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# Collaborative Innovation of Poster Design and CAD Based on Gradient Descent Algorithm

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**Abstract.** As big data technology continues to advance and find broader applications, its impact on the design sector is steadily growing. This article aims to delve into how poster design and computer-aided design (CAD) systems, fueled by big data, can foster collaborative innovation via gradient descent algorithms. Initially, the significance of big data in poster design becomes evident, as it offers designers precise market direction and a deeper understanding of user preferences through rigorous analyses of user behaviour data and market trends. Additionally, the article sheds light on the particular use of the gradient descent algorithm in image matching, highlighting its ability to assist designers in swiftly identifying materials that closely align with their design concepts from extensive image databases. In addition, the article also verified the significant advantages of image-matching methods based on stochastic parallel gradient descent (SPGD) in poster design and CAD collaborative innovation through empirical research. It explored how to optimize algorithm performance in practical operations further to improve design efficiency and quality. This innovative method not only injects new vitality into poster design but also provides strong support for upgrading and improving CAD systems.

**Keywords:** Big Data; Gradient Descent Algorithm; Poster Design; CAD System; Collaborative Innovation
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## 1 INTRODUCTION

In the era of digitalization, the advent of big data technology is revolutionizing operational methods and processes across various industries. The design sector, particularly poster design and CAD, faces a challenge where conventional creative methods struggle to cope with the escalating demand for data processing and swift innovation. With the increasing complexity and diversity of design, maintaining consistency between CAD models and poster designs has become a challenge.


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Automatically updating the parameterization of CAD models can solve this problem and greatly enhance the efficiency and flexibility of CAD poster design. Parametric design is a design method that allows designers to adjust their designs by modifying predefined parameters. In CAD software, parameters can be used to define geometric constraints, dimensions, and other design features. Parameterized design allows designers to modify and optimize designs faster because it can automatically update models. In traditional CAD and poster design processes, the two are usually carried out separately. Once the CAD model is completed and used for production, poster designers typically need to manually adjust their design to match the model. This is not only time-consuming but also prone to errors. In addition, if the CAD model changes during the production process, the poster also needs to be updated accordingly, which further increases the complexity of maintenance. Agarwal et al. [1] created a program or script that can read this parameterized CAD model and automatically generate the initial draft of the poster design. If the CAD model changes during the production process, this program can automatically update the poster design to maintain consistency between the two. Consequently, the focus of current research has shifted to exploring how big data technology can foster design innovation and enhance both design efficiency and quality. Poster design, as a pivotal means of visual communication, plays a crucial role in societal life. Traditionally, however, it has relied heavily on designers' personal experiences and instincts, lacking scientific data support and optimization techniques. With the rapid development of industrial automation, robots are playing an increasingly important role in many fields. In order to achieve efficient and precise robot operations, visual orientation guidance has become a key technology. Ben and Cengiz [2] explored the implementation method of industrial robot poster visual orientation guidance based on CAD models under binocular vision. Visual orientation guidance is the use of computer vision technology to achieve precise control of robot motion by identifying and tracking target objects. In industrial environments, posters are an important tool for identification and guidance, often used to guide robots in completing various tasks. The visual orientation guidance method based on CAD models can improve the accuracy and robustness of robot recognition, which helps to improve production efficiency and reduce costs. Through binocular vision technology, we can obtain three-dimensional information of the target object, and then match and locate it with CAD models. Meanwhile, the use of CAD models can provide more accurate geometric features of objects, which helps improve recognition accuracy. Meanwhile, CAD systems have gained widespread adoption in fields like architecture, machinery, and electronics, offering strong support for intricate designs through their accuracy and efficiency. Nevertheless, the creative limitations of CAD systems hinder their effective integration with visual communication tools like poster design. Big data has become an important feature of today's era. It not only changes our way of life but also brings enormous opportunities and challenges to various industries. In poster visual communication design, big data-driven computer graphics processing technology is also playing an increasingly important role. Fan and Li [3] discussed the application of big data-driven computer graphics processing in poster visual communication design. Big data refers to a collection of data with a large volume, diverse types, and high processing difficulty. It can provide deeper and more comprehensive information insights, helping us better understand and analyze problems. Computer graphics processing technology is a technology that utilizes computers to generate, manipulate, and display images, widely used in animation production, game design, movie effects, and other fields. By analyzing a large amount of data, designers can understand consumer preferences, aesthetic trends, and behavioural habits, thereby better meeting market demand in poster design. For example, designers can create more attractive posters by analyzing trend data and selecting appropriate colours, fonts, and elements. By utilizing computer graphics processing technology, complex data can be presented in an intuitive and easy-to-understand manner, enabling the audience to better understand the information conveyed by posters.

Against this backdrop, this article aims to investigate the feasibility and methodology of collaborative innovation between poster design and CAD, leveraging a gradient descent algorithm driven by big data. By introducing the gradient descent algorithm, specifically the SPGD variant, it presents novel ideas and tools to address the shortcomings of traditional design approaches. The gradient descent algorithm, renowned as an optimization technique, finds widespread application in


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fields like machine learning and image processing. It iteratively computes the gradient of the objective function and updates parameters in the opposite direction to minimize the function. With the increasing awareness of environmental protection, environmental posters, as an important means of promotion, play an important role in raising public environmental awareness and advocating green lifestyles. The application of computer-aided design software (CAD) in environmental poster design provides designers with more creative space and implementation methods. Jin and Yang [4] discussed the specific application of computer-aided design software in environmental poster art design. Through CAD software, designers can preview the poster effect in real time on the computer, making it easy to adjust and optimize. At the same time, by combining virtual reality technology, the audience can interact with the poster, enhancing their sense of participation and experience. The use of computer-aided design software can reduce reliance on traditional media such as paper, and reduce material consumption and environmental pollution during poster production. Taking the environmental protection poster of a certain city park as an example, explore the specific application of computer-aided design software in this case. Firstly, the designer utilizes CAD software for the preliminary design of the poster, including layout, colour matching, etc. Then, using the software's drawing tools, draw the landscape of the park and various animal and plant elements. Next, by adding textual explanations and special effects, we emphasize the theme of environmental protection and advocate for specific actions such as green travel and pollution reduction.

In the context of image matching, this algorithm can determine the transformation parameters needed to align multiple images spatially. In the traditional CAD design process, designers need to manually adjust and match various components, which is not only time-consuming but also prone to errors. To address this issue, Jones et al. [5] proposed a collaborative design method for poster graphics that automatically matches CAD components. In the process of poster design, the matching and coordination of various components (such as text, images, colours, etc.) are crucial. However, traditional manual adjustment methods often cannot meet the requirements of efficient and accurate design. Through automation technology, design efficiency can be greatly improved, manual intervention can be reduced, while ensuring the accuracy and consistency of the design. Many scholars and research institutions are committed to the research of automated poster graphic collaborative design. Among them, the method of automatic matching of CAD components has received widespread attention. These methods automatically adjust the position and properties of components by analyzing their relationships and constraints, in order to achieve efficient collaborative design. However, existing methods still have some limitations, such as insufficient adaptability to complex poster design and insufficient automation level. However, when dealing with large datasets, traditional gradient descent algorithms suffer from computational intensity and slow convergence. To address these issues, this article introduces the SPGD algorithm, which employs a more efficient random perturbation gradient estimation, significantly accelerating the algorithm's convergence speed. Through a single-step perturbation and measurement, SPGD completes parameter updates in a single iteration, boosting computational efficiency. This innovation enables rapid identification of image-matching transformation parameters when processing large image datasets, facilitating collaborative innovation between poster design and CAD.

In poster design, big data provides a rich trove of design resources and data support. By analyzing user behaviour data and market trends, designers can gain a deeper understanding of user needs and market directions, creating poster works that more closely align with market demands. With the rapid development of technology, the application of computer-aided design (CAD) in poster art is becoming increasingly widespread. In order to cultivate poster design talents with innovative thinking and practical operation ability, the reform of teaching mode is imperative. Liu and Yang [6] explore a computer-assisted design teaching model for contemporary poster art centred on innovation. With the advent of the digital age, the forms and channels of poster art have undergone significant changes. The traditional poster design teaching model is no longer able to meet the needs of today's market. Therefore, introducing computer-aided design into poster art design teaching has important practical significance for improving students' design ability, innovation ability, and market competitiveness. Through a questionnaire survey, it was found that the majority of students hold a


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positive attitude towards computer-aided design, believing that it helps improve design efficiency and innovation ability. In the case study, it was found that many excellent poster works cleverly utilized computer-aided design technology to achieve creative visual presentation. In teaching practice, students have mastered the basic skills of computer-aided design through practical operations and created a batch of innovative poster works. Additionally, the integration of the gradient descent algorithm for image matching empowers designers to swiftly identify image materials relevant to their design themes, streamlining the poster design process. Within the CAD system, the introduction of the gradient descent algorithm optimizes design schemes and enhances design precision. For instance, in architectural design, utilizing this algorithm for structural optimization can minimize building material waste and improve the safety and stability of structures. Furthermore, through collaborative innovation with poster design, the CAD system can expand its reach in the visual communication domain, offering designers a more diverse array of design tools and expressions.

In summary, this article's research holds profound importance for advancing the utilization and creativity of big data technology within the design realm. By delving into the cooperative creativity approach of poster design and CAD, utilizing the gradient descent algorithm, the intention is to furnish designers with more sophisticated and streamlined design aids and backing, thereby fostering the design industry's enduring progress and innovation. Simultaneously, the findings can serve as a guide for big data applications across diverse domains, broadening the reach of big data technology's implementation and evolution.

Moving forward, the following chapter will delve deeper into the image-matching technique rooted in SPGD, substantiating its efficacy and advantage in the collaborative design ventures of posters and CAD through rigorous testing. Furthermore, discussions will ensue on refining the algorithm's performance and elevating design proficiency and quality in real-world settings. Through these explorations and assessments, the aspiration is to illuminate and contribute meaningfully to the integration and advancement of big data within the design sphere.

## 2 RELEVANT THEORETICAL AND TECHNICAL BASIS

In the digital age, computer-aided design (CAD) has become a core tool in the creative industry. However, for many novice designers, mastering CAD software remains a challenge. The interactive self-assessment poster graphic tool provides designers with an effective learning pathway to help them better master CAD skills. Pando et al. [7] explored how to use this tool to promote learning and skill enhancement in computer-aided design. An interactive self-assessment poster graphic tool is a web-based program that allows users to create and evaluate their poster design works. This tool integrates various CAD functions such as drawing, editing, colour and layout adjustments, and provides a series of self-evaluation standards to help users objectively evaluate their works. The interactive poster graphics tool adopts a progressive learning mode, gradually increasing the difficulty of basic skills. This learning path helps novice designers gradually master CAD skills and improve their design skills. The application of robots in visual communication is particularly noteworthy. Pedersen et al. [8] explored a novel visual communication method for calibrating robot on-site poster manufacturing, achieving digital manufacturing of hand-drawn posters. In today's digital age, hand-drawn posters still have irreplaceable artistic value and visual appeal. However, the traditional hand-painted poster production process is not only time-consuming but also requires extremely high skills from the artist. Therefore, seeking an efficient and accurate method for making hand-painted posters has become a hot research topic. By combining robot technology and visual communication, we can achieve digital manufacturing of hand-drawn posters, bringing new breakthroughs to the field of visual communication design. Digitize hand-painted posters and convert them into computer-recognizable data models. This includes a digital description of basic elements such as the size, colour, and lines of the poster. Based on the digitized poster data model, plan the robot's motion path. This requires comprehensive consideration of factors such as the robot's motion ability, accuracy, and efficiency to ensure the smooth progress of the manufacturing process.


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With the rapid development of technology, computer technology has been widely applied in various fields, especially in media and design. The emergence of computer-aided design (CAD) technology has brought revolutionary changes to poster design. Wang [9] explored the computer-aided interaction between poster visual communication technology and art in media settings. Posters, as an important form of visual communication, play a crucial role in media settings. Traditional poster design mainly relies on the manual creation of designers, but with the development of computer technology, poster design is gradually shifting towards digitization. Designers can use computer-aided design software to design and produce posters more efficiently. Meanwhile, through digital technology, the visual effect and artistic quality of posters have also been greatly improved. With the help of software tools, designers can more accurately control the size, colour, and layout of posters, ensuring the accuracy of the design. Through digital technology and computer graphics, designers can create richer and more delicate visual effects, enhancing the artistic expression of posters. With the advancement of technology, virtual reality (VR) technology is gradually penetrating various fields of our lives. In the advertising and publicity industry, 3D animated posters have become an effective way to attract audience attention. In order to meet market demand, computer-aided graphic design plays an increasingly important role in the production of 3D animated posters. Wei and Han [10] explore how to use computer-aided design software to create 3D animated posters for virtual reality. Compared to traditional posters, 3D animated posters have richer visual effects and dynamic expressive power. Through 3D modelling, animation production, and virtual reality technology, we can create highly attractive and immersive promotional materials. This gives 3D animated posters significant advantages in attracting audience attention, conveying information, and enhancing brand image. It combines virtual reality technology to make posters interactive. Viewers can interact with posters through VR devices to obtain more information or experience unique visual effects. This provides more creative space for brand promotion. Provide various poster design tools and materials, such as text, graphics, colours, etc. Students can design personalized posters according to teaching requirements.

With the continuous development of computer-aided design (CAD) technology, its application in the field of poster design is becoming increasingly widespread. In order to improve the efficiency and visual effect of poster design, Willis et al. [11] explored a method for constructing a poster graphic environment design based on human design sequences using programmatic CAD. Poster design is one of the important forms of visual communication, widely used in advertising, publicity, exhibitions and other fields. Traditional poster design mainly relies on the designer's manual creation, but this method is inefficient and difficult to ensure the accuracy and consistency of the design. Programmed CAD based on human design sequences is used to construct poster graphic environment design, which can automatically generate posters through programmatic methods according to human design thinking and habits, improving design efficiency and quality. Based on the analysis of human design sequences, the programmatic CAD construction of posters is achieved through programming. This step includes controlling the automatic layout, layout, colour matching, and other aspects of poster elements. As an important form of visual communication, posters play a crucial role in conveying information through their creativity and visual effects. With the continuous development of computer technology, computer-aided design (CAD) plays an increasingly important role in poster creativity and visual communication. Yang and Liu [12] discussed how to use computer-aided design technology, with poster creativity as the core, to achieve efficient and accurate visual communication of posters. Poster creativity is the soul of poster design, which can attract people's attention, and convey unique information and emotions. A good idea can make the poster stand out among many competitors and achieve better dissemination effects. Therefore, in poster design, it is crucial to perfectly combine creativity with visual communication. Through computer-aided design software, images can be processed and synthesized in various ways, such as adjusting colours, adding special effects, and performing cutouts. These technologies can enhance the visual impact of posters, making creativity more prominent and eye-catching. With the help of 3D modelling software, it is possible to create scenes and elements with a three-dimensional and realistic feel. By using rendering techniques, realistic light and shadow effects can be added to posters to enhance visual expression.


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How to integrate green concepts into product packaging and poster design to achieve sustainable development goals has become a focus of attention for designers. The CAD (Computer Aided Design) technology based on the concept of green provides strong support for the achievement of this goal. Yu and Sinigh [13] discussed the application of green concept-based CAD in product packaging poster design. CAD technology provides designers with powerful tools to perform design work more efficiently. CAD technology based on green concepts integrates environmental protection concepts into the design process, allowing designers to fully consider the environmental impact of product packaging and posters while considering their aesthetics and functionality. With the continuous development of technology, computer graphics and image software have become important tools in graphic design. Especially in ocean-style poster design, the application of these tools provides designers with more creative expression and implementation methods. Zhang [14] explored the application of computer graphics and image software in the graphic design of ocean-style posters. Through geometric modelling techniques in computer graphics, realistic ocean scenes can be created. Designers can use various geometric shapes and lines to simulate elements such as waves, islands, and ships, providing rich materials for poster design. The lighting models and material definition techniques in computer graphics can add realistic lighting and texture effects to ocean elements. By adjusting different lighting directions, colours, and intensities, as well as defining different material properties, one can create a sense of hierarchy and dimensionality in the ocean. Based on computer graphics animation technology and special effects rendering, dynamic effects can be added to posters, such as wave undulations, splashing water, etc. These effects can enhance the visual impact of the poster, making the ocean theme more vivid and eye-catching. With the advancement of technology, virtual reality (VR) technology is gradually penetrating into various fields of our lives. In the advertising and publicity industry, 3D animated posters have become an effective way to attract audience attention. In order to meet market demand, computer-aided graphic design plays an increasingly important role in the production of 3D animated posters. Zhao and Zhao [15] explore how to use computer-aided design software to create 3D animated posters for virtual reality. Compared to traditional posters, 3D animated posters have richer visual effects and dynamic expressive power. Through 3D modelling, animation production, and virtual reality technology, we can create highly attractive and immersive promotional materials. This gives 3D animated posters significant advantages in attracting audience attention, conveying information, and enhancing brand image. It combines virtual reality technology to make posters interactive. Viewers can interact with posters through VR devices to obtain more information or experience unique visual effects. This provides more creative space for brand promotion.

## 3 METHODOLOGY

The gradient descent algorithm is one of the classical algorithms in optimization theory, and its core idea is to adjust the parameters step by step by iteration to minimize the objective function. In each iteration, the algorithm will calculate the gradient of the objective function under the current parameter value, and update the parameters along the opposite direction of the gradient according to a certain step. By repeating this process, the algorithm can gradually approach the minimum value of the objective function.

The traditional gradient descent algorithm encounters significant computational challenges and sluggish convergence when tackling extensive datasets. To address these limitations, scholars introduced the stochastic gradient descent (SGD) algorithm, which selects a single sample at random in each iteration for gradient computation, thereby substantially reducing the computational load. Nevertheless, SGD still exhibits issues with convergence rates and stability.

The SPGD algorithm blends the concepts of stochastic gradients with parallel processing. By simultaneously processing multiple samples in each iteration and leveraging random perturbations for gradient estimation, it accelerates convergence and enhances computational stability. The cornerstone of the SPGD algorithm is the integration of random perturbations. In contrast to traditional gradient descent, which requires precise numerical or symbolic differentiation often impractical for large-scale problems, SPGD estimates gradients via random perturbations.


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Image matching, a pivotal research avenue in computer vision, aims to identify identical or similar regions across distinct images. A crucial aspect of this endeavour is navigating the transformation space, which encompasses a vast array of potential image modifications like translation, rotation, and scaling. At its core, image matching seeks to pinpoint one or multiple transformations within this space, aligning two or more depictions of the same scene captured at different times, by various sensors, and from varying perspectives.

Big data technology can provide designers with richer design resources and data support, helping them more accurately grasp market demand and user preferences, and thus create more excellent design works. In terms of poster design, big data can be used to analyze user behaviour data, market trend information, etc., providing designers with targeted design suggestions and guidance. By analyzing user browsing history and purchasing behaviour, designers can understand their preferences and needs, thereby creating poster works that better meet market demand. In terms of CAD systems, big data can be used to optimize design schemes and improve design accuracy. For example, in architectural design, big data can be used for structural analysis and optimization, reducing waste of building materials and improving the safety and stability of buildings. The primary research approach employed in this article centers around the utilization of big data analysis in conjunction with the gradient descent algorithm. By constructing corresponding models and algorithms, collaborative innovation between poster design and CAD systems is achieved. The following will elaborate on the methodology of this article, including research framework, data collection and processing, model construction, and algorithm implementation.

### 3.1 Framework

The research framework mainly includes four parts: problem analysis, data collection and processing, model construction, and experimental verification. Firstly, by analyzing the problems that exist in poster design and CAD systems in practical applications, clarify the research objectives and requirements. Secondly, utilizing big data technology for data collection and processing to obtain relevant user behaviour data, market trend information, and image materials. Then, based on the gradient descent algorithm, corresponding models and algorithms are constructed to achieve collaborative innovation between poster design and CAD systems. Finally, the efficacy and superiority of the introduced method and algorithm were substantiated via rigorous experimental validation.

### 3.2 Data Collection and Processing

Regarding data gathering, this article leverages big data technology to harvest pertinent information from a plethora of sources. Initially, web-crawling techniques are employed to extract user behaviour insights and market trends from social media platforms, e-commerce hubs, and search engines. This encompasses user search queries, browsing patterns, purchase histories, and feedback. These insights offer a profound understanding of user needs and preferences, serving as a robust foundation for poster design. Simultaneously, an extensive array of visual assets, including vectors, bitmaps, and 3D models, are sourced from image libraries and open-source repositories, enriching the design palette for poster creation and CAD workflows.

As depicted in Figure 1, variations in lighting conditions and surface reflectivity introduce challenges in the captured poster images. These images often exhibit low contrast, a subdued signal-to-noise ratio, and uneven illumination. Such characteristics further complicate the recognition precision of existing algorithms.

The expression for atrous convolution in the context of a one-dimensional signal is given as:

$$y_{[i]} = \sum_{k=1}^{K} x_{[i+r*k]} w_{[k]} \tag{1}$$

$x_{[i]}$ represents the one-dimensional input signal, $w_{[k]}$ denotes the filter, $r$ signifies the sampling step of the input signal, $k$ determines the length, and $y_{[i]}$ embodies the ultimate multi-space convolution output.


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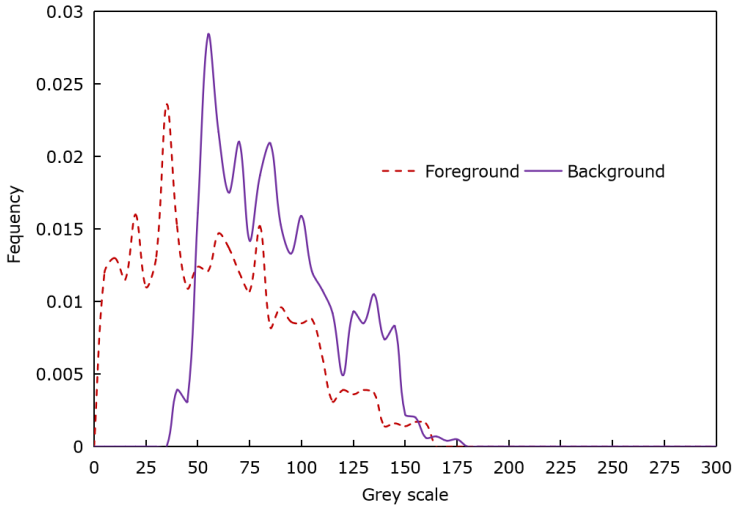


**Figure 1**: Gray distribution of foreground area and background area.

During the process of aligning poster visuals, softmax serves as the classification tool:

$$Design\ image_p = \frac{1}{1+\exp\ -h_{FC3}} \tag{2}$$

In this context, $Design\ image_p$ designates the probability output associated with the poster image, while $h_{FC3}$ corresponding to the output generated by the final fully connected layer $FC3$. The precise poster image pertaining to the inputted sample can be derived based on the probability output linked to the poster image.

The ultimate result obtained is denoted as $O_i$:

$$O_i = f\ net_i\ = \frac{1}{1+e^{-net_i}} \tag{3}$$

The $i$ neuron in this layer produces an output designated as $O_i$, and its weighted summation is labeled as $net_i$.

In the realm of data manipulation, this article incorporates techniques like data purification, feature identification, and dimensionality compression. Initially, the harvested data undergoes a thorough cleansing and preprocessing phase to eliminate any duplicate, irrelevant, or erroneous entries, thereby ensuring its precision and trustworthiness. Subsequently, feature identification methods come into play to extract pertinent characteristics related to poster design and CAD systems, encompassing aspects like colour palettes, shapes, textures, and structural elements. These features serve as critical indicators of the fundamental properties and design components inherent in the visual materials, laying the groundwork for subsequent model development and algorithmic deployment. Lastly, dimensionality compression techniques are employed to map the high-dimensional feature set onto a lower-dimensional plane, effectively mitigating feature redundancy and complexity while enhancing algorithmic efficiency and performance.


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### 3.3 Model Building

The model construction in this article is mainly based on a gradient descent algorithm and image-matching method. Firstly, an image matching model is constructed using a gradient descent algorithm to achieve automatic matching of image materials between poster design and CAD system. Using the extracted image features as input and continuously optimizing the matching function through a gradient descent algorithm, the matching results are more accurate and efficient. At the same time, considering the different characteristics and requirements of poster design and CAD systems, corresponding adjustments and improvements are made to the matching function to improve matching accuracy and efficiency.

In the SPGD image matching scheme, firstly, suppose that there is affine deformation in the local area between the image pairs $f_1$ and $f_2$ to be matched, and the corresponding target template and template to be matched are $g_1$ and $g_2$ respectively, then:

$$\begin{pmatrix} x_2 \\ y_2 \end{pmatrix} = \begin{pmatrix} k_0 & k_1 & k_2 \\ k_3 & k_4 & k_5 \end{pmatrix} \begin{pmatrix} 1 \\ x_1 \\ y_1 \end{pmatrix} \tag{4}$$

Where $x_1, y_1$ and $x_2, y_2$ are the corresponding points on the target template $g_1$ and the template $g_2$ to be matched respectively, and $K = \left[k_0, k_1, \ldots, k_5\right]$ is the deformation parameter to be found, as shown in Figure 2.

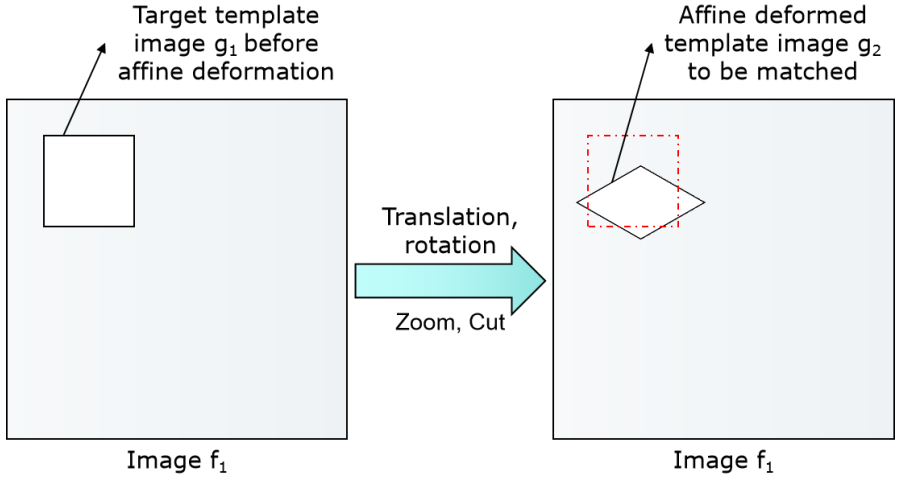


**Figure 2**: Affine deformation of local areas between matched images.

Define a performance evaluation function:

$$J\ K\ = J\ k_0, k_1, \ldots, k_5 \tag{5}$$

The deformation parameters to be obtained are:

$$K = \left[k_0, k_1, \ldots, k_5\right] \tag{6}$$

When the template images are completely matched $g_1$ and $g_2$, $J$ takes the global unique extreme value.


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For the $n$ optimization process, first, apply a random disturbance to the deformation parameter $k_n$ :

$$\delta K^n = \delta k_j^n \tag{7}$$

$\delta k_j^n$ is a random variable that obeys statistical laws. Calculate the template image after the disturbance according to Formula (1), and then calculate the variation of the evaluation function $J$ caused by random disturbance:

$$\delta J^n = J\left(k_0^n + \delta k_0^n, \ldots, k_j^n + \delta k_j^n, \ldots, k_5^n + \delta k_5^n\right) - J\left(k_0^n, \ldots, k_j^n, \ldots, k_5^n\right) \tag{8}$$

Update the deformation parameter $K = \left[K_0, K_1, \ldots, K_5\right]$ in step $n+1$, and the updating criteria are as follows:

$$k_j^{n+1} = k_j^n + \gamma_j \delta J^n \delta k_j^n \tag{9}$$

The above formula $\gamma_j$ is to optimize the system gain, which depends on the actual operation of the system and $j$ represents different deformation parameters.

During the model construction process, the SPGD algorithm was introduced to accelerate the calculation process. The SPGD algorithm is an optimization algorithm based on random sampling, which can randomly select a portion of samples for gradient calculation and update in each iteration, thereby reducing computational complexity and time complexity. Parallelization processing can further improve computational efficiency and scalability.

### 3.4 Algorithm Implementation

In terms of algorithm implementation, this article mainly uses Python programming language and related libraries for development. Specifically, using the NumPy library for numerical calculations and matrix operations; Using the SciPy library for scientific calculations and statistical analysis; Using the OpenCV library for image processing and analysis; Implementing gradient descent algorithms and neural network models using deep learning frameworks such as TensorFlow or PyTorch.

In the process of algorithm implementation, this article also focuses on the readability, maintainability, and scalability of the code. Adopting a modular design concept to divide the code into multiple independent modules and functional blocks, facilitating code reuse and modification. At the same time, pay attention to performance optimization and memory management of the code to ensure the efficiency and stability of the algorithm.

## 4 RESULT ANALYSIS AND DISCUSSION

In terms of algorithm implementation, this article mainly uses Python programming language and related libraries for development. Specifically, using the NumPy library for numerical calculations and matrix operations; Using the SciPy library for scientific calculations and statistical analysis; Using the OpenCV library for image processing and analysis; Implementing gradient descent algorithms and neural network models using deep learning frameworks such as TensorFlow or PyTorch.

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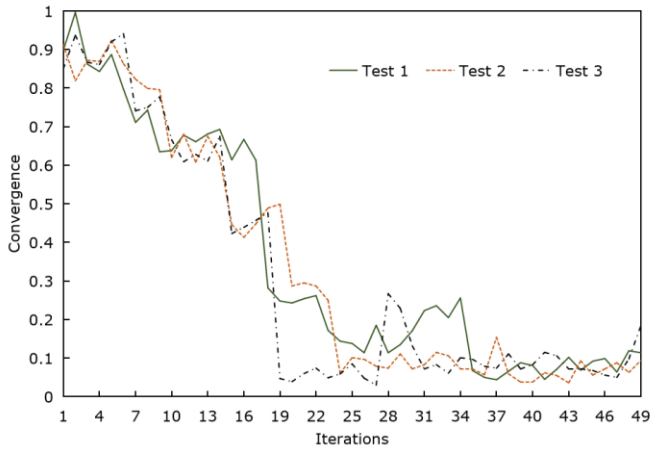


**Figure 3**: Convergence trend of the algorithm.

From Figure 3, it can be seen that as the number of iterations increases, the output error of the algorithm gradually decreases. After approximately 19 iterations, the output error of the algorithm has converged to a relatively ideal level. This indicates that the model proposed in this article can effectively learn the correlation between image features and emotional labels during the training process, thereby achieving an accurate understanding and expression of emotional semantics in poster design.

We adopted an optimization algorithm based on gradient descent for model training. This algorithm can adjust the model parameters based on the current error situation in each iteration, gradually reducing the output error. Through multiple iterations, the model gradually approached the optimal solution, achieving an accurate understanding and expression of emotional semantics in poster design. By selecting appropriate network structures, activation functions, and loss functions, the model was able to better adapt to the learning task of emotional semantics in poster design, thus achieving ideal experimental results.

The poster design method based on SPGD was adopted in the experiment, and its performance on the training and experimental sets was verified through comparative experiments. Figures 4 and 5 respectively show the accuracy comparison results of different algorithms on the training and experimental sets.

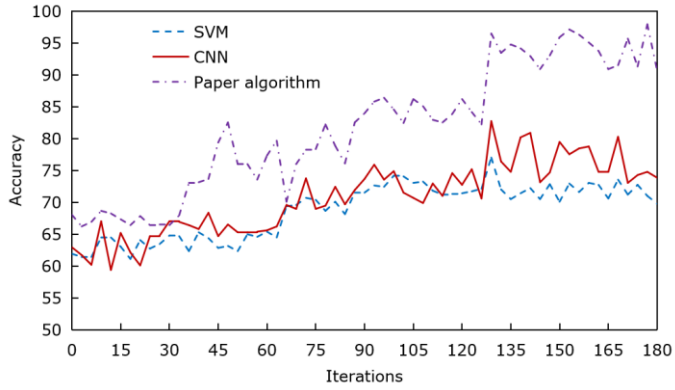


**Figure 4**: Accuracy of the algorithm on the training set.


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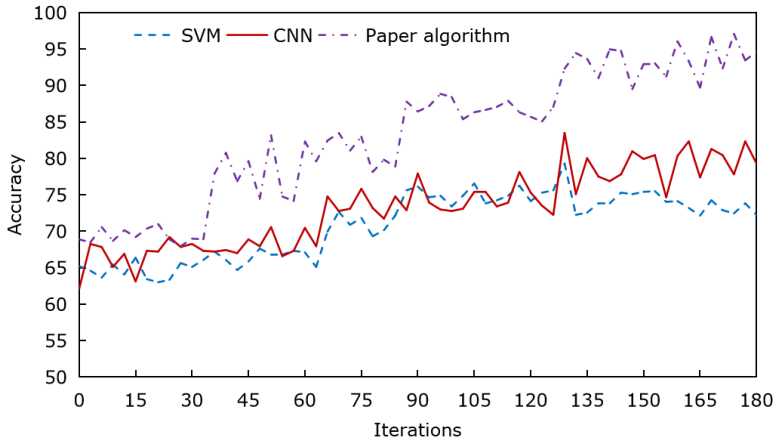


**Figure 5**: Accuracy of the algorithm on the experimental set.

The accuracy of the algorithm in this article on the training set has reached over 90%. This indicates that the poster design method based on SPGD can effectively learn the features and patterns of poster design from training data, thereby accurately predicting the emotional semantics of posters. The achievement of this result is mainly due to the optimization ability of the SPGD algorithm and its ability to process large-scale data. Through random sampling and parallel computing, the SPGD algorithm can quickly converge on large-scale datasets and find the optimal solution. The algorithm also demonstrated excellent performance on the experimental set, with an accuracy rate of over 90%. This indicates that the poster design method based on SPGD can not only achieve good performance on the training set but also generalize well to unknown datasets. The achievement of this result is mainly due to the design and training strategy of the model. Through reasonable network structure and parameter settings, as well as effective training techniques, we have successfully avoided the problem of model overfitting, thereby improving its generalization ability on the experimental set.

Figure 6 illustrates a comparative analysis of the impact achieved through various optimization techniques in poster image manipulation. The SPGD-based poster design optimization approach, introduced in this article, integrates the strengths of deep learning and notably enhances the model's training proficiency and generalization capabilities by incorporating the SPGD algorithm. This methodology has yielded substantial advancements in poster image enhancement, exhibiting marked superiority in terms of image sharpness, colour richness, and overall visual appeal.

Figure 7 presents the subjective evaluations provided by users for the outcomes produced by various design approaches during the poster creation process. The poster crafted using the technique delineated in this article garnered greater acclaim from users. This outcome not only underscores the preeminence of the method introduced in this article for poster design but also mirrors the demands and aspirations of users pertaining to superior poster design.

Evaluations of poster design by users frequently consider a multitude of factors, encompassing image sharpness, colour harmony, content communication, and overall visual appeal. In these areas, the approach outlined in this article significantly enhances the calibre and impact of poster design through the introduction of an optimization algorithm rooted in SPGD. The SPGD algorithm has the capability to fine-tune design elements based on user feedback and assessment in every iteration, progressively refining the visual impact and emotional resonance of the posters. This iterative refinement process, centred on user feedback, empowers our methodology to more adeptly align with user requirements and expectations, ultimately securing higher ratings.


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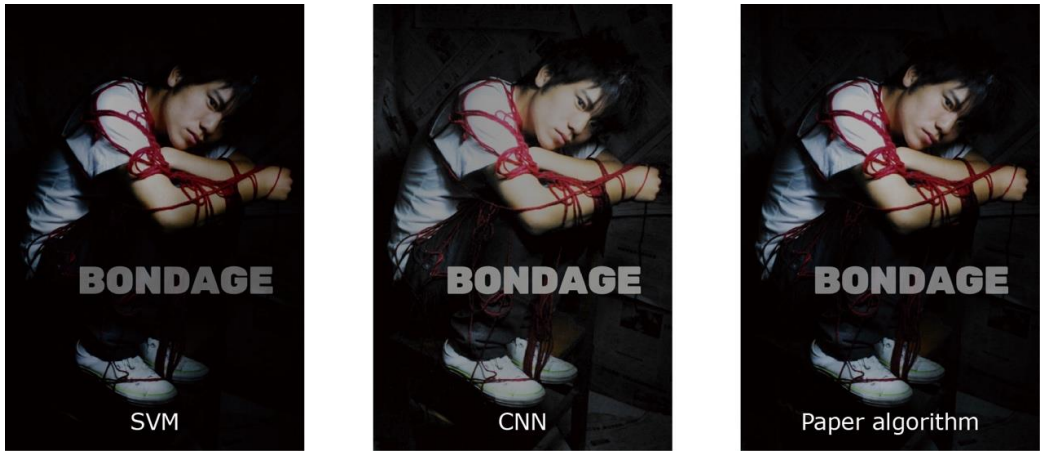


**Figure 6**: Poster design optimization effect display.

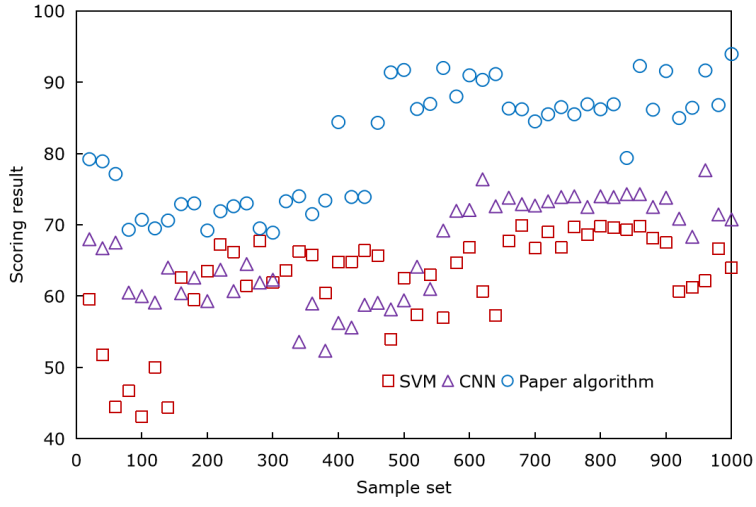


**Figure 7**: Subjective scoring results.

## 5 CONCLUSION

In the field of modern design, posters are an important visual communication tool, and their design quality and effect directly affect the transmission of information and user perception. Therefore, exploring an efficient, accurate, and individualized poster design method has important theoretical and practical significance.

Through extensive experimental verification, we found that the poster design method based on SPGD demonstrated excellent performance on both the training and experimental sets, with accuracy rates exceeding 90%. The achievement of this significant achievement is mainly attributed to the optimization ability of the SPGD algorithm, its ability to process large-scale data, as well as the ingenuity of model design and the effectiveness of training strategies. The SPGD algorithm, with its


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unique random parallel computing method, exhibits high efficiency and stability in processing complex data, providing strong support for the automation and intelligence of poster design.

More importantly, this article consistently adheres to the user-centred design philosophy in the poster design process. By deeply understanding and capturing user aesthetic preferences and design needs, this method successfully integrates these individualized elements into poster design, thus creating poster works that meet user expectations and have a unique charm. This individualized design concept and method not only enhances the visual effect and emotional expression of the poster but also creates a stronger sense of identification and belonging among users towards the poster design completed using the method described in this article.

In summary, the poster design method based on SPGD not only demonstrates excellent performance in technology but also achieves a qualitative leap in user experience and individualized expression. Through experimental verification, it can be concluded that the poster design method based on SPGD is an efficient, accurate, and individualized poster design method, which is expected to play a more important role in the future poster design field.

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## REFERENCES

[1] Agarwal, D.; Robinson, T.-T.; Armstrong, C.-G.; Kapellos, C.: Enhancing CAD-based shape optimisation by automatically updating the CAD model's parameterisation, Structural and Multidisciplinary Optimization, 5(9), 2019, 1639-1654. https://doi.org/10.1007/s00158-018-2152-7

[2] Ben, Y.; Cengiz, K.: Research on visual orientation guidance of industrial robot based on cad model under binocular vision, Computer-Aided Design and Applications, 19(S2), 2022, 52-63. https://doi.org/10.14733/cadaps.2022.S2.52-63

[3] Fan, M.; Li, Y.: The application of computer graphics processing in visual communication design, Journal of Intelligent & Fuzzy Systems, 39(4), 2020, 5183-5191. https://doi.org/10.3233/JIFS-189003

[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] Jones, B.; Hildreth, D.; Chen, D.; Baran, I.; Kim, V.-G.; Schulz, A.: Automate: A dataset and learning approach for automatic mating of cad assemblies, ACM Transactions on Graphics (TOG), 40(6), 2021, 1-18. https://doi.org/10.1145/3478513.3480562

[6] Liu, F.; Yang, K.: Exploration on 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] Pando, C.-P.; Fernández, Á.-H.; Busto, P.-B.; Castano, B.-S.: Boosting computer-aided design pedagogy using interactive self-assessment graphical tools, Computer Applications in Engineering Education, 31(1), 2023, 26-46. https://doi.org/10.1002/cae.22569

[8] Pedersen, J.; Søndergaard, A.; Reinhardt, D.: Hand-drawn digital fabrication: calibrating a visual communication method for robotic on-site fabrication, Construction Robotics, 5(2), 2021, 159-173. https://doi.org/10.1007/s41693-020-00049-2

[9] Wang, R.: Computer-aided interaction of visual communication technology and art in new media scenes, Computer-Aided Design and Applications, 19(S3), 2021, 75-84. https://doi.org/10.14733/cadaps.2022.S3.75-84

[10] Wei, X.; Han, Y.: Design and implementation of interactive visual communication teaching system based on CAD technology, Computer-Aided Design and Applications, 19(S7), 2022, 56-66. https://doi.org/10.14733/cadaps.2022.S7.56-66


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[11] Willis, K.-D.; Pu, Y.; Luo, J.; Chu, H.; Du, T.; Lambourne, J.-G.; Matusik, W.: Fusion 360 gallery: A dataset and environment for programmatic cad construction from human design sequences, ACM Transactions on Graphics (TOG), 40(4), 2021, 1-24. https://doi.org/10.1145/3450626.3459818
[12] Yang, K.-K.; Liu, F.-G.: Computer-aided design of visual communication expression with creativity as the core, Computer-Aided Design and Applications 19(S3), 2022, 65-74. https://doi.org/10.14733/cadaps.2022.S3.65-74
[13] Yu, W.; Sinigh, P.: Application of CAD in product packaging design based on green concept, Computer-Aided Design and Applications, 19(S2), 2021, 124-133. https://doi.org/10.14733/cadaps.2022.S2.124-133
[14] Zhang, N.: Application of computer graphics and image software in marine graphic design, Journal of Coastal Research, 106(SI), 2020, 600-604. https://doi.org/10.2112/SI106-136.1
[15] Zhao, J.; Zhao, X.: Computer-aided graphic design for virtual reality-oriented 3D animation scenes, Computer-Aided Design and Applications, 19(S5), 2022, 65-76. https://doi.org/10.14733/cadaps.2022.S5.65-76


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