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Computer-Aided Design AND APPLICATIONS

Computer-Aided Brand Logo Design Based on Generative Adversarial Networks

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Abstract. The objective of this article is to investigate a computer-assisted approach to brand logo design, leveraging the capabilities of the generative confrontation network. This addresses the prevalent issues of inefficiency and limited creativity encountered in conventional design processes. To accomplish this, a tailored Generative Adversarial Network (GAN) model is developed, aimed at automatically crafting distinctive and artistically appealing brand logos. Through rigorous experimental validation and comparative assessments, it is evident that our proposed method excels in terms of diversity, originality, and overall design quality. The logos generated exhibit notable variation in style, form, and colour palette while maintaining a strong sense of identity and aesthetic appeal. When compared to traditional methods and other deep learning-based approaches, our method consistently outperforms across all evaluated metrics. Furthermore, the practical utility and applicability of our method are underscored through detailed case studies and real-world implementations. The findings indicate that the integration of GAN-based techniques in computer-aided brand logo design can significantly enhance the creative process, offering designers a broader range of inspiration and flexibility to cater to diverse application scenarios.

Keywords: Generating Adversarial Networks; Computer-Aided Design; Brand Logo Design
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1 INTRODUCTION

Brand logo design refers to creating a unique, easy-to-identify symbol or pattern that can represent the brand image through visual elements such as graphics, characters, and colours. In today's era of digitalization, the design of brand images has become increasingly important. Brand image is not only a direct reflection of corporate image but also an important carrier of corporate culture and values. In order to better meet the needs of brand design, Asadi et al. [1] analyzed a brand image CAD design that integrates colour and texture features. This system combines advanced computer-aided design technology and image processing technology to generate brand images with unique visual effects

efficiently. These texture features can be combined with colour features to create a more layered and three-dimensional brand image. It is the core component of brand image and has the characteristics of simplicity, uniqueness, identifiability, durability and adaptability. Amidst intensifying market competition, the brand logo emerges as a pivotal aspect of a corporation's identity, with its design quality directly impacting the corporate brand image and market competitiveness. In the current field of industrial design and manufacturing, the shaping of brand image and the visual presentation of products are equally important. Ben and Cengiz [2] analyzed the visual positioning design of industrial brands under binocular vision technology. By simulating the visual mechanism of the human eye, the binocular vision system can accurately capture the shape, size, and position information of objects, providing accurate data support for brand design. In brand design, CAD models can also be used to simulate product usage scenarios and interaction methods, helping designers better predict and evaluate product market acceptance. Meanwhile, through the rendering and animation effects of CAD models, designers can more vividly showcase brand characteristics and product advantages, thereby enhancing the brand's market competitiveness. Traditionally, the brand logo design process relied heavily on the designer's expertise and creativity. However, this approach is constrained by the limitations of manual design and time costs, making it challenging to adapt to the rapidly evolving market demands.

In recent years, the rapid advancement of artificial intelligence technology, particularly the widespread application of GAN in computer vision, has presented new opportunities for computer-aided brand logo design. GAN, with its powerful generative ability and adversarial training mechanism, provides new possibilities and perspectives for brand quality perception. In brand communication, brand experience and brand personality play an intermediary role, jointly influencing consumers' perception of brand quality. Coelho et al. [3] explored the value of GAN in brand quality perception and analyzed in depth the mediating role of brand experience and brand personality in this process. In brand communication, the application of GAN can greatly enrich the presentation forms of brand image, bringing consumers a more vivid and intuitive visual experience. The generative confrontation network is an adversarial model comprising two neural networks: a generator and a discriminator. The generator aims to produce realistic sample data based on random noise or given conditions, while the discriminator's task is to distinguish whether the input samples originate from real datasets or are forged data generated by the generator. Brand design is a comprehensive work involving multiple levels, in which graphic elements are an important component of brand image. CAD graphics processing technology can accurately draw and edit various graphic elements, making the brand design more professional and personalized. Through CAD software, designers can easily adjust the size, proportion, and colour of graphics, achieving uniformity and coordination of brand image. Fan and Li [4] use the text editing function of CAD software to add various styles of text descriptions and slogans to brand graphics, enhancing the readability and infectiousness of the design.

Through competition and confrontation during the training process, the generator and discriminator continuously enhance their respective capabilities, enabling the generator to ultimately produce sample data with a distribution closely resembling real data. Feng [5] analyzed the image shaping of brand vision in the digital environment. With the support of digital technology, the expression forms of brand vision have become more diverse and flexible. Traditional colour applications are limited by physical media and printing technology, while in the digital environment, brands can present richer and more delicate colour effects through various digital platforms and media. This change not only enhances the visual appeal of the brand but also enhances the emotional connection between the brand and consumers. This adversarial learning approach has led to GANs achieving remarkable results in areas such as image generation, style transfer, and super-resolution. Driven by the wave of digitization and intelligence, augmented reality (AR) technology and neural networks have become important driving forces for innovation and development in multiple industries. In the field of destination branding, the integration and application of this technology not only enhances user experience but also promotes industry transformation and upgrading. Huertas and Gonzalo [6] explored the specific role of augmented reality neural networks in these fields.

Augmented reality neural networks can also be combined with big data analysis to accurately locate the interests and needs of tourists, providing targeted suggestions for destination brand building.

The objective of this study is to explore an innovative method for computer-aided brand logo design based on the generative confrontation network. This approach aims to enhance design efficiency and quality, providing technical support for enterprises in shaping their unique brand identities. The study's main contents include analyzing the theoretical basis and design principles of brand logo design, examining the fundamental principles and development status of GANs, exploring innovative methods for computer-aided brand logo design using GAN, designing and implementing simulation experiments to validate the proposed methods' effectiveness, and conducting applied research and evaluating the methods' effectiveness based on practical cases.

The innovation of this study is primarily reflected in several aspects: (1) proposing a novel method for computer-aided brand logo design based on the generative confrontation network, (2) constructing a generation confrontation network model tailored for brand logo design, and (3) verifying the effectiveness and practicability of the proposed method through simulation experiments and case studies. This research provides new insights and technical support for brand logo design.

This article comprises seven distinct sections. Commencing with the introduction outlines the research's background, significance, content, innovations, and the article's structure. Following this, the second section presents a literature review, discussing the current research status and trends. The third section delves into the theoretical underpinnings and design principles of brand logos, alongside the fundamentals and advancements of generating countermeasure networks. In the fourth section, an innovative approach for computer-aided brand logo design, leveraging generating confrontation networks, is elaborated upon. The fifth section formulates and executes simulation experiments to validate the efficacy of this method and interprets the findings. Subsequently, the sixth section undertakes applied research and impact assessments using real-world case studies. Finally, the seventh section recapitulates the article's essence and envisions future research trajectories and focal points.

2 RELATED WORK

A brand logo is not only a representative of the corporate image but also a key factor in brand communication and market competition. Kozinets [7] conducted in-depth research on the logo design style, form, and palette innovation of CAD algorithm brands. The logo design style of CAD algorithm brands should reflect their advanced technology and professional and reliable brand image. Designers can adopt a minimalist and modern design style, emphasizing the smoothness of lines and the geometric sense of shapes. This design style can not only highlight the brand's sense of technology but also maintain visual clarity and easy recognition. Kshetri et al. [8] explored how Web 3.0 and the metaverse affect organizational brand design and product strategy, and analyzed the opportunities and challenges they bring to organizations. The decentralized nature of Web 3.0 makes the brand design more focused on user engagement and co-creation. Organizations can build decentralized platforms to invite users to participate in the brand design process, achieving deep interaction and cooperation between brands and users. This co-creation model not only helps to enhance brand awareness and loyalty but also brings valuable user feedback and creative inspiration to the organization. In the artistic design of brand logos, GAN design can be applied to generate diverse design schemes. By training the generator network, it learns various design elements and styles of the brand logo and then generates various different design schemes for designers to choose from. GAN design has significant advantages in brand logo art design. Firstly, it can automatically generate diverse design solutions, greatly expanding the creative space of designers. Through GAN design, designers can easily explore various design styles and element combinations, in order to find the most suitable design solution for brand characteristics [9]. The generative adversarial network consists of two parts: a generator and a discriminator. Through continuous adversarial training, the generator can learn the distribution of real data and generate realistic new data. In brand logo design, generative adversarial networks can learn a large number of design rules of brand logos, and

then generate new logos that meet design requirements. This application method not only improves design efficiency but also breaks the limitations of traditional design and achieves a more personalized brand logo design. Luffarelli et al. [10] explored an innovative computer-aided brand logo design method based on generative adversarial networks, aiming to provide enterprises with more efficient and personalized brand logo design solutions.

With the continuous progress of technology, machine learning has become a core technology in many fields, including the field of computational product design. Brand recognition is an important part of product design, its accuracy and efficiency directly affect the market competitiveness of the product. Manavis et al. [11] explored the application of machine learning in computational product design brand recognition methods and analyzed the advantages and challenges it brings. The construction of classifiers is the core task of machine learning in brand recognition. By training a large amount of brand design data, machine learning models can learn the differences between different brands and build classifiers that can accurately identify brands. Traditional brand recognition methods often rely on tedious manual analysis and design, which is inefficient and difficult to handle large-scale data. To overcome these challenges, Manavis et al. [12] proposed a novel visual brand recognition (CbVBI) product design method based on adversarial network computing. CbVBI utilizes the ability of GAN to learn brand visual features to construct a visual model that can recognize different brands. It aims to achieve more efficient and accurate brand recognition through the power of machine learning.

The metaverse provides a new perspective and tools for brand building, and digital technology plays a crucial role in this process. Traditional brand building often relies on advertising, public relations, and other means, while in the metaverse, digital technology can help brands achieve deeper and more comprehensive shaping. Digital technology can help brands build virtual brand images and scenarios. Through technologies such as 3D modelling and virtual reality, brands can create unique virtual spaces in the metaverse, showcasing their culture, philosophy, and products. This virtual brand image and scene not only has a high visual impact but also provides consumers with an immersive brand experience, enhancing brand awareness and memory [13]. Nowadays, brand building is no longer an isolated process, but a complex system closely connected to multiple dimensions such as consumers, the market, and technology. In this era, a brand is not only a symbol of a company but also a bridge for establishing emotional connections and conveying values between the company and consumers. Therefore, Swaminathan et al. [14] re-examined the theoretical framework of brand shaping and considered its boundaries and possibilities in the new era. The communication channels of brands are becoming more diversified. In addition to traditional advertising, public relations and other means, new media such as social media and short videos have also become important platforms for brand communication. This makes the interaction between brands and consumers more frequent and direct. The rapid development and widespread application of new media technology have blurred the boundary between brand visual communication technology and art, and the integration of the two has become a new trend in brand design and promotion. In this context, Generative Adversarial Networks (GANs), as a cutting-edge computer-aided technology, provide strong support for the interaction between brand visual communication technology and art. By utilizing generative adversarial networks, Wang [15] quickly generates personalized brand images based on brand concepts and target audience preferences. These images can include logos, patterns, colour combinations, etc., which not only align with the core values of the brand but also attract consumer attention.

In brand visual communication design, creativity is the soul and core of design, which determines the uniqueness and attractiveness of the brand image. As an efficient and accurate design tool, computer-aided design provides strong support for the realization of creativity. Yang and Liu [16] focused on creativity and explored the application of computer-aided design in brand visual communication and expression. Through rendering, animation, special effects and other functions in design software, designers can add more dynamic effects and visual impact to their design works, making creative expression more vivid and interesting. The brand art style design of product packaging involves multiple elements, including colour, pattern, font, material, etc. Colour is the most intuitive element in packaging design, which can quickly convey the brand's emotions and

atmosphere. Patterns can showcase the brand's characteristics and cultural connotations. As a carrier of information transmission, fonts need to be coordinated with brand image. Zhao et al. [17] explored the appearance design method and advantages of agricultural product packaging brand artistic style with the assistance of intelligent computers. The feasibility of the brand logo design scheme has been significantly improved through algorithm optimization and simulation preview. In the digital age, brand images are an important carrier of corporate image and market promotion, and their classification and recognition technologies are increasingly receiving attention. Traditional brand image classification methods often rely on a single feature extraction or classifier, making it difficult to achieve high-precision and stable classification. To address this issue, Zitouni et al. [18] analyzed brand image classification technology based on new information fusion methods, providing a new solution for precise recognition and management of brand images.

3 THEORETICAL BASIS

3.1 Concept and Design Principle of Brand Logo Design

Broadly speaking, the utilization of computer-aided design in brand logo creation has had a belated yet swift progression, garnering significant interest and investments from numerous scholars and businesses alike in its associated explorations and implementations. As a deep learning model emerging in recent years, the Generative Antagonistic Network has shown great ability in image generation and style transfer and has been gradually applied to brand logo design. However, at present, most of the research focuses on theoretical discussion and preliminary application, and there are relatively few specific methods and practical cases on how to design a brand logo in combination with generating a countermeasure network. Therefore, this study has important theoretical value and practical significance. Brand logo design refers to creating a unique, easily recognizable symbol or pattern that can represent the brand image through visual elements such as graphics, characters and colours. The principles of brand logo design mainly include accuracy, conciseness, uniqueness, identifiability, communication and artistry. For example, Table 1 specifically shows the principles of brand logo design.

Principle	*Demand*
Accuracy	Logo design can accurately convey the core values and concepts of the brand.
Conciseness	Logo design is concise but not simple and expresses the richest meaning with the least elements.
Uniqueness	Logo design has unique creativity and expression.
Identifiability	The logo design is easy to recognize and remember.
Communicative	Logo design can quickly convey brand information.
Artistry	Logo design has high aesthetic value and artistic expression.

Table 1: Brand logo design principles and requirements.

The methods of brand logo design mainly include creative conception, graphic expression, colour application and font selection. For example, Table 2 specifically shows the methods and importance of brand logo design.

Design method	*Describe*	*Importance*
Creative conception	The core of brand logo design determines the uniqueness and communication power of the logo.	High
Graphic representation	The foundation of logo design expresses the brand concept and image through graphic elements and forms.	High
Colour	Enhance the communication effect of signs, through the	Middle

application	symbolic meaning and emotional association of colors.	
Font selection	Convey the brand personality and temperament, and show it through the style and characteristics of fonts.	Middle

Table 2: Brand logo design method and its importance.

The assessment criteria of brand logo design mainly include uniqueness, recognition, communication, aesthetic feeling and adaptability. These assessment criteria are interrelated and influence each other, which together constitute a comprehensive assessment system of brand logo design. See Table 3 for details.

Assessment criterion	*Describe*
Uniqueness	Does logo design have distinctive creativity and expression?
Recognizability	Is the logo design easy to recognize and remember?
Communicative	Can logo design accurately convey the core values and concepts of the brand?
Sense of beauty	Does logo design have high aesthetic value and artistic expression?
Adaptability	Whether the logo design have good expansibility and variability and can meet the application requirements of different media and sizes?

Table 3: Brand logo design assessment standards.

The utilization of CAD in brand logo creation predominantly enhances efficiency, expands expressive possibilities, and fine-tunes design proposals [15]. CAD software facilitates designers' ability to draft, revise, and refine graphics swiftly, boosting design productivity. Moreover, CAD tools offer extensive libraries and functionalities, empowering designers to devise increasingly original and varied expressions. Additionally, CAD technology allows for design simulation and optimization, aiding designers in pinpointing design directions and refining intricacies. Incorporating CAD into brand logo design not only streamlines the process and elevates quality but also bolsters the comprehensive and professional establishment of a brand's visual identity.

3.2 Application of GAN in the Field of Computer Vision

In the field of computer vision, the application of GAN mainly focuses on image generation, image editing, style transfer, and so on. By training the GAN model, images with specific style and content can be generated from random noise or given conditions. Furthermore, GAN can also be used to edit and modify existing images, such as super-resolution reconstruction, denoising, restoration, and other tasks [16]. In addition, GAN can also be used to realize the migration and transformation between different styles, such as applying the style of one painting to another image. These applications not only enrich the research content and technical means in the field of computer vision but also provide more diversified and innovative solutions for practical application scenarios.

In brand logo design, the potential value of GAN is mainly reflected in providing innovative design ideas and schemes, improving design efficiency and quality [17]. By training the GAN model, designers can generate unique and creative brand logo design schemes according to given conditions or requirements. Furthermore, GAN can also be used to edit and modify existing signs to meet the application requirements in different scenarios. In addition, using the style transfer ability of GAN, we can also integrate elements of different styles into the brand logo design to create more abundant and diversified expressions. These potential values give GAN broad application prospects and development space in brand logo design.

4 INNOVATIVE METHOD OF COMPUTER-AIDED BRAND LOGO DESIGN BASED ON GAN

4.1 GAN Model Construction

This section will introduce an innovative method of computer-aided brand logo design based on GAN. This method utilizes the powerful generating ability of GAN and combines the traditional principles and methods of brand logo design to realize automatic and innovative brand logo design. Specifically, by constructing an appropriate GAN model, we can learn the relevant data of brand logo design and generate a unique and artistic logo design scheme. In addition, it will discuss how to improve the quality and diversity of design schemes through data preprocessing, feature extraction, model training, and optimization.

Before GAN model training, it is necessary to preprocess and extract the characteristics of brand logo design data. The preprocessing steps mainly include data cleaning, normalization, image enhancement, and other operations to eliminate noise and improve data quality and consistency. Contrast enhancement aims at improving the contrast of images, making dark areas darker and bright areas brighter. Commonly used methods include:
Logarithmic transformation:

$$\text{Log Transform x} = \log 1 + x \tag{1}$$

Power law transformation:

$$\text{Gamma Transform x},\gamma = x^{\gamma} \tag{2}$$

Linear transformation:

$$\text{Linear Transform x} = ax + b \tag{3}$$

Where x is the original pixel value, a and b are adjustment parameters, and γ is the gamma value. Brightness and contrast can be adjusted by the following formula:

$$\text{Adjusted Value} = \alpha \cdot \text{Original Value} + \beta \tag{4}$$

Where a is the brightness adjustment factor (0.5 will darken the image and 2 will brighten the image) and β is the offset?

Normalization is to adjust the size of data to a specific range, usually to standardize the input of the network. For image data, this usually involves scaling pixel values between 0 and 1. The formula is as follows:

$$\text{Normalized Value} = \frac{\text{Original Value-Minimum Value}}{\text{Maximum Value - Minimum Value}} \tag{5}$$

Where Original Value is the original pixel value, Minimum Value and Maximum Value are the minimum and maximum pixel values in the image, respectively? Histogram equalization is a method to improve image contrast, which equalizes the histogram of the image by redistributing pixel values. The formula is:

$$P\ i = \frac{C}{N}\sum_{j=0}^{i-1} P\ j \tag{6}$$

Where $P\ i$ is the probability of the equalized pixel value i; $P\ j$ is the probability of the pixel value j in the original image; C is a normalized constant; N is the total number of pixels in the image. Noise elimination usually involves filtering technology. The basic formula of the filter is:

$$I_{out}\ x,y = \sum_{i=-N}^{N}\sum_{j=-N}^{N} I_{in}\ x+i,y+j \cdot w\ i,j \tag{7}$$

Where I_{in} is the input image, I_{out} is the output image, N is the size of the filter, and $w\ i,j$ is the weight function, which represents the contribution of i,j position to the output image. Feature extraction is to extract representative feature information from the original data through a specific algorithm or model, which can reflect the characteristics of brand logo design. This characteristic information will be used as the input of the GAN model to generate a brand logo that meets the design requirements.

According to the characteristics of brand logo design, key features can be extracted by image segmentation, shape analysis, and colour analysis. In this article, the logo graphics are separated from the background by image segmentation technology, and the outline and internal structure of the graphics are extracted. The shape characteristics and topological structure of logo graphics are extracted by shape analysis technology; Color analysis technology is used to extract information such as colour composition and distribution of signs. These extracted features will provide strong support for the subsequent GAN model training. Figure 1 shows the network model structure of this article.

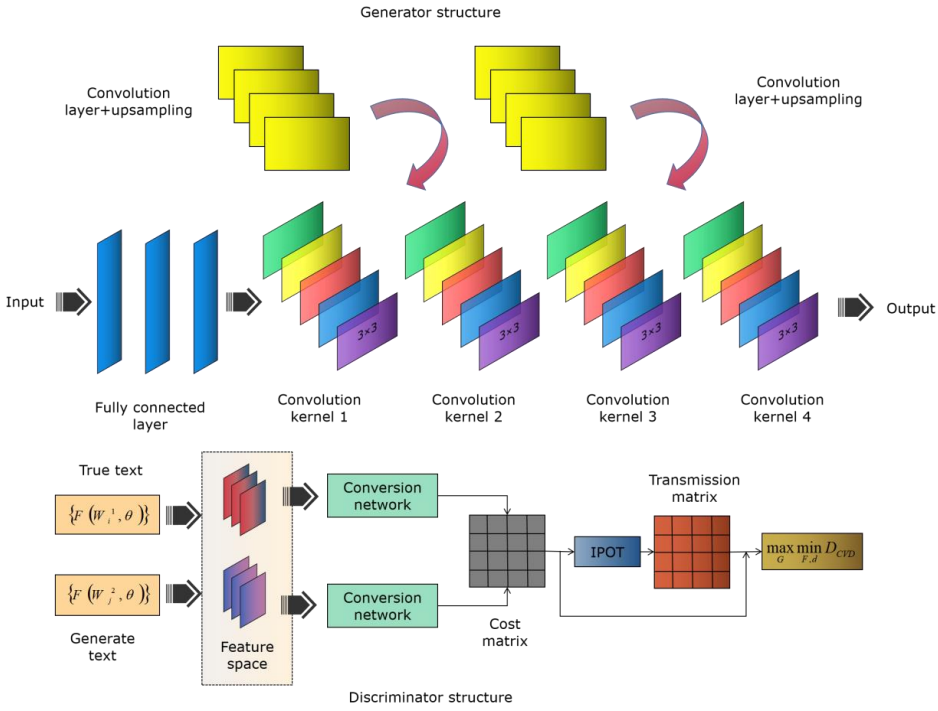

Figure 1: Network model structure.

To build a GAN model tailored for brand logo design, it is crucial to devise a method that can produce logo graphics aligned with specific design criteria, leveraging extracted feature information. This article proposes a GAN architecture that encompasses both a generator and a discriminator. The generator's role is to craft logo graphics using input features and random noise, while the discriminator aims to discern whether the logos presented are genuine from datasets or imitations produced by the generator. Typically, the generator's loss function is determined by an adversarial loss, which quantifies the resemblance between the generated data and authentic data perceived by the discriminator. In the realm of binary classification, adversarial loss is commonly formulated through cross-entropy loss:

$$\text{Generator Loss} = -\text{E}_{z\sim p_z\ z}\left[\log\ D\ G\ z\ \right] \tag{8}$$

Where $G\ z$ is the image generated by the generator, $D\ x$ is the probability of the discriminator output, indicating the probability that the input x comes from the real data, and z is the random noise extracted from the prior noise distribution $p_z\ z$.

The loss function of the discriminator is usually defined by classification loss, which measures the ability of the discriminator to correctly classify real data and the generator to generate data. For binary classification, the loss function of the discriminator can be expressed as:

$$\text{Discriminator Loss} = -\text{E}_{\text{x}\sim p\text{data x}}\left[\log\ D\ x\ \right] -\text{E}_{z\sim p_z\ z}\left[\log\ 1-D\ G\ z\ \right] \tag{9}$$

Where $pdata\ x$ is the probability distribution of real data and $\log$ is a logarithmic function, which is used to calculate losses. In the training process, the generator and the discriminator are updated alternately, so that they compete with each other and finally reach a dynamic equilibrium state. The generator can generate data that is difficult for the discriminator to distinguish. In addition, this article introduces the conditional GAN model better to meet the specific requirements of brand logo design. In brand logo design, conditional information such as design style and colour can be used as additional input. The loss function of conditional GAN can be expressed as:

$$\text{Generator Loss} = -\text{E}_{\text{c}\sim p_c\ \text{c},\text{z}\sim p_z\ z}\left[\log\ D\ G\ z\middle|c\ \right] \tag{10}$$

$$\text{Discriminator Loss} =$$

$$-\text{E}_{\text{x}\sim p\text{data x},c\sim p_c\ c}\left[\log\ D\ x\middle|c\ \right] -\text{E}_{\text{z}\sim p_z\ z,c\sim p_c\ c}\left[\log\ 1-D\ G\ z\ \right] \tag{11}$$

Where c is the conditional variable and $p_c\ c$ is the probability distribution of the conditional variable.

When training the GAN model, it is necessary to adopt an appropriate optimization algorithm and learning strategy to adjust the model parameters so that the generator can generate logo graphics close to the real data distribution. Adam's optimization algorithm is adopted in this article. In the learning strategy aspect, the generator and discriminator are trained by alternating training to improve the convergence speed and stability of the model.

4.2 Generation and Post-Processing of Brand Logo

After model training, the trained GAN model can be used to generate a brand logo that meets the design requirements. The automatic generation is realized by inputting specific feature information and random noise. In order to further improve the quality and usability of the generated results, it is necessary to post-process the generated flags. Post-processing mainly includes image filtering, color adjustment, size scaling, and other operations to eliminate possible noise and artifacts and improve image clarity and visual quality. In addition, according to the actual needs, the generated logo is cut and rotated to meet the application needs in different scenarios.

5 SIMULATION EXPERIMENT DESIGN AND RESULT ANALYSIS

5.1 Experimental Design and Results Display

Simulation experiments are conducted in this section to validate the efficacy of the GAN-based computer-aided brand logo design approach. The experimental environment configuration includes a high-performance computer, TensorFlow framework, and necessary programming tools. In terms of data set, this article collects a large number of real-world brand logo images, covering different industries, styles, and complexity to ensure the comprehensiveness and diversity of the experiment.

In the experimental design stage, the experimental objectives, assessment indicators and comparison methods are determined. The experimental objectives include verifying the diversity, innovation and design quality of the generated signs. The assessment indicators include the uniqueness, recognition and artistic beauty of the generated logo.

During the implementation of the experiment, firstly, the data set is preprocessed and feature extracted, and then a brand logo design model based on GAN is constructed. In the process of model training, the appropriate optimization algorithm and learning strategy are adopted, and the model is repeatedly trained to ensure its convergence and performance to reach the best state. The training process is shown in Figure 2.

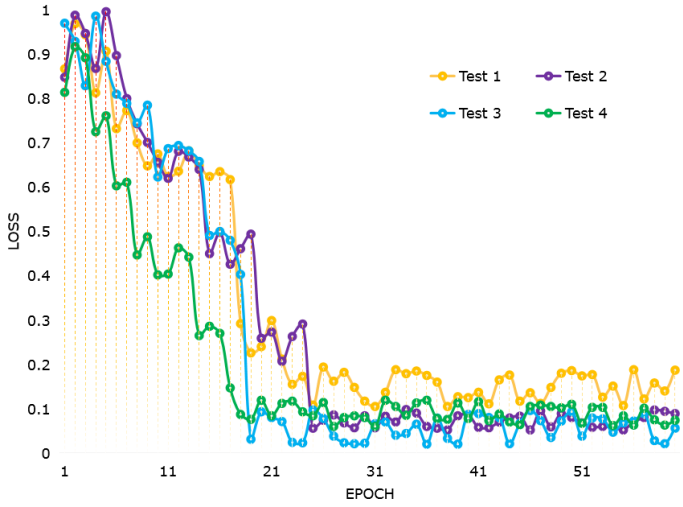

Figure 2: Model training situation.

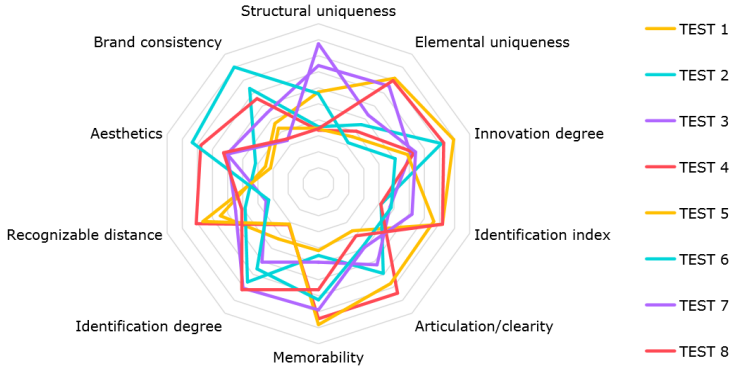

Figure 3: Test results of quantitative indicators.

Upon completing the model training, the test set is utilized to evaluate the model, with detailed experimental outcomes documented. In terms of the experimental findings, numerous brand logo images are produced, showcasing the model's generative capabilities. These logos exhibit notable diversity in style, shape, and colour.

Regarding the evaluation metrics, this section employs a blend of quantitative and qualitative techniques to assess the results comprehensively. Quantitative indicators include uniqueness score and recognition score of generated marks, which are calculated by a specific algorithm and can objectively reflect the quality of generated marks. Qualitative assessment invited professional designers to make subjective assessments of the generated logo, including artistic beauty and innovation. The test results of quantitative indicators are shown in Figure 3. The subjective assessment results of professional designers are shown in Figure 4.

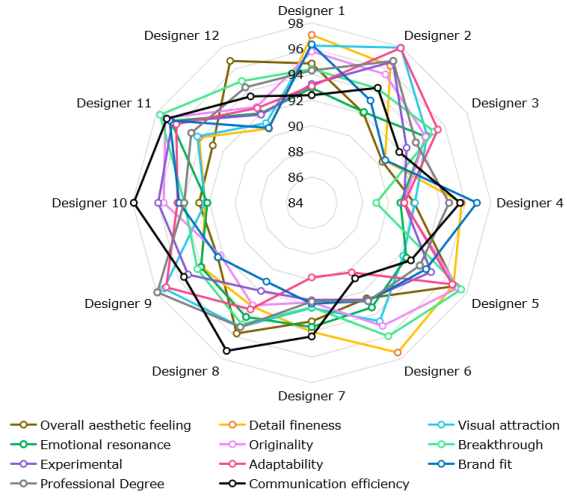

Figure 4: Subjective assessment results of professional designers.

Furthermore, in order to verify the effectiveness of computer-aided brand logo design methods based on GAN more comprehensively, this article also carries out comparative experiments with other methods. The comparison methods include the traditional brand logo design method, rule-based automatic generation method and CNN-based generation method. The comparison results of several methods are shown in Figure 5.

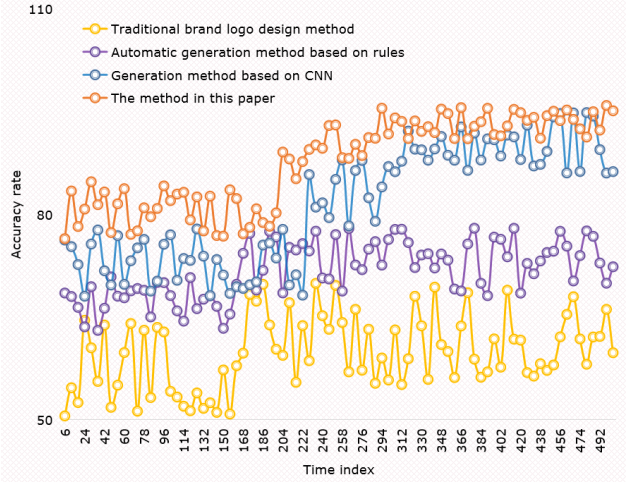

Figure 5: Comparison results of several methods.

Upon conducting a comparative analysis of the results obtained in this section, it has been observed that the method utilizing GAN exhibits superior performance in terms of diversity, innovation, and design quality when compared to other methodologies. Additionally, the algorithm demonstrates high accuracy, further highlighting its potential application and promising future in the realm of brand logo design.

5.2 Results Analysis and Discussion

After thoroughly analyzing and discussing the experimental outcomes, this article concludes that the computer-aided brand logo design approach leveraging GAN technology exhibits significant advantages in terms of diversity, innovation, and design quality. Unlike traditional methods, this approach can effortlessly produce numerous unique and artistically pleasing brand logo designs, thereby offering designers a wider range of inspiration and options. Moreover, this method can be easily customized to cater to specific user requirements, making it suitable for various applications and scenarios.

6 CASE STUDY AND PRACTICAL APPLICATION

6.1 Case Selection and Background Introduction

In order to explore the effect of computer-aided brand logo design methods based on GAN in practical application, this section selects several representative cases for research. These cases cover brands of different industries, different scales and different market positioning, aiming at comprehensively demonstrating the application value and potential of this method in different scenarios.

In the process of case selection, this article focuses on choosing challenging and representative brands, such as emerging technology brands, traditional manufacturing brands, fashion consumer brands and so on. These brands have a certain popularity and influence in the market, and their logo design is of great significance to brand image and market competitiveness. Through the in-depth study and analysis of these cases, we can better understand the advantages and limitations of computer-aided brand logo design methods based on GAN in practical application.

6.2 Practice and Assessment of Computer-Aided Brand Logo Design Based on GAN

After confirming the research case, the computer-aided brand logo design method based on GAN is used for practice. First of all, this article deeply analyzes and understands the brand background, market positioning and target audience of each case, so as to ensure that the generated logo can fit the brand image and market strategy. Next, according to the specific needs of each case, the GAN model is customized and optimized. This includes selecting appropriate network architecture, adjusting model parameters and optimizing training strategies. Through repeated training and adjustment, several unique and innovative brand logo design schemes have been successfully generated for each case. In the aspect of displaying practical results, this article presents the generated logo design scheme graphically and visually, so as to show its effect more intuitively (as shown in Figure 6).

In the aspect of assessment, various methods are used to assess the practical results. First of all, this section invited professional designers and brand experts to make subjective assessments of the generated logo, including innovation, aesthetics, recognition and so on. The specific assessment results are shown in Figure 7.

Secondly, this article also collected the views and opinions of the target audience on the generated logo through questionnaires and user interviews (see Table 4). The above assessment results provide us with valuable feedback and suggestions, which are helpful to further improve and optimize the method proposed in this article.

By conducting a case study and practical implementation, this section validates the efficacy and promise of the computer-aided brand logo design approach rooted in GAN technology. It is

anticipated that with the ongoing advancement and refinement of technology, this methodology will assume a progressively significant role in the realm of brand logo design.

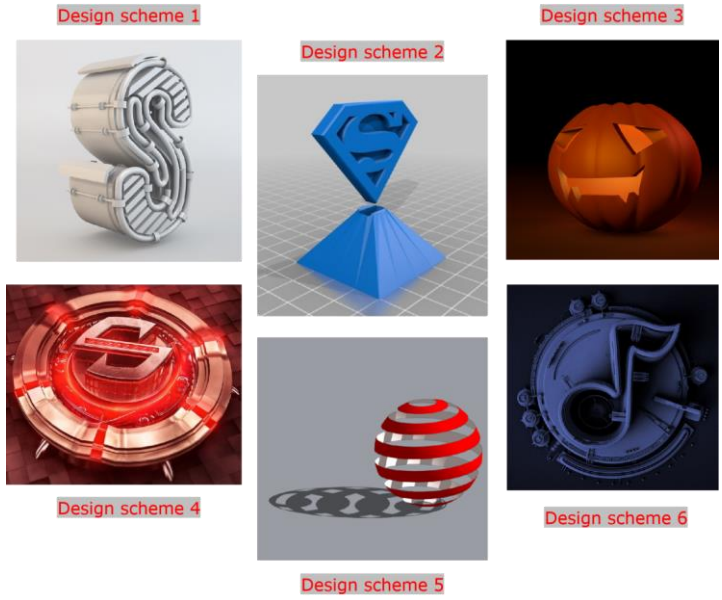

Figure 6: Overview of brand logo design scheme.

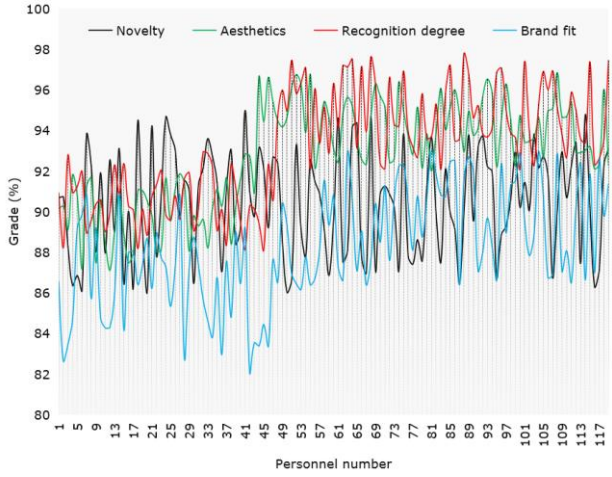

Figure 7: Professional assessment results.

Audience Group	*Age group*	*Occupation*	*Overall satisfaction with the generated logo (1-5)*	*Uniqueness of the logo (1-5)*	*Recognition of the logo (1-5)*	*Recognition of brand philosophy conveyed by the logo (1-5)*	*Would you like to use the logo to represent the*

							brand?
Designer	25-35	Graphic design	4	4	3	4	Yes
Enterprise manager	35-45	Marketing	5	5	4	5	Yes
Student	18-24	Design related majors	3	4	4	3	Yes
Consumer	25-35	Freelancing	4	4	5	4	Yes
Marketing personnel	28-38	Advertising planning	5	5	5	4	Yes

Table 4: Views and opinions of the target audience on the generation of signs.

7 CONCLUSIONS

After conducting extensive research and implementing GAN technology, this article successfully developed a model capable of automatically generating distinctive and artistically appealing brand logo designs. This model seamlessly integrates traditional brand logo design principles and methods, revolutionizing the process with automation and innovation. The research methodology employed in this article encompasses various technical approaches, including data preprocessing, feature extraction, model development, and training optimization, to ensure optimal model performance and high-quality generation. Through rigorous experimental validation and comparative analysis, it has been demonstrated that this method significantly excels in terms of diversity, innovation, and design quality. Furthermore, the practicality and application value of this method have been further substantiated through case studies and real-world applications.

Drawing from the findings and insights gained through this research, this article offers the following recommendations and inspiration for the realm of brand logo design:

(1) Emphasize Innovation and Individuality: In crafting brand logos, it is essential to prioritize innovation and personalization to underscore the brand's uniqueness and allure. By leveraging novel technologies and methodologies, designers can transcend the constraints of traditional design and conceive more original and distinctive logo concepts.

(2) Attune to User Needs and Market Trends: Brand logo design should be responsive to evolving user preferences and market landscapes, ensuring alignment with the brand's identity and strategic direction. A profound understanding of the target audience's tastes and values is paramount for crafting a logo that resonates with users' psychological expectations.

(3) Foster Interdisciplinary Collaboration and Dialogue: The art of brand logo design intersects with diverse fields, spanning from artistic design to computer science and marketing. Fostering collaboration and communication across these disciplines can catalyze knowledge fusion and innovative synergies, unlocking new vistas of inspiration and possibility for brand logo design.

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