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Computer-Aided Design AND APPLICATIONS

Modeling and Reinforcement Learning Assessment System for Quality Improvement of Advertising Design

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Abstract. This article focuses on examining the synergistic use of CAD (Computer Aided Design) modelling and RL (Reinforcement Learning) within advertising design, enhancing both efficiency and quality. Initially, it delves into the unique demands of advertising design on CAD modelling, detailing the comprehensive construction process of an advertising CAD model, encompassing sketch design, 3D modelling, and material and lighting configurations, among other pivotal stages. Following this, the article introduces an RL-based evaluation system for advertisement design quality. This system automatically assesses and refines designs through the definition of state and action spaces, the crafting of a suitable reward function, and the selection of an optimal RL algorithm. Experimental outcomes reveal that integrating CAD modelling with RL in an advertising design assessment system markedly boosts both the efficiency and quality of the design process. Specifically, the system can shorten the design cycle, improve the consistency and stability of the design, and provide creative inspiration and optimization suggestions for designers to help them achieve more innovative and personalized advertising designs. It provides a new solution for the advertising design industry.

Keywords: CAD Modeling; Reinforcement Learning; Advertising Design; Quality Assessment; Creative Design
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1 INTRODUCTION

The current communication mode between commercial advertisements and advertising target groups has shifted from traditional one-way output to a two-way interactive mode. Mobile social media platforms, such as WeChat, are important entry points for advertising traffic, conducting a

case study on interactive advertising on mobile social media platforms, analyzing the characteristics and commonalities of various forms and interaction methods of interactive advertising, and summarizing the representative features of each type. The two-way interaction mode can make audience feedback more accurate and immediate, and the design concept of commercial advertising also adapts to changes in the interaction mode. Focus on the page layout and interaction mode design of interactive advertisements in the framework layer, and propose design strategies for "functional visibility" of interaction modes and user-controlled trial listening rhythm. The design tasks and specific strategies for the strategic layer, scope layer, structural layer, framework layer, and presentation layer, including the nodes, sections, structural types, and navigation design and information design of interactive advertising in the advertising information architecture [1]. On this basis, the design pattern of the user experience element model will be transplanted and applied to the design of mobile social media interactive advertising, and the five levels of interactive advertising in the experience element model will be discussed separately. It has been seven years since the first batch of interactive advertisements appeared on WeChat, and the content form and interaction methods of interactive advertisements have made considerable progress. However, some interactive advertisements also have problems, such as rigid interaction forms or excessive interaction. Finally, these strategies are applied to guide the practical creation of the work for verification [2].

In the era of an attention economy, the advertising volume of traditional media has declined, and various new media channels are competing for consumer traffic and attention. Interactive advertising on mobile social media needs to take into account the characteristics and creative requirements of advertising, mobile devices, and social media. Faced with increasingly diverse advertisements, consumers are becoming more sensitive and picky, and even the popularity of innovative interactive advertisements has declined. Due to the emergence of H5 advertising production platforms and tools, interactive advertising also faces the risk of homogenization. Interactive advertising itself also has problems, such as uneven quality and insufficient innovation. In addition, platforms with dissemination effects and social attributes, such as short video apps, can learn from the form of transplanting WeChat H5 interactive advertising. Studying the interactive design of mobile social media advertising has certain practical value, which can provide ideas for interactive advertising design and production and facilitate creators to design new forms of interactive creativity [3]. The first batch of H5 advertisements on mobile social media in China was launched seven years ago. Currently, research on interactive advertising on mobile social media mainly focuses on communication methods and effects, audience research, and technical discussions. In various types of interactive advertising design research, there is partial coverage of mobile social media interactive advertising. The development of interaction design to this day has guided the creation of various types of excellent interaction works with many theories. The project aims to use the research and summarization of the existing forms, contents, and interaction methods of interactive advertising and combine relevant interaction design theories to guide the design of interaction methods for interactive advertising, enriching the extension of interaction design theory [4].

In the era of the experience economy, online media has become the most frequent tool for information exchange, which can satisfy people's spiritual pursuits by improving products through various technologies. The development of H5 advertising has promoted designers to explore user experience and continuously improve interaction design to meet user needs. H5 advertising, as an advertising form with interactive advantages, has evolved into various interactive advertisements that are occupying the advertising market [5]. The article concludes through theoretical analysis of interaction design, experience design, user experience, and various H5 advertising examples that H5 interactive advertising design needs to focus on user experience to achieve design requirements such as good visual atmosphere, strong user participation, and diverse forms of expression. The study also found that the rapid development of H5 advertising has exposed some problems, such as a lack of design aesthetics, page homogenization, and single interaction methods. Conceptual explanation, elaborating on key terms such as HTML5 and H5 advertising, user experience honeycomb theory, testing methods, and the evolution of experience design [6].

The popularization of HTML5 has promoted the birth of H5 advertising, which spreads through various online electronic platforms and has become the latest trend in advertising development for a time. Based on the above research and practical results analysis, the final conclusion for H5 interactive advertising design in the era of the experience economy is proposed, along with suggestions and prospects for H5 advertising in the future [7]. Conduct research and analysis on different types of H5 advertisements and determine the specific application and impact of user experience in H5 advertising instances. Storyboard production, prototype design, and the specific thinking and innovative design methods of interactive design in H5 interactive advertising. Apply the design methods and interactive design thinking developed through research to practical creation.

User experience has become an important mobile marketing tool for H5 advertising, integrating graphic, audio, and video formats to express advertising appeals better and gain user favour [8]. The theory is mainly based on the application of H5 in interactive advertising and the analysis of the NetEase H5 case in order to draw its own conclusions. Spread advertising as an interactive mini-game, focusing on user experience and meeting users' spiritual needs. This method can also be used in public welfare promotion and other aspects [9]. Only when the user's experience is improved, and their spirit is satisfied can information be transmitted more deeply to the user. Firstly, by summarizing three aspects- user experience, experience design, and interaction design-, it is concluded that a perfect H5 interactive advertising design needs to be based on a user-centered experience design. The topic is based on user experience and mainly studies the design and optimization of H5 interactive advertising through two aspects: emotional experience and interaction design. By analyzing and comparing different types of H5 advertising cases, the design points of H5 interactive advertising are identified. The article's progressiveness lies in the use of visual effects, auditory effects, and interactive effects [10]. The interactive modes of interactive advertising can be divided into three basic types: emotional resonance, storytelling, and fun games. Based on the user experience, focusing on user interaction can improve the promotional effect and better understand user needs. By integrating user experience design optimization methods for H5 interactive advertising in different ways on the market, a new design approach is formed that allows users to participate in the design experience. The design features are divided into: information design, motion design, sound design, and hypertext linking.

The introduction highlights the advertising design industry's challenges and research background and clarifies the study's aim and importance. Sections two and three delve into the unique demands of advertising design for CAD modelling and its specific applications. Section four explores the design and implementation of an RL-based advertisement quality assessment system. Section five validates the proposed method's efficacy and advantages through experiments and analysis. Lastly, the research findings are summarized, emphasizing practical significance and forecasting future applications and trends of CAD modelling and RL in advertising design.

2 RELATED WORK

CAD modelling technology plays a crucial role in the early stages of advertising design due to its accuracy and flexibility. This process not only shortens the design cycle but also improves design efficiency, enabling advertising to respond more quickly to market changes. However, relying solely on CAD modelling is not enough to ensure high-quality advertising design. At this point, reinforcement learning evaluation systems have become an indispensable part. Moreno et al. [11] simulated a manual evaluation process to automate and intelligently evaluate advertising designs, identify potential shortcomings, and propose improvement suggestions. Through CAD software, designers can create highly realistic product models or scene layouts, ensuring that advertising content is visually consistent with the actual product, thereby enhancing consumers' trust in advertising information. Reinforcement learning models can learn and understand multiple dimensions of advertising design evaluation criteria, such as visual appeal, information dissemination efficiency, target audience fit, etc., providing real-time feedback and optimization guidance for advertising designers.

In addition, the introduction of deep learning technology has brought revolutionary changes to the improvement of advertising design quality. Moreno et al. [12] model can guide designers to create advertising works that are more in line with the target audience's taste by accurately capturing consumers' style preferences, thereby improving the attractiveness and conversion rate of advertisements. As you mentioned, our deep learning model is capable of automatically extracting features from full-body images and identifying and predicting style-defined features in clothing themes. This ability can be directly applied to advertising design, greatly improving the personalization and relevance of advertising content. In addition, the personalized advertising generator developed by Sin and Yun [13] combines the advantages of CAD modelling, reinforcement learning evaluation, and deep learning techniques to achieve automatic generation and optimization of advertising content. Its high user acceptance rate of 80.56% fully demonstrates the effectiveness of data-driven methods in improving the quality of advertising design. This generator can not only generate a large amount of high-quality advertising materials in a short period of time but also make real-time adjustments based on user feedback and market performance to ensure that advertising content is always in the best state.

Traditional methods often come with high costs and uncertain schedules. To address these challenges, Safarkhani et al. [14] developed and evaluated a reinforcement learning-based advertising design quality improvement model and evaluation system. This system not only considers the strategic behaviors of all parties involved in the advertising creation process but also incorporates key elements of quality improvement and cost control. Different advertising projects have different expectations for design quality, which directly affects the creative direction and investment resources of bidders. ASMR advertising, as an emerging marketing tool, has shown unique appeal on platforms such as YouTube, with its core being to elicit comfort and relaxation from viewers through specific auditory stimuli. CAD modelling technology can ensure the accurate reproduction of advertising products in virtual environments, achieving a high degree of realism in product form, materials, and lighting effects. However, traditional advertising design often focuses on the overlay of visual elements, neglecting the in-depth exploration of auditory experience. Tang [15] found that ASMR advertising is particularly effective for complex and emotional audiences with high emotional needs, revealing the important role of emotional resonance in advertising communication. Therefore, incorporating ASMR elements into advertising design not only enriches the sensory level of advertising but also provides possibilities for achieving more accurate emotional outreach. This is particularly important for ASMR advertising, as the audience needs to enjoy auditory stimulation while building a comprehensive understanding of the product through visuals (although it may be simpler in ASMR advertising). Unprecedented expansion of forms and forward-looking innovators attempt to break the traditional and conservative mode of information dissemination. The traditional one-way information dissemination model of media can no longer fully meet the needs of the general public in the information age, and the design form of public service advertisements should no longer be constrained by traditional media attributes. Research has pointed out that interactive design is based on the interactive character of new media, using unique immersive experiences such as virtual and reality alternation, as well as human-computer interaction and creative implantation design methods, to achieve the presentation and interaction of visual, auditory, tactile, and other sensory information, creating infinite possibilities for the future of public service advertising. The article starts with the definition of new media, the interactive characteristics of new media, and the development of public service advertising art and design. Based on excellent application cases of interactive design in public service advertisements at home and abroad, this study focuses on the thinking and methods of interactive design, providing guidance for the interactive design of new media public service advertisements. The interactive design of new media public service advertisements conforms to the development of the times, and its communication concepts and methods are gradually shifting towards diversified development. The creative dimension is also shifting from single to multi-dimensional, and the communication surface is more vivid, extensive, and effective, indicating that interactive design will become the mainstream direction of public service advertising design in the future.

3 APPLICATION OF CAD MODELING IN ADVERTISING DESIGN

3.1 Demand Analysis of Advertising Design CAD Modeling

As a highly creative and visually oriented field, advertising design has special requirements for CAD modelling:

(1) Advertising design pursues visual impact, which requires the model to have high detail performance and rendering quality so as to show the best effect in all kinds of media.

(2) Because of the fast iterative nature of advertising design, CAD modelling needs to support efficient workflow, which can quickly respond to design changes and shorten the design cycle.

(3) Advertising design often involves a variety of media and sizes, which requires CAD models to have good adaptability and scalability to ensure the consistency and coordination of design in different scenes.

(4) Advertising design emphasizes innovation and individuality, and CAD modelling should provide rich tools and library resources to support designers in realizing unique creative ideas.

3.2 Model Construction

The construction process of the advertising design CAD model includes the following key steps:

Sketch design: This is the starting point of model construction. Designers use the sketch drawing function of CAD software to outline the initial idea of advertising design quickly. The sketch design stage pays attention to the capture and expression of creativity, which lays the foundation for the subsequent 3D modelling.

3D modelling: On the basis of sketch design, designers use the 3D modelling function of CAD software to transform two-dimensional sketches into 3D models. This stage requires careful operation to ensure the accuracy and proportional coordination of the model. Designers will use commands such as stretching, rotation and Boolean operation to create complex geometric shapes and realize flexible adjustment of the model through parametric design. The specific formula is as follows:

Stretching:

$$M_3D = \text{Extrude}\ M_2D, d \tag{1}$$

Where M_3D is a 3D model; M_2D is a two-dimensional sketch; d is the distance of stretching?

Rotation:

$$M_3D = \text{Rotate}\ M_2D, \theta, axis \tag{2}$$

Where θ is the angle of rotation; $axis$ is the axis of rotation.

Boolean operation:

$$M_3D = \text{Union}\ M_A, M_B \tag{3}$$

$$M_3D = \text{Intersection}\ M_A, M_B \tag{4}$$

$$M_3D = \text{Difference}\ M_A, M_B \tag{5}$$

Where M_A and M_B are the models for Boolean operation; Union stands for union operation; Intersection stands for intersection operation; Difference stands for difference set operation.

Parametric design:

$$M_3D = \text{f}\ \vec{p} \tag{6}$$

Where $\vec{p}$ is a parameter vector that controls the shape of the model; f is a parametric design function.

Binocular vision, a significant aspect of machine vision, employs two cameras to capture images of an object from distinct angles based on the parallax principle. By computing positional disparities (parallax) between corresponding image points, 3D geometric information about the object is derived. This approach mimics human stereoscopic vision, enabling machines to perceive object depth akin to humans. Figure 1 illustrates the different analyses of binocular vision.

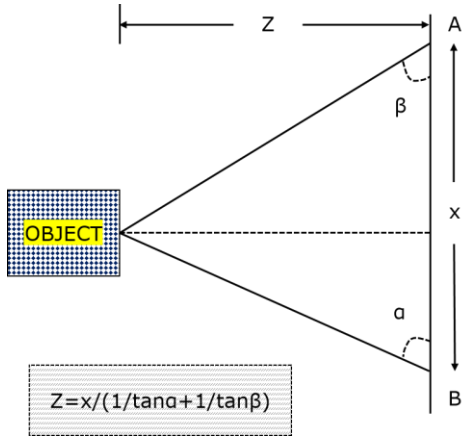

Figure 1: Difference analysis of binocular vision.

Compared with monocular vision, binocular vision obtains 3D information through the parallax principle of two cameras, which has higher measurement accuracy and wider application scenarios. This article combines binocular vision technology to construct a set of advertising design quality assessment systems based on 3D reconstruction. The system uses a binocular vision system to obtain the 3D model of advertising design and evaluates the design quality from multiple dimensions (such as size accuracy, shape consistency, material performance, etc.). Compared with the traditional two-dimensional image assessment method, the 3D assessment system based on binocular vision can reflect the real effect of advertising design more comprehensively and improve the accuracy and reliability of the assessment.

Materials and lighting settings: After the 3D model is established, the next step is to add materials and lighting effects to the model. The selection and setting of materials are very important for the visual effect of advertising design, which determines the appearance, texture and colour expression of the model. Material settings:

$$\text{Material} = \text{color},\text{texture},\text{reflectivity},\text{specularity},\ldots \tag{7}$$

Where color is the material colour; texture is the texture of the material; reflectivity is reflectivity; specularity is a highlight effect. Lighting settings affect the shadow and reflective effect of the model, which is the key to creating an atmosphere and highlighting key points. Lighting settings:

$$\text{Lighting} = L_a\text{mbient},L_d\text{irectional},L_p\text{oint},L_s\text{pot},\ldots \tag{8}$$

Where $L_a\text{mbient}$ is ambient light; $L_d\text{irectional}$ is directional light; $L_p\text{oint}$ is a point light source; $L_s\text{pot}$ is the spotlight.

Rendering and output: Finally, designers use the rendering function of CAD software to transform 3D models into high-quality images or videos. In the process of rendering, you can adjust the rendering parameters, such as resolution, ray tracing depth, anti-aliasing, etc., to obtain the best visual effect. After rendering, the designer can output the work to various formats, such as JPEG, PNG, MP4, etc., for subsequent use.

3.3 Example Display

Taking the advertising design of the beverage as an example, the designer first drew a sketch of the beverage bottle with CAD software and transformed it into a realistic 3D model through the 3D modelling function. Then, the designer added transparent glass material, realistic liquid material and appropriate lighting effects to the model, which made the beverage bottle shine in the picture. Finally, through rendering and output, a high-quality advertising picture was obtained, which successfully attracted the attention of consumers. The 3D modelling process and output advertising pictures are shown in Figure 2.

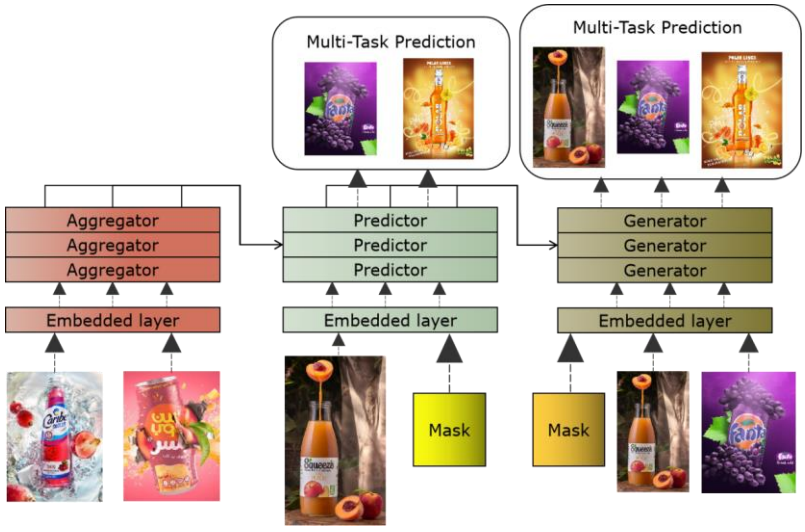

Figure 2: 3D advertising picture modelling.

4 RL ASSESSMENT SYSTEM DESIGN

4.1 Algorithm Selection and Implementation

This topic aims to clarify how to integrate the interactive characteristics of new media into the interactive design of public service advertisements in the new media environment and how to effectively utilize the visual, auditory, and tactile language elements and immersive experiences created by new media to better leverage the interactive functions of new media in public service advertisements, and maximize the dissemination of public service advertisements in the construction of socialist spiritual civilization.

The state space includes image features, text content, and layout information:

$$\mathrm{S} = I, T, L \tag{9}$$

Where I stands for image features; T stands for text content; L stands for layout information. The action space covers possible optimization operations, such as modifying colours, adjusting layout, and changing fonts:

$$\mathrm{A} = C, P, \mathrm{F} \tag{10}$$

Where C represents the action of modifying colour P represents the action of adjusting the layout; F stands for the action of changing fonts. The reward function is designed according to the quality assessment standard of advertising design:

$$\mathrm{R}\ s,a,s' = f\ \mathrm{Quality}\ s',s \tag{11}$$

Where s is the current state; a is the action to be performed; s' is the new state after executing the action; $\mathrm{Quality}\ s',s$ is a quality improvement function to evaluate the new state relative to the old state; f is a function that transforms quality improvement into reward.

This section focuses on designing the network architecture for the global network and worker thread. To enhance algorithm performance, meticulous adjustments were made to the network structure. These adjustments encompass altering the layer count for both the Actor and Critic networks, tuning the number of neurons per layer, and selecting appropriate activation functions. Through iterative experimentation and refinement, an optimal network structure was identified, capable of efficiently extracting advertising design features and precisely predicting action advantages, thereby boosting the algorithm's overall performance, as depicted in Figure 3.

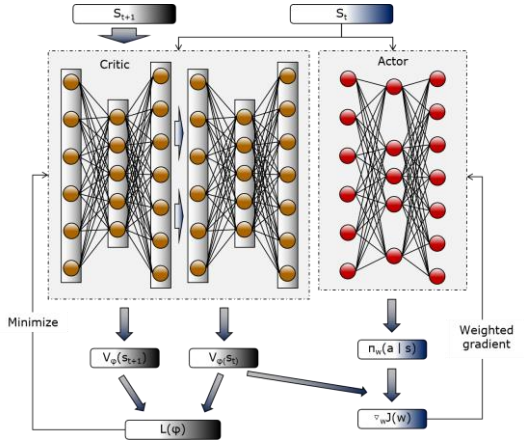

Figure 3: A3C network structure.

The global network includes the Actor-network and Critic network, which are used to output action probability distribution and estimate state value function respectively. Each worker thread has its own independent Actor-Critic network copy, and asynchronous learning is carried out in its own environment instance. By regularly updating the learned gradient to the global network, efficient parameter sharing and updating can be realized.

4.2 Experiment and Assessment

In the process of realizing the algorithm, this article carries out the steps of super-parameter tuning, network structure adjustment and reward function optimization to find the best performance. After the algorithm optimization is completed, this section has carried out a comprehensive assessment. First, through training experiments, observe the learning curve of the algorithm to evaluate its learning efficiency and convergence, as shown in Figure 4.

The figure clearly illustrates the algorithm's rapid convergence during the initial training phase, with performance progressively stabilizing and optimizing as training rounds increase. Specifically, following approximately 200 training rounds, the algorithm's assessment accuracy stabilized and maintained a high level thereafter. This outcome demonstrates the A3C algorithm's high learning efficiency and favourable convergence properties.

Furthermore, to validate the A3C algorithm's superiority in evaluating advertising design quality, this section compares it with alternative RL algorithms, and the experimental results are presented in Figure 5.

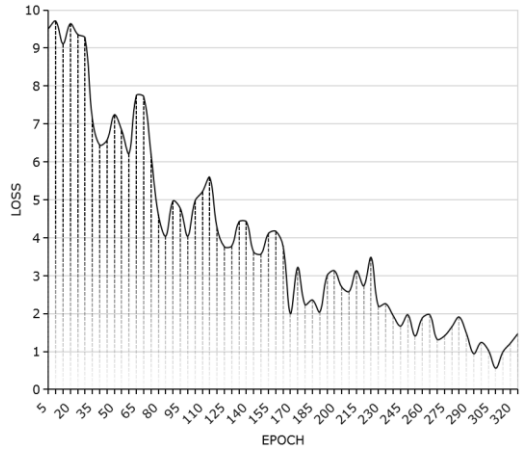

Figure 4: Algorithm learning curve.

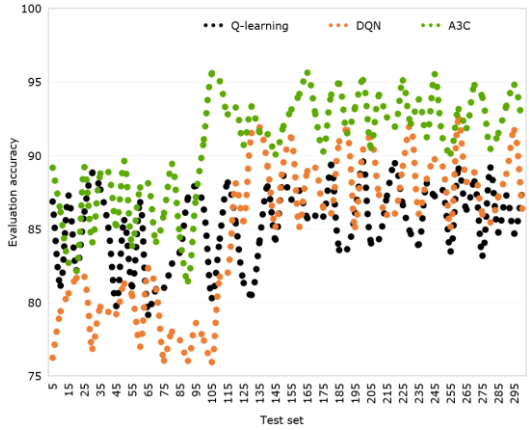

Figure 5: Accuracy of algorithm assessment.

The A3C algorithm in this article has the best performance in evaluating accuracy, with an accuracy of 95.8%. In contrast, the accuracy of the Q-learning algorithm is 89.2%, while the accuracy of the DQN algorithm is 92.3%. This outcome conclusively demonstrates the superior accuracy and advantages of the A3C algorithm presented in this article for assessing advertising design quality.

By comparing the learning effect and performance of different algorithms, we further confirm the superiority of the A3C algorithm in the task of advertising design quality assessment. Finally, the trained agent can be applied to the actual advertising design scene, and its effect and value in practical application can be tested through application assessment.

5 EXPERIMENTAL DESIGN AND RESULT ANALYSIS

5.1 Data Set Preparation and Experimental Setup

Additionally, pivotal visual attributes of each advertisement, such as colour distribution, compositional elements, and creative highlights, were extracted using computer vision technology, serving as the foundation for subsequent experimental analyses.

Regarding experimental parameters, selections were made based on the dataset's size and characteristics, encompassing appropriate batch sizes, learning rates, and training rounds. The training strategy involved an initial pre-training phase followed by fine-tuning. This approach entailed pre-training on large-scale datasets to enable the model to grasp fundamental advertising design principles, subsequently fine-tuning on smaller, task-specific datasets to enhance the model's generalization and relevance.

5.2 Analysis of Results

In the aspect of the assessment index, the combination of subjective assessment and objective assessment is adopted. In terms of subjective assessment, this article invited 30 professional designers and 30 audiences to rate the advertising design. Scoring adopts a 10-point system, and comprehensive assessment is made from multiple dimensions such as colour matching, composition layout and creative expression. Figure 6 displays the subjective assessment results.

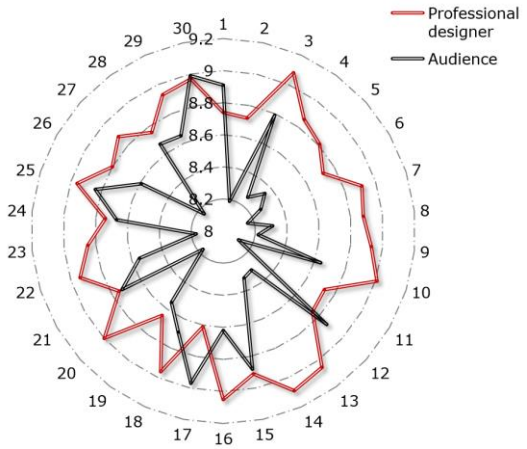

Figure 6: Subjective assessment results.

As can be clearly seen from Figure 6, the advertising design optimized by the A3C algorithm has obtained a high score in subjective assessment. Specifically, the average score given by professional designers is about 8.9, and the average score given by the audience is about 8.5. This shows that the advertising design optimized by the algorithm has been well-recognized by professionals and ordinary audiences.

In terms of objective assessment, this article uses computer vision and natural language processing technology to quantitatively analyze the colour, composition and creativity of advertising design. By extracting the colour features, shape features and text content of advertising design, we calculated a series of objective indicators, including colour harmony, composition balance and creativity novelty. The result is shown in Figure 7.

The A3C algorithm-optimized advertising design excels in objective evaluation, evident from the high average scores: 9.2 for colour harmony, 8.8 for composition balance, and 9.0 for creativity and novelty. These results indicate the algorithm's efficacy in enhancing colour coordination, layout composition, and creative expression during the advertising design optimization process.

5.3 Case Study

A typical case is selected for in-depth analysis. This case is an advertisement designed for a fashion brand. Under the traditional design method, the designer spent a lot of time and energy on sketch design and 3D modelling, but the effect was not satisfactory. Using the advertising design

assessment system proposed in this article, designers can quickly build high-quality 3D models and optimize the design through the RL algorithm. The final advertising design and its score are shown in Figure 8.

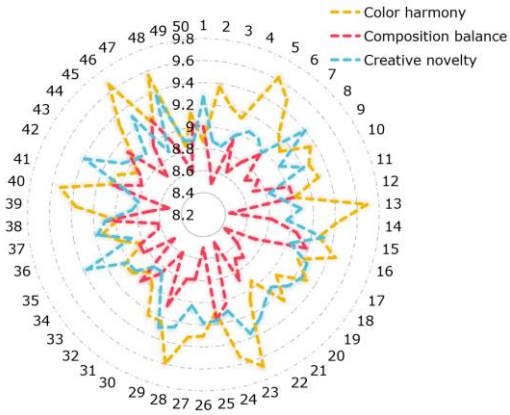

Figure 7: Objective assessment results.

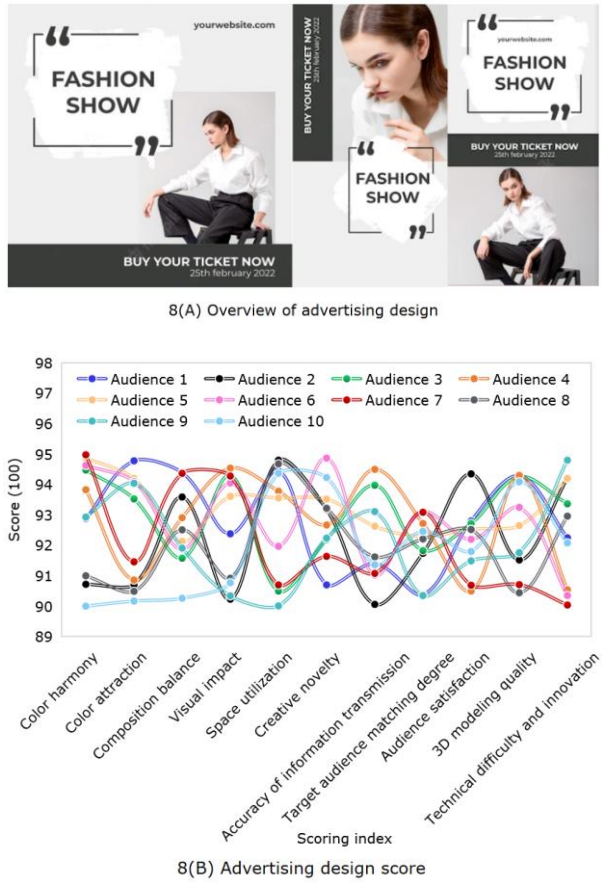

Figure 8: Advertising design details.

As shown in Figure 8, the advertising design adopts the unique tone of fashion brands in colour matching, forming a distinct brand recognition. In terms of composition elements, the designer skillfully used the principles of contrast and balance to make the advertising picture both impactful and harmonious. In terms of creativity, the designer combined the brand concept and the preferences of the target audience to create a unique and eye-catching visual image. Finally, the advertising design successfully attracted the attention of the target audience and enhanced the brand's popularity and reputation. This achievement fully proves the effectiveness and practicability of the advertising design assessment system proposed in this article. With the help of this system, designers can complete the task of advertising design more efficiently and accurately, and create greater value for brands and audiences.

6 CONCLUSIONS

This article focuses on the integration of CAD modelling and RL in advertising design, introducing a novel advertising design evaluation system. The findings reveal that this system boosts both efficiency and quality in advertising design, offering a fresh approach to the industry. Key discoveries encompass the precision and visualization strengths of CAD modeling, alongside RL's potential to elevate advertising creativity and appeal. The technological advancement lies in merging CAD modelling with RL to build a system capable of automatically assessing and refining advertising design quality.

The research outcomes hold substantial promise for practical advertising design applications. Primarily, the system expedites the design process, enhancing efficiency and enabling designers to swiftly adapt to market shifts. Secondly, it employs objective, quantitative criteria to minimize subjective bias, thereby ensuring consistent and reliable design quality. Lastly, the system provides creative insights and optimization strategies, assisting designers in transcending traditional methodologies and achieving more innovative, personalized designs.

As technology advances and markets evolve, the application of CAD modelling and RL in advertising design is poised to become more widespread and profound. Future research may explore integrating additional cutting-edge technologies, such as virtual reality and artificial intelligence, to further enhance advertising design's immersiveness and interactivity.

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