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Computer-Aided Design AND APPLICATIONS

Computer-Aided Film Visual Effects Production Based on Class Activation Mapping

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Abstract. The traditional method of producing visual effects for movies (VFX) has long relied on skilled craftsmanship and professional sensitivity, often resulting in longer production times and higher costs. In contrast, the recent surge in computer vision (CV) has ushered in a new era of film magic creation. In this article, we reveal the computer-aided framework for film VFX production, utilizing the latest technological breakthroughs. This method utilizes Convolutional Neural Networks (CNNs) to fine-tune deep neural networks and train them to distinguish patterns and recognize specific attributes in images. Then, these networks begin to perform various tasks, including image classification and precise localization of specific elements. In addition, we have integrated Class Activation Mapping (CAM) technology, which can draw the focus area of CNN and merge it into the basic image. This visual aid helps clarify where the model's attention is focused, providing crucial intuitive feedback throughout the entire learning process. To verify the system's proficiency, we conducted a simulation analysis. The results show that the proposed computer-aided framework not only simplifies the production of VFX but also becomes an excellent learning tool. It enables learners to have a stronger grasp of the complexity and technology behind VFX production. In addition, the educational methods outlined in this article emphasize the profound impact of visual aids in promoting learner engagement and understanding.

Keywords: Computer Vision; Computer-Aided Design; Visual Effects; Convolutional Neural Networks; Visual Teaching
DOI: https://doi.org/10.14733/cadaps.2024.S27.44-59

1 INTRODUCTION

CV is an interdisciplinary science that explores methods for extracting information from images or videos, understanding their content, and making decisions based on this understanding. It covers different fields of knowledge, including image processing, machine learning, and pattern recognition. CV can be used for automatic detection, tracking, recognition, and 3D reconstruction of target objects in images. These advances are valuable tools for increasing VFX movie production. The spatial design

of film art is not only intended to create an atmosphere and deepen the theme but also to reflect its individual artistic value while serving the plot of the film, providing visual enjoyment. With the continuous development of movies, the public has a deeper understanding and demand for film space design. After the substantial role of film art spatial modelling in film, spatial modelling plays an irreplaceable role in the aesthetic expression of film art. Visual elements are the fundamental elements that make up visual art. As the most intuitive aesthetic tool for humans, visual elements occupy a very important position in art. Whether it is graphic design, fashion design, home design, or interior design, they all involve visual elements, and their functionality and symbolism are widely used in film art space modelling. Gao and Li [1] applied visual elements to their spatial modelling, presenting them in the form of miniature models. From the characteristics and expressions of film art spatial modelling, they studied and elaborated on the application of visual elements. Ge et al. [2] used suspenseful film art spatial modelling as the object and constructed the modelling through the spatial visual elements and colour visual elements of visual elements. It interprets the artistic emotional expression of visual elements in the application of film art space modelling. By constructing various and ever-changing spatial forms through the compositional relationships between various visual elements. The spatial design can highlight the tone of the film, promote the development of the plot, and convey the characteristics of emotions. Thus presenting the unique narrative and artistic aesthetic value of film art space design.

With the sustained and rapid development of the film industry, VFX has become an important component of contemporary cinema. The production of VFX movies involves various technologies, such as image processing, animation creation, and scene synthesis. From a historical perspective, the creation of these effects mainly relied on skilled craftsmen manually adjusting each individual frame. Gu et al. [3] talked about the artistic charm and its impact on visual communication design. The transformation of design tools and the changes in communication forms brought about by digital technology have enabled visual communication design to break free from traditional flat spaces and move towards multi-dimensional three-dimensional spaces. That is to say, the visual communication forms of creative design completely rely on digital technology, such as CG illustration, website publicity on the Internet, etc. He [4] combined multimodal discourse analysis methods in exploring the dynamic design of movie posters. Exploring the dynamic design elements and expression patterns of visual language in movie posters, as well as the theoretical achievements of film studies. And conduct an overall evaluation and analysis of the movie's dynamic posters. The theoretical foundation of multimodal discourse analysis establishes the three major functions of systemic functional linguistics theory. It divides the expression of image meaning into representational meaning, interactive meaning, and compositional meaning and conducts visual grammar research on them. The theory of multimodal discourse analysis provides a theoretical approach for research, which was initially based on language system analysis. However, translating it into the study of dynamic posters in movies has good applicability. Based on this analytical framework, study the visual grammar of movie dynamic posters, and explore the expression methods and rules of movie dynamic posters through practical case analysis.

Hu [5] designs surface phenomena that are conducive to breaking through design by combining multimodal discourse analysis and expressive techniques in film studies. It studies the expression of visual content and design elements in movie dynamic posters from the essence of design. While analyzing the inherent nature of movie dynamic posters, examine the limitations of traditional movie posters and list the advantages of wide dissemination, fast speed, and strong targeting of movie dynamic posters. It analyzed two ways of expressing dynamic posters in movies. Summarized the five design principles of content simplification, information visualization, overall rhythm, theme enhancement, and interactive interaction. In order to provide theoretical supplementation and practical guidance for the design of dynamic posters in movies. The spatial design of a movie is the environment in which the characters in the movie rely for survival, depending on the type of movie. Each movie has its own unique spatial form expression, and the spatial form is presented one by one with the promotion of the movie plot, forming a unique style characteristic of the movie's spatial form. Through literature review and reading relevant books, most of the research on suspenseful spatial forms is focused on narrative direction. However, there is very little visual representation of

spatial design, as can be seen from domestic suspense movies in recent years. As a comprehensive art form, the visual aspect of film is also particularly important. The organic combination of visual elements makes the spatial design of the film have its own unique aesthetic value. Jia and Tian [6] studied this topic and conducted a modelling analysis on visual elements. To study and summarize one's own creative ideas on the characteristics and expressions in suspenseful spatial modelling. It demonstrates the diverse expression and construction role of visual elements in the design of suspenseful film art spaces.

The stage of continuous innovation in media presentation and visual communication design directly determines whether the dissemination effect and force of advertising can be maximized. The design is based on the premise of whether the application characteristics of media can be perfectly and deeply combined with visual communication design. The application in its design field has brought about a new form of art - digital art design. A new form of art that is clearly different from traditional visual communication design, from creation to transmission, feedback to interaction, is an innovation. Digital technology visual communication design has unique self-language and characteristics compared and has significant advantages in design communication. The art world has entered an era of explosive integration of culture and technology [7]. Digital technology, as a new tool for visual communication design, has quickly swept through our design field. Which has brought about many different forms of creation and expression. Li [8] analyzed the constituent elements and practical applications of visual elements from the concepts of visual elements and suspenseful film and television art space modelling. It analyzes the characteristics and expressive techniques of film art spatial modelling. In the creation of art, visual elements are everywhere, and it is analyzed from the concepts of visual elements and suspenseful film and television art space modelling. Analyzed the classification of visual elements, the definition and characteristics of suspenseful films, as well as the task and expressive techniques of film art spatial modelling in films.

However, the latest developments in the field of artificial intelligence have opened up a new era of automation and intelligence in this field. These developments include the application of deep learning in image art style transformation and the use of object detection and tracking methods for object replacement in dynamic scenes. These innovations not only improve production efficiency but also expand the creative scope of filmmakers.

The visual teaching method combines graphics, images, and animation, making it a powerful tool for elucidating abstract concepts or complex processes. It has been proven that this teaching method is particularly effective in educating students about the complexity of VFX film production. Visual aids help learners master basic principles and procedures, thereby enhancing understanding and mastery.

The importance of this study is twofold: firstly, by integrating cutting-edge CV, we have achieved automation and intelligence in the production of VFX movies, thereby shortening production time, controlling costs, and enhancing the competitiveness of the film industry; Secondly, through intuitive teaching methods, the complexity of VFX film production has become easier to understand and comprehend, improving teaching effectiveness, igniting students' passion and creativity, and cultivating outstanding talents in the field of VFX film production.

The innovation of this article includes: proposing a new framework for a computer-aided movie VFX production system, which can automatically recognize and classify image features and visualise the key elements of VFX movie production using CAM algorithms, providing producers with tangible visual feedback.

2 RELATED WORK

Digital technology will bring infinite possibilities and significant significance to our future visual communication design art. Liu and Liu [9] conducted profound thinking and exploration on this and expressed it through this paper. I hope to attract the joint attention of practitioners and developers in the field of digital technology. It can bring new thinking to both digital technology developers and practitioners through the research in this article, which can further promote the in-depth cooperation between digital technology R&D promoters. To contribute to the flourishing development of visual

communication design and digital technology in the future. Visual elements are indispensable in graphic design, spatial design, and even painting and are one of the important elements that inevitably appear in artistic design. They exist in various forms in artistic creation. In plastic arts, visual elements refer to the most basic visual symbols used for visual communication and expression in artistic images and are the fundamental elements that constitute visual art. Visual elements are formed through the use of basic elements such as points, lines, and surfaces, using different dynamic combinations to form new forms. Liu and Yao [10] analyzed in plastic arts that visual elements refer to the most basic visual symbols used in artistic images for visual communication and expression and are the fundamental elements that constitute visual art. Visual elements are formed through the use of basic elements such as points, lines, and surfaces, using different dynamic combinations to form new forms. It presents a visual art form to convey various objective and subjective information of art creators.

Film art space modelling is a comprehensive art that continuously absorbs the characteristics of other art categories in the process of gradual development. It combines various types of plastic arts, such as graphic design, painting, and stage art, as well as integrates nature and life, forming a unique spatiotemporal composite spatial shape of film art. The complexity and diversity of film art have also made it a comprehensive and independent form of plastic art. From a formal perspective, film art is a form of screen art that creates "shaping images that develop in motion.". The design of film art space plays a functional role in showcasing the world of film characters while also possessing the characteristic of giving the film its own artistic charm in terms of aesthetics. The modelling of film art space has the characteristics of the overall artistic space, the continuity of film time and space, the integration of scenery and people, the participation of modelling language, the uniqueness of modelling forms, and the popularization of creative consciousness [11]. Lukaevi et al. [12] drew inspiration from existing outstanding digital design artworks. An example of the practical application of outstanding visual works. It extracts the core reasons why these examples can be successfully applied and analyzes them in detail, tracing the key points that can achieve success or the reasons for suffering a disastrous defeat. The application of digital photography technology in the field of graphic design, such as advertising design, has been explored by many excellent practitioners and researchers. There are also a large number of rich and excellent research papers and related works that have been published. It also includes the emerging 3D series of digital technologies in visual communication design as part of this article.

By collecting and reading relevant literature, it can be found that there has been systematic research on movie posters both domestically and internationally. Movie dynamic posters are a new form of expression in movie posters, different from traditional movie posters. At present, dynamic and targeted research on movie posters is still relatively rare, and Song and Yang [13] have strong targeting when selecting research subjects to determine the research content. In addition, in recent years, with the booming development of the film market, more and more dynamic movie posters have appeared in front of us. There are a large number of existing design cases, including many exciting and talked about movie dynamic poster design cases. In today's era, there are increasingly more technical means and promotional media available for promoting movies. Exploring dynamic poster design solely from the perspective of flat poster design is insufficient. Tekeoglu [14] conducted interdisciplinary research based on the study of aesthetic significance, using multimodal discourse analysis and some theoretical paradigms of information communication. Not only discussing design, but also comprehensively analyzing movie dynamic posters from multiple perspectives such as systemic functional linguistics, communication studies, and film studies. These theoretical paradigms were used to conduct visual grammar analysis of movie dynamic posters and research on the design of movie dynamic posters.

The existing digital technology can now support movie posters to appear in a dynamic form. The audience's spirit and life require new ways of expression, and the dynamic design of movie posters can quickly spread through new media in a short time. The process of designers designing dynamic movie posters and viewers interpreting them is actually a process of encoding and decoding information. It is particularly important to effectively encode movie posters so that they can be efficiently interpreted by the audience. The discourse of movie posters is composed of various

symbols such as images, colours, and language, so reading dynamic movie posters is the decoding of a complex multimodal process. Through detailed decoding, it is beneficial for us to understand the poster content and further understand the theme presented in the film [15]. The addition of dynamic effects, sound effects, and interactive effects to movie posters makes the poster visuals more expressive and the content richer. Visual posters have transformed from a single display to a diversified display, increasing the audience's sensory impact, and creating a good atmosphere while stimulating pain points and deepening the audience's impression. Because of its rich and diverse media, and based on the Internet era, the transmission of dynamic movie posters has broken through the limitation of time and space, and movie posters are no longer a single static presentation mode. The Internet platform is used to facilitate the audience to receive the information transmitted by the dynamic posters at any time and anywhere. Movie dynamic posters inherit the design elements of traditional posters, as they combine new production techniques to bring new forms of presentation. Compared to the calm exposition of traditional movie posters, dynamic effects bring stronger visual effects, generate strong visual impact, and make posters more visually appealing and aesthetically pleasing [15].

Digital art design has given rise to more forms of artistic expression compared to traditional visual communication design. The design of game interfaces or web interfaces under digital control technology, interactive experience design under digital control technology, design tools under digital control technology, digital product promotion under digital control technology, and other newly derived art forms. The sound art design of digital art design is composed of our background music, visual music, character speech, sounds from other animals and plants, and environmental sounds. Wei and Han [16] encompass the visual art design in digital art, which is essentially composed of the constituent elements of our traditional graphic design. It includes important elements in traditional graphic design such as logo design, graphic design, text design, colour matching design, and visual proportion design. Digital art design is a form of art design, which is composed of new communication forms, such as graphic characters, interactive interfaces on the Internet, dynamic videos, 3D series digital technology, etc. Visual communication design not only retains the traditional graphic design but also adds interactive experience technology and time and three-dimensional space technology. In the art and design industry, especially in the visual communication design industry, digital art and design have been widely used. And it has played a significant role in the development of a more three-dimensional. It has attracted the attention and discussion of practitioners. However, currently, there is no complete, reasonable, standardized, and accurate theoretical system. Xiang [17] analyzed the ideological aspects of digital art design in the creative process in his exploration of digital art design. Further exploration was conducted on the artistic beauty of digital art design works and their visual communication design.

Due to the characteristics of information storage methods, digital information can be transmitted infinitely repeatedly. It can ensure the authenticity and reproducibility of the dissemination process and can simultaneously cover a large amount of information to record and disseminate more human life factors fully. It can ensure that the information timeliness in the dissemination process is achieved with zero distance, and more forms of information can be recorded, saved, and disseminated through more diverse and comprehensive reproduction media [18]. In general, multimedia digital technology establishes interactive visual communication design conditions between designers and audiences. Because multimedia digital technology greatly enhances the inclusiveness of creative design information [19]. The dynamic design of movie posters applied in interactive interactions not only perfectly reproduces the expressions and postures of the characters in the posters but also greatly increases the connotation of the posters and enhances the information content they contain. Furthermore, the dynamic design of the eyes and expressions is more eye-catching than the static background, making it easier for the audience to discover the information that the characters want to reveal in their eyes. Compared to traditional static posters, the dynamic design of movie posters makes contact and interaction more diverse [20].

CV integration into the VFX film production field has reached a considerable level. Many renowned film studios and research institutions are currently exploring the integration of advanced CV algorithms into their VFX workflow. Especially the use of deep learning techniques for complex

operations, such as style transformation and facial replacement, has become a common practice in contemporary film production.

The focus of this study is to create an innovative computer-aided system tailored specifically for the production of VFX movies. The main research objectives include: building a visual driving framework suitable for VFX, exploring the application of CNN in image feature recognition and classification, conducting in-depth research on the application of CAM algorithms in these feature visualizations, and creating user-friendly educational resources to improve the efficiency of VFX training.

3 DESIGN OF COMPUTER-AIDED MOVIE VFX PRODUCTION SYSTEM

3.1 System Design

Before developing a computer-aided system for VFX movie production, a comprehensive requirements assessment must be conducted. The system should meet the requirements of the entire workflow of VFX movie creators, including fast recognition of image features, automatic classification of VFX elements, visual descriptions of these features, and an easy-to-use interface. In addition, in order to adapt to the constantly changing film VFX technology in the coming years, the system should demonstrate strong stability and scalability. For a comprehensive requirements analysis, please refer to Table 1:

Type	*Subclass*	*Specific requirement description*
Image feature recognition	edge detection	This system can quickly and accurately recognize the peripheral details of images, including contour features such as lines and curves.
	texture analysis	The system conducts an in-depth analysis of texture features present in images and successfully extracts important qualities, including roughness, directionality, and regularity.
	Colour recognition	The system accurately identifies the main tones and colour coordination present in the image, laying the foundation for future colour matching and coordination.
	Format compatibility	The system must be able to handle various standard image formats, including but not limited to JPG, PNG, BMP, etc.
	automatic classification	By utilizing the recognized image features, the system automatically classifies elements into predefined groups, such as natural, abstract, scientific, and technological.
	Label system	The elements of classification are appropriately labelled to provide users with the convenience of quickly searching through specific keywords.
	Category scalability	Create an extensible category system that allows users to customize new categories based on their actual needs and preferences.
Classification of special effects elements	visual display	Utilize graphic representations such as heatmaps and enlarged views of edge contours to display texture details and visually present the recognized features.
	Interactive Tools	Provide an interactive visualization utility that allows users to dynamically modify display settings and viewpoints to meet different observation requirements.
	Real-time	Visual feedback can enable timely parameterized

	feedback	adjustment and analysis.
Feature Visualization	Simple design	Design a simple and user-friendly interface to ensure that users can effortlessly master various functions and quickly start and run.
	Custom settings	Enable users to personalize interface layout and adjust parameter settings based on personal preferences and work needs.
	Real-time preview and export	Add a real-time preview function, allowing users to view adjustment effects in real time;
	processing speed	Ensure that the system can process image data at an effective response speed.
	memory management	Improve memory usage to prevent system pauses or crashes when processing large images or continuous workloads.
	Multi-threading support	Add multithreading support to fully utilize computer hardware resources fully, thereby improving overall processing efficiency.

Table 1: Precision necessity check of image VFX processing system.

The visualization layer presents detailed visual effects and feature visual information to users, promoting user interaction and achieving result export.

Carefully designed interfaces ensure smooth communication and data exchange between layers, thereby ensuring the overall stability and efficiency of the system. The selection and implementation of key algorithms are crucial in the system development process. In addition, integrating CAM algorithms into CNN models helps with the visual representation of features, a concept that will be further explored in the following chapters.

3.2 Image Feature Recognition and Classification Based on CNN

CNN marks a profound deep learning algorithm structure carefully designed to address challenges surrounding images. This neural network cleverly exports localized features from images using convolutional layers, pooling layers, and a series of other elements, effectively linking these features to the final task output through fully connected layers. Before utilizing the powerful capabilities of CNN to recognize and classify image features, the first step is to assemble an appropriate image dataset. These datasets cover various popular image elements that are crucial for creating VFX movies, such as characters, backgrounds, props, etc. The dataset is sourced from publicly accessible image repositories. After obtaining the raw data, a series of preprocessing measures must be taken to improve data quality and ensure its compatibility.

In this publication, image pixel values are normalized within a predefined range of [0,1].

$$y_{i,j} = \frac{x_{i,j} - \min\ X}{\max\ X\ - \min\ X} \tag{1}$$

In the normalized image, let $y_{i,j}$ represent the pixel value of the i,j position. Meanwhile, $\min\ X$ and $\max\ X$ represent the lowest and highest values observed in the original image matrix X, respectively.

The convolutional layer is responsible for identifying local image features, while the aggregation layer is used to reduce the dimensionality of the data and improve the robustness of the features. The fully connected layer is usually located at the endpoint of the network, linking the recognized features with the final classification output.

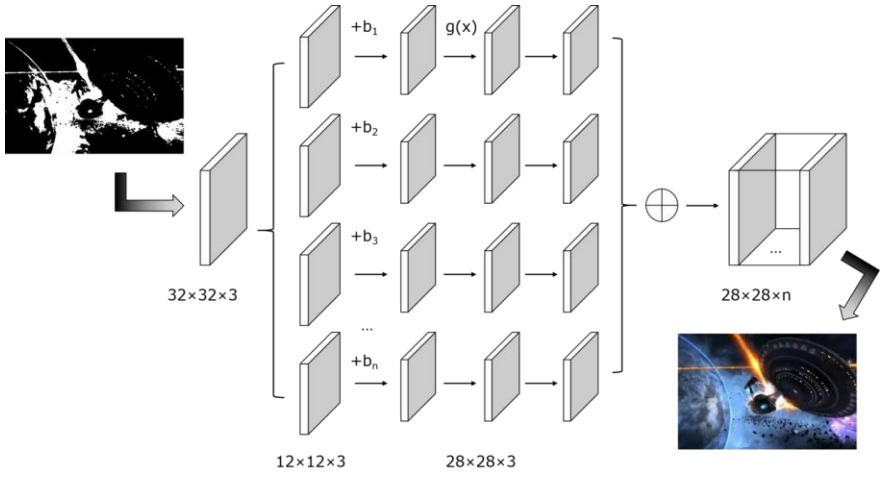

Figure 1: CNN structure.

Figure 1 shows the CNN structure. The loss function used is cross-entropy, and its mathematical expression is given by the following formula:

$$H\ \ p,q\ \ = -\sum_{x} p\ \ x\ \ \log q\ \ x \tag{2}$$

While q representing the predicted result. The decrease in cross-entropy indicates a stronger correspondence between two probability distributions, indicating an improvement in the neural network model. Consider the unique mapping that appears from the t convolutional layer, as follows:

$$M_t = \ \ m_1, m_2, m_3, \ldots, m_s \tag{3}$$

$$p_i = \max\ \ M_t\ \ = \max\ \ m_1, m_2, m_3, \ldots, m_s \tag{4}$$

While using optimization algorithms to improve its parameters and reduce prediction errors gradually. The optimization method chosen in this study is SGD (Random Gradient Descent). SGD involves randomly selecting a single sample for each iteration to update parameters rather than using the entire dataset for gradient calculation. This method significantly improves the efficiency of SGD, especially when dealing with large datasets. The formula for updating parameters in SGD is as follows:

$$\theta_{new} = \theta_{old} - \alpha \cdot \nabla_{\theta} J\ \ \theta \tag{5}$$

The learning rate (represented as a) determines the magnitude of parameter adjustment during the update process. θ_{old} represents the model parameter values for the current iteration and θ_{new} represents the updated model parameter values for subsequent iterations.

After the model training is completed, a series of tests must be conducted to confirm the model's proficiency in recognizing and classifying image features. The experiment detailed in this article needs to evaluate the classification accuracy of the testing part and compare it with RNN. Please refer to Figure 2 for the results of classification accuracy evaluation.

The experimental results show that compared with the RNN method, our method exhibits superior classification accuracy on the test dataset, achieving an accuracy rate of over 95%. This significant improvement is attributed to the innovation and enhancement introduced in our model design, algorithm optimization, and data processing techniques. Therefore, these advancements enhance the model's generalization ability and classification performance.

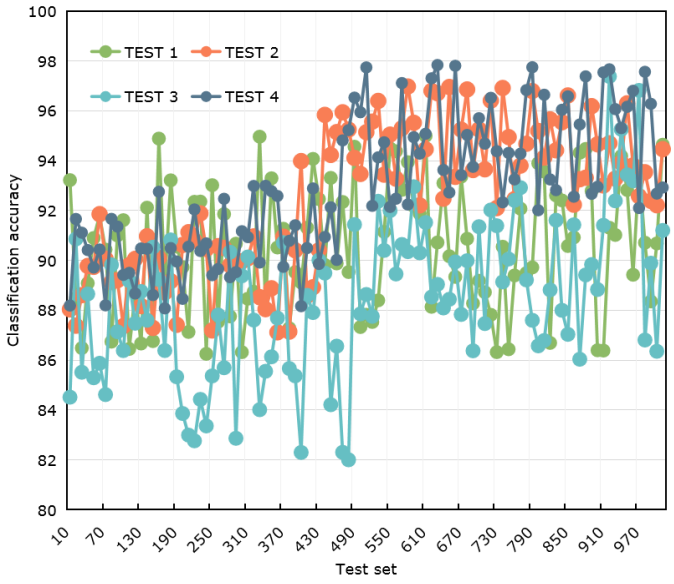

Figure 2: Results of classification accuracy evaluation.

The results of the comparative experiment are shown in Figure 3.

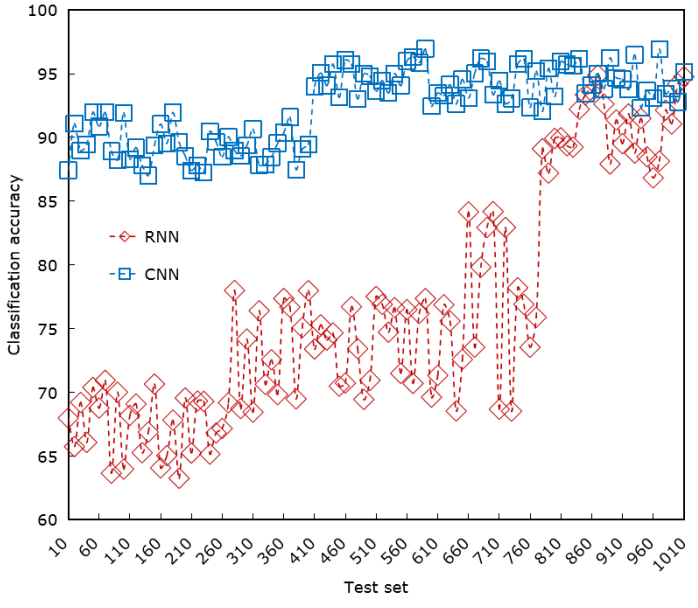

Figure 3: Comparative experimental analysis.

Although RNNs have advantages in processing sequence data, they may encounter limitations such as vanishing or exploding gradients in specific tasks. Our approach effectively addresses these challenges by adopting cutting-edge network architectures and optimization algorithms, thereby achieving higher classification accuracy. By conducting quantitative evaluations and utilizing visual

descriptions of the experimental results mentioned above, we can thoroughly evaluate the performance and advantages of CNN models.

3.3 Application of CAM Algorithm in Feature Visualization

It is crucial to obtain feature maps from trained CNN before applying the CAM algorithm to visualize features. These images are typically extracted from the final convolutional layer of the network, containing rich semantic details of the image.

$$F_c = F\left[H_c \times W_c \times D_c\right] \tag{6}$$

$$W' = \frac{W}{\sqrt{D}} \tag{7}$$

This formula D represents the depth of the weight matrix W. In order to align the CAM represented M_c with the original feature map F, we adjusted it to the same size $H \times W$. The resulting heat map is denoted as H_c and can be calculated using the following equation:

$$H_c = \text{upsample}\ M_c, size = H, W \tag{8}$$

$$\text{color} = \text{CMap}\ \text{value} \tag{9}$$

The given equation, value represents the pixel values derived from the heatmap while color representing the corresponding colours.

In the field of VFX film creation, producers can use the feature visualization output of CAM algorithms to intuitively understand the model's attention to different regions in the image. This insight enables manufacturers to clearly execute precise VFX enhancements and optimizations (see Figure 4).

Figure 4: Feature visualization results.

In addition, functional visualization provides valuable assistance in creating movie trailers and seamlessly integrating scene design elements. Figure 5 shows the improvement in accuracy. The degree of overlap between regions is a key criterion for evaluating feature visualization's effectiveness (Figure 6). The content shown in Figure 6 reveals a striking phenomenon: significant regional overlap is evident. This fully demonstrates that the CAM algorithm exhibits extremely high accuracy in identifying key feature regions closely related to the VFX production task of movies. For

filmmakers, this precision has immeasurable value. It provides them with an intuitive and efficient tool that enables them to quickly capture the core features in images, enabling them to create and adjust more accurately.

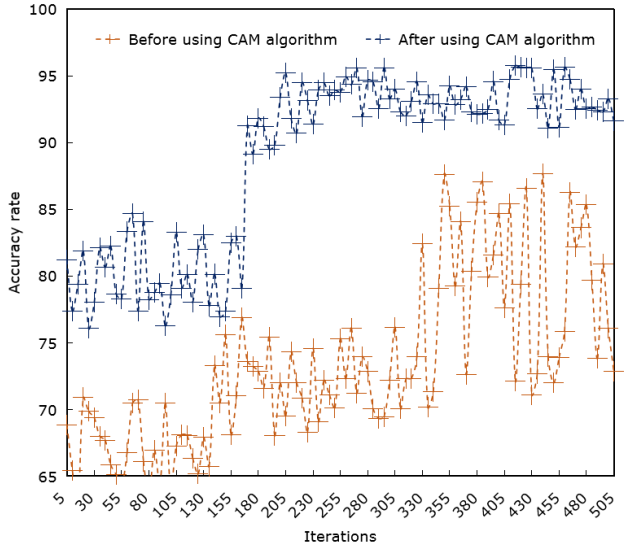

Figure 5: Improvement in accuracy.

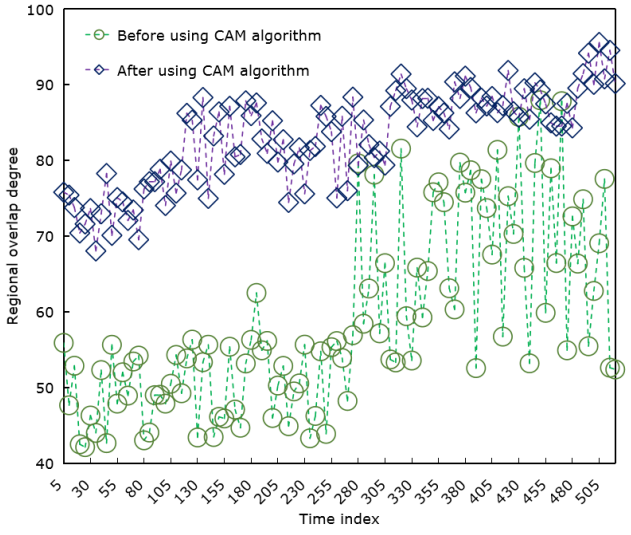

Figure 6: Region overlap degree.

4 IMPLEMENTATION AND VERIFICATION OF COMPUTER-AIDED SYSTEM FOR VFX PRODUCTION OF MOVIES

In the system implementation phase, it is crucial to choose the appropriate development settings and tools initially. When it comes to computer-aided systems for movie VFX production, this article

chooses a Python-driven development environment, mainly due to its extensive image processing library and profound learning structure. For detailed information on the selected development environment, please refer to Table 2.

Type	*Selectable Items*	*Reason*
Operating system	Windows	Provide stable runtime settings and support a range of development utilities.
Programming language	Python	It is simple and easy to understand, with strong readability, and has received widespread support from the community, possessing strong scientific computing capabilities.
Development system	TensorFlow	It provides the basic tools needed to build and educate neural networks.
Subordinate rights	PyCharm	Used for programming and troubleshooting.
	Git	Version management ensures seamless development processes.

Table 2: Development environment.

Based on the overall system design, this article decomposes the system into independently developed different functional components. The main functional units include:

Image input and preprocessing module: Read the image file uploaded by the user and perform necessary preprocessing steps, such as adjusting image size and normalizing the image.

Feature extraction and classification module: Using a trained CNN model to extract relevant features from images and classify them, thereby generating classification decisions and corresponding feature representations.

VFX operation module: Based on classification decisions and user input, various movie VFX operation techniques are applied, such as combining style conversion and dynamic effects, to change images.

Visual feature representation module: Use the CAM algorithm to generate heatmaps to visualize important features, helping users understand the key elements and reasons behind image classification.

Output and sharing module: Save modified images and visual feature representations to a file or allow easy sharing on social networking platforms.

After developing each functional unit, this article continues with system integration and rigorous testing. Please refer to Table 3 for detailed test results.

Testing phase	Test content	Test objectives	Test result
unit testing	Design testing scenarios for each functional module.	Ensure the accuracy of autonomous operation of functional modules.	pass
integration testing	Thoroughly inspect the combined operations of all individual operating units.	Ensure that functional modules interact and collaborate effectively as expected.	pass
System testing	Conduct end-to-end testing of the entire system.	Evaluate the consistency between the system and user requirements and expected design specifications.	pass
Characteristic test	Evaluate system response time and resource utilization	Confirm that the system displays the best functionality.	pass

	under different workloads.

Table 3: System integration and test results.

Figure 7 illustrates the system response time under different workload levels.

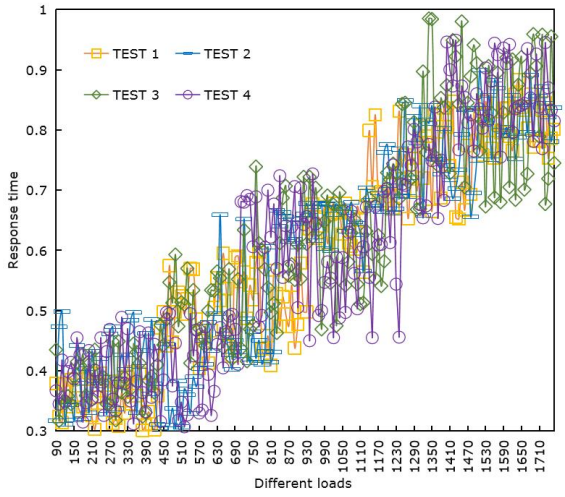

Figure 7: System response time under different workloads.

Figure 8 shows the analysis of resource utilization efficiency.

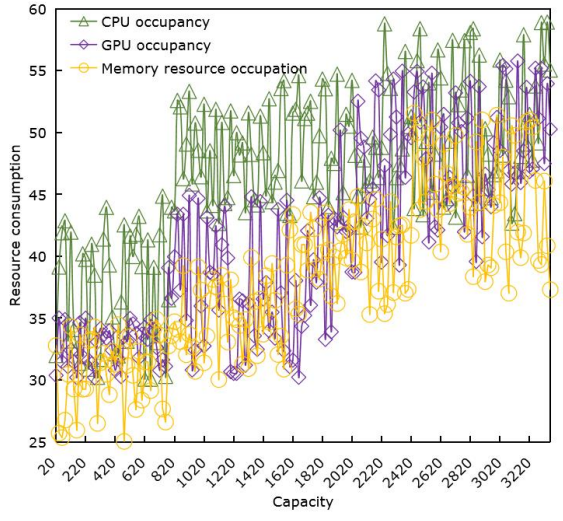

Figure 8: Evaluation of system resource utilization.

Observations indicate that the system is not only fully functional but also exhibits consistency and reliability. As the workload increases, the response time of the system shows a stable trend, indicating its ability to manage situations involving multiple users or tasks effectively. Meanwhile,

during standard operation, the resource efficiency of the system remains within a reasonable range, indicating no resource waste and sufficient reserves to cope with unexpected surges in demand.

In addition, this study invited professionals in the VFX film field to use the system and collected their insights and suggestions on enhancing system functionality and interface design. The user experience feedback is shown in Table 4.

User ID	Professional background	Level	Feedback and suggestions
U001		8.51	The system is running smoothly, but there may be significant delays in previewing certain effects. Our goal is to enhance the responsiveness of the preview function.
U002	Movie VFX Artist	9.28	The interface design is simple and clear, beautiful and generous, ensuring user-friendliness. I hope to combine additional options for personalized settings.
U003		8.95	The function of importing 3D models runs well, but the process of adjusting materials lacks a user-friendly interface. Suggest enhancing material editing tools.
U004	Visual design	8.05	The function of editing animation curves is very powerful; However, the timeline control has experienced a certain degree of lag and needs improvement to achieve smoother operations.
U005		9.55	The system demonstrates strong interoperability with editing tools and has a user-friendly interface. It is expected that there will be an extended transition effect library in future updates.

Table 4: User experience.

By adopting a series of different evaluation techniques mentioned above, the computer-aided movie VFX production system has undergone a thorough and fair performance evaluation. The evaluation results indicate that the system performs excellently in classification accuracy, has a fast response time, and shows minimal resource utilization, thus meeting the practical needs of film producers.

5 THE APPLICATION OF VISUAL TEACHING IN THE VFX PRODUCTION OF MOVIES

5.1 Visual Instruction Content Design

Creating educational materials for VFX in movies is an important component of this process. Using the computer-aided VFX film production system mentioned earlier, and considering the academic needs of students and the abilities required by the VFX department, this article carefully creates an educational course that combines theoretical knowledge with practical skills. This course first explains the basic principles and workflow involved in the production of VFX movies, including various effects, production tools, and cutting-edge technologies. Subsequently, it transitioned to exploring the application of visualization technology in movie VFX production, including creating realistic virtual environments through 3D modelling and rendering, as well as extracting and integrating VFX components through image processing and computer vision. In order to enhance students' understanding and mastery of these technologies, this course combines a series of practical assignments, enabling learners to consolidate their understanding and application of visualization technology through practical implementation.

5.2 Teaching Experiments and Effect Analysis

In order to determine the effectiveness of visual education resources, this study conducted a series of teaching experiments. For the purpose of these experiments, two groups of students were selected:

one as the experimental group receiving visual teaching methods, and the other as the control group receiving teaching through traditional methods. Both groups participated in a one-semester VFX film production course. After the end of the teaching semester, a detailed comparison was made between the academic performance of the two groups of students, as shown in Table 5.

Evaluating indicator	*Experimental group*	*Control group*
Professional knowledge in VFX film creation	92	73
innovation ability	89	65
construction quality	4.3	3.1
Comprehensive evaluation	8.9	6.8

Table 5: Teaching Experiment Results.

The data shows that the experimental group has reached a relatively high level of professional expertise in film special effects creation, and their innovation ability and output quality have also improved, surpassing the control group. This emphasizes the important impact of visualization in education, which greatly improves students' academic and practical performance.

Throughout the entire teaching process, we strive to collect student feedback in order to quickly identify and correct any issues, thereby improving our teaching practices. Feedback collected through surveys and personal interactions indicates that students generally recognize visual education content as clearer, more attractive, and more inspiring. In addition, students also provided constructive feedback. In response, we have adjusted our teaching strategies and methods, further improving our visual education content and process.

6 CONCLUSIONS

This study aims to develop an advanced computer-aided VFX film creation system that utilizes complex CVs and combines them with visual teaching techniques. The purpose is to significantly improve the teaching efficiency of VFX works and enhance students' academic literacy. Which provides a lot of help for image asset management in VFX production. Next, the CAM algorithm is used for feature visualization, which can clearly analyze the basic features of images, thereby helping VFX artists understand image content more thoroughly and perform precise effect editing. Finally, the effectiveness of the proposed method was demonstrated through its application in visual teaching practice.

In summary, this study effectively incorporated CV into the field of film VFX production and related educational fields. By combining technological progress with teaching methods, this study has greatly influenced talent cultivation and improved the teaching level of the VFX industry.

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