time feedback and make adjustments as needed, which not only improves the accuracy of copying but also significantly improves efficiency. Compared to traditional methods, SFA not only accurately grasps the stroke path and structural arrangement of calligraphy, but also provides a comprehensive perspective for calligraphy art analysis through stable data support. A series of detailed experiments have revealed the extraordinary ability of the SFA algorithm to capture calligraphy features with precision and efficiency. While ensuring high image fidelity, the SFA algorithm effectively reduces computational complexity and improves rendering speed, making it an ideal choice for high-precision, multi-iteration image rendering tasks. In addition, our comparative experiment further highlights the advantages of the SFA algorithm in image rendering and computational speed. It is worth mentioning that when we combine the SFA algorithm with CAD technology, the digital reconstruction and editing work of calligraphy art has been greatly promoted. Although the combination of the SFA algorithm and CAD technology for the analysis and replication of calligraphy art, we must also be aware that technology cannot completely replace human artistic creation. The unique charm and personality of calligraphy are the essence that technology cannot replicate. Therefore, when using CAD technology for calligraphy copying, we should be cautious and avoid overly relying on technology and ignoring the essence of art.

Hongbo Pan, https://orcid.org/0009-0009-1927-6203
Shunjie Pan, https://orcid.org/0009-0002-3295-707X
Bo Pang, https://orcid.org/0009-0006-4963-986X

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