www.cad-journal.net Computer-Aided Design AND APPLICATIONS

Computer-Aided Creation and Teaching of New Media Art Based on Virtual Reality

Mengyuan Fu[1] and Mingyu Jiang[2]

[1,2] International Academy of Arts, Jilin International Studies University, Changchun 130117, China, [1]fumengyuan@jisu.edu.cn, [2]jiangmingyuaini@163.com

Corresponding author: Mengyuan Fu, fumengyuan@jisu.edu.cn

Abstract. This article aims to explore the potential applications of virtual reality (VR) technology in computer-aided creation and teaching of new media art (NMA), proposing an innovative system architecture. To achieve this, we investigate core technologies like image feature detection and 3D reconstruction, designing a series of experiments to validate the system's performance. In the process of visual principle stereo construction for image feature extraction, this paper uses deep learning network algorithms to perform 3D reconstruction of image features. During the deep learning feature extraction process of neural networks, algorithm feature extraction and construction of texture images were carried out. A 3D image feature analysis framework under VR conditions was constructed through the analysis of different significant indicators. In the process of high-precision feature monitoring, satisfactory user responses have been obtained for the framework of teaching quality and texture images.

Keywords: Virtual Reality; New Media Art; Computer-Aided; 3D Reconstruction
DOI: https://doi.org/10.14733/cadaps.2025.S4.69-83

1 INTRODUCTION

Virtual reality has stirred up waves of intelligence and propelled the digital age into a new stage. Human activities are closely connected to digital media, and the public can use digital media to express, create, and communicate anytime, anywhere, and freely [1]. Therefore, relevant supportive policies have been introduced one after another, and greater emphasis has been placed on the talent cultivation of digital media art. Then, from the perspectives of technology, communication, and art, observe the current performance of digital media art in the increasingly intelligent stage and identify the hidden problems and solutions under the wave of intelligence. To understand the digital transformation brought about by digital media art in the era of virtual reality and to explore the characteristics and future development of digital media art [2]. Observing the response strategies of digital media art education in universities under the influence of the expansion of the digital media industry, reflecting on digital media art education in Chinese universities, and understanding the relevant policies of the country to support the development of digital media art. Finally, observe, summarize, and envision the innovative practices and development of digital media art in the current and even future post-virtual reality era [3]. Digital media art relies on digital media technology to showcase creativity, which has a profound and crucial impact on the development and growth of cultural and creative industries. Countries around the world are paying attention to the economic benefits brought by cultural and creative industries. Understand the relationship between digital media technology and virtual reality, have a clear concept of digital media technology, and have a general understanding of the application scenarios of digital media technology in the era of intelligence [4]. Therefore, some scholars adopt interdisciplinary research methods, comparative research methods, literature research methods, and other approaches to clarify the concepts of digital media and digital media art through academic research by domestic and foreign scholars. Reflect on innovative development strategies for digital media art, analyze the digital media industry, and think about talent cultivation related to the new talent demand brought about by the development and growth of the digital media industry [5].

This model can help us identify the key factors that affect students' motivation, optimize teaching resources and teaching strategies and ensure the effectiveness of technology application and student participation. The deep integration with mobile technology not only constructs new dimensions of learning but also greatly enriches teaching methods, becoming an important force in promoting the development of modern education. In this context, further expanding AR technology to the field of "computer-assisted creation and teaching of new media art based on virtual reality (VR)" not only deepens the application level of technology but also brings revolutionary changes to art creation and education models [6]. Students are not only able to intuitively observe and understand artworks in three-dimensional space but also have the freedom to create, modify, and test their designs in a virtual environment. This "learning by doing" approach greatly stimulates their creativity and exploratory desire. The experimental results showed that students who participated in VR-based computer-assisted creation and teaching of new media art exhibited significant improvements in motivation level and academic performance. By introducing Keller's teaching material motivation survey model, we can systematically evaluate the motivation level of students majoring in education, medicine, art, and new media art at the University of Seville to use mobile devices combined with AR and VR technology for learning and creation in the classroom [7]. At the same time, combined with the interactive note-taking function provided by AR technology, students can seamlessly switch between reality and virtuality, closely integrating theoretical learning with practical operations, promoting the internalization of knowledge and the cultivation of innovative abilities. In the field of new media art, VR technology provides an unprecedented immersive experience for computer-assisted creation.

The innovation of virtual and augmented reality technology has not only brought disruptive changes to traditional human-computer interaction methods but also profoundly influenced multiple fields of creation and teaching, including new media art [8]. This new form of interaction has demonstrated particularly prominent advantages in computer-aided creation and teaching of new media art, especially when it comes to tasks such as 3D spatial manipulation, creative expression, and complex scene construction. Some scholars aim to explore the applicability of natural interaction in computer-assisted creation and teaching of new media art based on virtual reality and evaluate its superiority over traditional computer operating modes such as mice and keyboards. This interface supports fine-finger interaction, allowing users to construct, shape, and modify new media artworks in virtual space as if they were operating physical materials. Simulating real touch, grip, rotation and other operations also promotes real-time feedback and iteration of creativity, accelerating the smooth progress of the creative process [9]. It surpasses the interface design dominated by the window, icon, menu, and pointer (WIMP) paradigm in the past. This interactive method greatly enhances users' immersion and creativity, making the creative process more intuitive and efficient. These technologies greatly expand the way users interact with digital content by introducing natural user interfaces, such as highly realistic finger interactions. The introduction of natural interaction not only enables artists and students to interact with creative objects in virtual environments more intuitively and naturally [10].

The study will focus on: analyzing VR technology's application status and development trends in NMA to clarify its potential in artistic creation and teaching; investigating the application of computer-aided creation technology in NMA and exploring how it can assist artists in creating VR art; and constructing an NMA teaching system based on VR, with experimental verification and effect assessment to provide a novel and effective teaching mode for NMA.

2 RELATED WORK

The combination of computer-aided creative tools (such as 3D modelling software, animation engines, etc.) and VR technology makes the creative process more efficient and intuitive, providing unlimited possibilities for the presentation of artistic works. This immersive learning method greatly enhances students' interest and participation in learning. Virtual reality technology also plays an important role in new media art education. In addition, VR provides students with a virtual environment for practical operation, reducing risks and costs in actual creation, and promoting the deep integration of theory and practice. Liu and Liu [11] used VR platforms to freely construct, modify, and display their works in three-dimensional space, and this real-time feedback creative process greatly stimulated their imagination and creativity. Through VR teaching platforms, students can immerse themselves in exploring the internal structure, light and shadow effects, and even the emotional expression of artistic works. With the widespread popularity of computer design software in the fields of art and design, as well as the rapid development of computer technology, the interdisciplinary integration of art and design with computer science has become an irreversible trend. Through VR technology, students can "step into" a virtual art creation space, intuitively feel every detail of the design work, and thus gain deeper insights and inspiration in the creative process. Especially in the context of "computer-assisted creation and teaching of new media art based on virtual reality (VR)", exploring suitable teaching models to comprehensively improve students' artistic literacy, computer skills, and innovation abilities has become an important issue facing universities. Liu and Phongsatha [12] utilized VR technology to present the material library in three-dimensional form, allowing students to freely browse and select materials in a virtual environment, greatly improving the convenience and efficiency of material use. In the intelligent teaching of art and design majors in universities, introducing computer-aided design courses based on virtual reality can not only provide students with an immersive learning experience but also greatly enrich teaching methods and promote the deep integration of theory and practice.

When designing a typical environment for the system, the actual needs of the art and design industry should be fully considered, such as simulating different creative scenarios, exhibition spaces, etc. To improve the efficiency of the system, it is necessary to establish a clearly classified and easily retrievable material library. It has given birth to the emerging field of computer-aided design (CAD), which holds a pivotal position in art and design majors in universities. For VR environments, it is necessary to design intuitive and easy-to-understand UI interfaces to ensure that students can easily complete various operations while wearing VR devices. Simplifying user operations and improving system availability are key aspects of the design process. Through VR technology, students can practice on-site in a virtual environment, predict the final effect of design work in advance, and make more accurate adjustments and optimizations. Sansom and See [13] further enhance the user experience by continuously optimizing user experience design, such as providing interactive methods such as voice control and gesture recognition. Interface design is the bridge that connects users and systems, and its importance is self-evident. In VR environments, interface design needs to pay more attention to immersion and interactivity.

Computer graphics-assisted art design, as a core means of creative expression in the digital age, relies on advanced digital methods and concepts to construct virtual models, greatly enriching the boundaries and possibilities of art design. The system aims to provide students with an immersive and interactive art creation and learning environment through VR technology. Shi and Niu [14] explored the application of various modern design methods in computer-assisted creation and teaching platforms for new media art based on virtual reality. In the wave of new media art, how to effectively integrate existing online teaching resources and build a computer graphics and image-assisted art design teaching platform that integrates virtual reality (VR) technology has become the key to improving teaching quality centred on digital content innovation. Further exploration was conducted on how to combine this method with virtual reality technology to construct a new computer-aided design platform system. This enables abstract computer graphics principles and image-assisted design techniques to be presented intuitively, thereby deepening understanding and stimulating creativity. For example, utilizing the stereoscopic spatial perception capability of VR for 3D modelling and rendering, achieving real-time adjustment and feedback of design through gesture recognition or voice control, as well as experimental exploration of simulating real-world lighting and material effects. More importantly, the platform's intuitive interactive teaching method established through digital means makes the teaching of spatial form theory more intuitive and vivid. In addition, VR technology provides students with opportunities to experience art across time, space, and culture, broadening their horizons and enhancing the diversity and innovation of design. Based on an in-depth analysis of the overall design methods of art products, Zhao et al. [15] not only reviewed the implementation path of traditional computer-aided design modular decomposition methods in computer art design. These practices not only promote the in-depth development of digital computer graphics theory, but also bring revolutionary changes to the teaching philosophy, digital teaching methods, and talent cultivation strategies of image-assisted art design. Students can operate in a virtual environment and experience the impact of different forms, colours, and materials on the overall design, effectively improving their modelling and aesthetic judgment abilities.

3 APPLICATION OF VR TECHNOLOGY IN NMA

3.1 Computer-Aided Creative Technology

VR technology, as an important support of NMA, is gradually changing the face of artistic creation. This technology offers artists a novel creative space through simulating 3D and immersive environments, empowering them to freely exhibit their creativity within the virtual realm and discover endless artistic possibilities. Figure 1 illustrates the utilization of VR technology in NMA.

Figure 1: Application of VR technology in NMA.

In VR, artists can freely construct and shape virtual space and are not bound by physical laws and materials in the real world. This enables artists to create bolder and more innovative works of art and achieve effects that are difficult to achieve by traditional artistic means. VR technology provides an immersive artistic experience. The audience can feel the charm of the virtual world and interact with the works of art deeply. VR technology also has cross-border characteristics. It can be combined with music, dance, drama and other art forms to create cross-border works of art and enrich the manifestations of NMA. By simulating real brushes and pigments, VR paintings enable the audience to freely display their creativity in the virtual space and create unique paintings. VR sculpture works use VR modelling tools to enable the audience to create three-dimensional sculpture works in virtual space. How to effectively use VR technology for artistic creation and how to introduce this technology into NMA teaching is an urgent problem to be solved at present.

Computer-aided creative technology, as an assistant to NMA's creation, is gradually favoured by artists. By using computer algorithms and data processing capabilities, this technology provides artists with rich creative materials to help them create more efficiently. Computer-aided artistic creation. Figure 2 shows the computer-aided art design works.

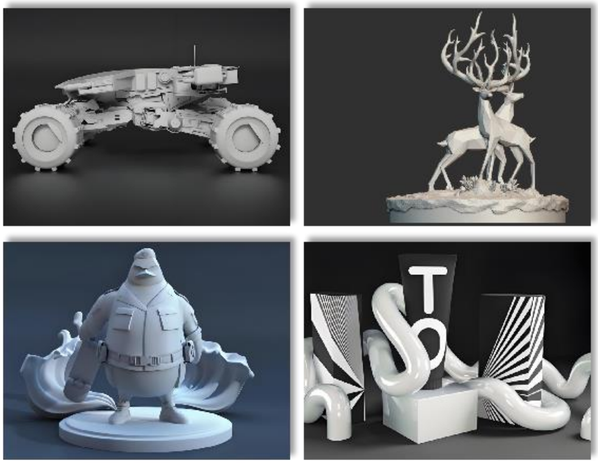

Figure 2: Computer-aided artistic creation.

In NMA, the application of computer-aided creative technology is manifested in several key aspects. Firstly, it equips artists with robust data processing and visualization capabilities, enabling them to transform extensive datasets into visual imagery and animations through computer algorithms. Construction of NMA teaching system based on VR

3.2 System Requirement Analysis

(1) Students' learning needs: Students aspire for a more intuitive and interactive experience during the NMA learning process. They anticipate that VR technology will enable them to immerse themselves in and appreciate the charm of artistic works. Additionally, students desire personalized learning resources and feedback to cater to diverse learning styles and ability levels.

(2) Teachers' teaching needs: Teachers anticipate that the teaching system will enhance their efficiency in conducting teaching activities. The system ought to facilitate teachers in uploading and managing teaching resources, designing interactive teaching segments, monitoring students' learning progress and effectiveness in real time, and offering data support for teaching evaluation and enhancement.

(3) Technical realization requirements: The system must exhibit high stability, compatibility, and scalability. In selecting technology, mature VR technology solutions should be prioritized to ensure user-friendliness. Furthermore, the system must support multi-platform access to accommodate the usage habits of different users.

3.3 Implementation of Key Function Modules

When building an NMA teaching system based on VR, we need to focus on the realization of the following key functional modules:

(1) Construction and optimization of virtual environment: Use 3D modelling software such as 3DS MAX to construct virtual teaching scenes and art exhibition spaces. By optimizing the model structure and rendering parameters, the realism and fluency of the virtual environment are improved.

(2) Integration and distribution of teaching resources: develop a teaching resource management system to support uploading and distribution of teaching resources in various formats. The system should have intelligent classification and retrieval functions to facilitate users to quickly find the required learning resources.

(3) Development of interactive teaching function: realize real-time explanation, online question and answer, mutual assessment of works and other interactive teaching functions in the virtual environment. By integrating speech recognition and natural language processing technology, the interactive and intelligent level of the system is improved.

(4) User assessment and analysis system: Establish a comprehensive user assessment and analysis system to record students' learning progress, achievements and participation in interaction. Mining students' learning rules and characteristics through data analysis technology, and providing targeted teaching suggestions for teachers.

4 ALGORITHM IMPLEMENTATION AND EXPERIMENTAL DESIGN

This study encompasses the design and implementation of an image feature detection and 3D reconstruction algorithm for the NMA teaching system. The forthcoming section will elaborate on the implementation process and experimental design of this algorithm, with the objectives of validating its effectiveness and performance, as well as exploring its potential applications in computer-aided creation and teaching.

4.1 Algorithm Realization

Image feature detection plays a pivotal role in the NMA teaching system, being crucial for the subsequent computer-aided creation and teaching processes. To attain high-precision feature detection, this study employs a CNN algorithm rooted in deep learning. By utilizing multi-layer convolution, pooling, and a fully connected layer, the algorithm is capable of autonomously learning intricate feature representations within images, thereby offering extensive feature information for NMA creation and teaching. Refer to Figure 3 for an illustration of the conceptual framework of the NMA image feature detection model.

This model adopts a classic CNN structure and has been optimized using extensive training data to ensure the effective extraction of key image features. Through forward propagation, we obtain the image's feature vector, which encapsulates advanced feature representations such as edges, textures, shapes, and more. Lastly, these feature vectors undergo post-processing, including dimensionality reduction and normalization, to extract the crucial features necessary for subsequent 3D reconstruction and computer-aided creation.

To further mitigate noise, a smoothing function can be applied via convolution with the image function. An example of such a smoothing function is the Gaussian function.

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

A smaller adjustable parameter σ leads to higher spatial positioning accuracy but poorer suppression of high-frequency noise. To obtain a better photo group $V\left(p\right)$ patch filtering is applied using the formula below:

$$\left|V^{*}(p')\right|\left(1-g^{*}(p)\right) < \sum_{p\in U(p)}\left(1-g^{*}(p)\right) \tag{2}$$

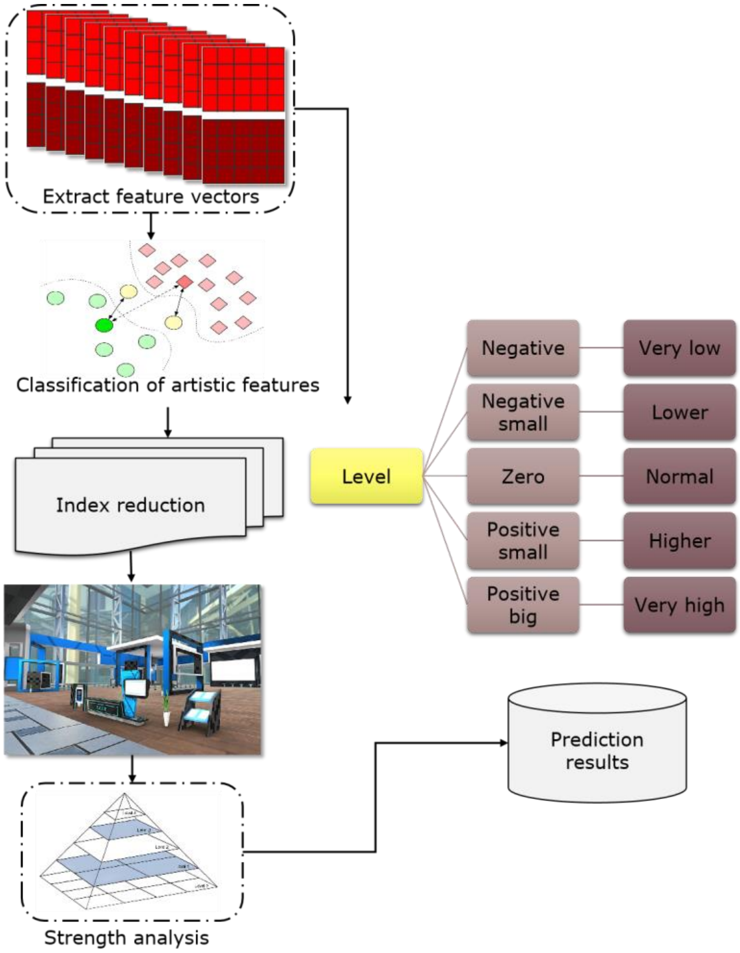

Figure 3: Feature detection model.

$U(p)$ denotes the set of patches failing to meet the necessary visible information criteria. When M is considered a solid model, the spatial indicator function employed in surface reconstruction is as follows:

$$\Phi(p)=\begin{cases}1, & p\in M\\ 0, & p\notin M\end{cases} \tag{3}$$

However, when constructing a new media art teaching system based on virtual reality, if some image processing technologies are directly applied, the background may be over-saturated, making it difficult to distinguish between the subject and the background, thus affecting the user's immersive experience and learning effect. To solve this problem, this article introduces a threshold mechanism in the system design to control it reasonably. When counting and counting the image histogram in the virtual reality environment, a specific threshold is set for pixels with different grey levels to ensure the accuracy of statistics and effectively distinguish the subject from the background:

$$p\ \alpha_i = \begin{cases} \frac{p}{h} & h_i > p \\ \frac{h_i}{h} & h_i < p \end{cases} \quad (4)$$

The formula $p\ \alpha_i$ signifies the occurrence probability of the i gray value, h denotes the total pixel count and α_i represents the background grayscale.

To enhance the efficacy of feature detection further, the CNN model undergoes fine-tuning. This involves adjusting parameters such as the convolution kernel size, step size, and pooling strategy of the convolution layer to better accommodate the unique characteristics of NMA images. Additionally, data augmentation techniques, including rotation, scaling, and flipping, are employed to diversify the training dataset and bolster the model's generalization capabilities.

3D reconstruction is another core algorithm in the NMA teaching system, which can transform the extracted image features into visual 3D models and provide intuitive spatial perception for computer-aided creation and teaching. To achieve high-precision 3D reconstruction, a method based on stereo vision is adopted in the research.

In the realm of new media art creation and teaching, the utilization of camera models proves beneficial for comprehending and simulating the visual mapping relationship between the real and virtual worlds. To streamline the expression involving multiple coordinate systems and intricate transformation processes, I opted to employ the homogeneous coordinate representation method in my derivations. This approach facilitates the transformation from the three-dimensional world coordinate system to the camera coordinate system, followed by the image coordinate system, and ultimately to the pixel coordinate system, all in a more unified, concise, and easily computable format. Through the camera model, the visual effects in the virtual reality environment can be accurately simulated and rendered. Introducing the algebraic component of $n+1$ dimension allows for the direct expression of translation, rotation, and scaling transformations of n dimension points in matrix form. The camera model's mathematical expression is as follows:

$$u \cong \begin{bmatrix} f/dx & s & x_0 \\ & f/dy & y_0 \\ & & 1 \end{bmatrix} \begin{bmatrix} R_{3\times3} & T_{3\times1} \end{bmatrix} X_W = K \begin{bmatrix} R & T \end{bmatrix} X_W = PX_W \quad (5)$$

The matrix P , known as the projection matrix, encompasses the camera's internal parameter matrix K , rotation matrix R , and translation matrix T . By combining it with the plane coordinates u of the same point derived from feature matching, the three-dimensional coordinates X_W are determined. Among them, the camera's internal parameter matrix K is solely dependent on the camera's internal structure, independent of the reconstruction process, and can be ascertained through camera calibration.

The reconstruction of sparse point clouds is usually realized by the incremental algorithm. This reconstruction process begins with two view units, through which their projection matrices and corresponding three-dimensional point clouds can be recovered. Subsequently, this process will constantly consider new single views and unify these new views into the world coordinate system shared by existing views, thus gradually expanding and enriching the overall imaging geometry.

In the idealized model, the projected light beam of each point will accurately intersect the optical centre of the camera, which means that the light from the camera can accurately pass through the corresponding point in the three-dimensional space and form a clear image on the imaging plane of the camera. Similarly, projection beams from different cameras will meet at the same point in space. The objective function represents the sum of squared projection errors for all points sharing the same name:

$$\min \sum_{i,j} d\left(P^i \hat{X}_j, x_j^i\right)^2 \quad (6)$$

The formula indicates that the sum of squared distances between the estimated re-projection point $P^i\hat{X}_j$ and the actual projection point x_j^i is minimized, x_j^i denoting the projection coordinates of the j point on the i image.

According to the principle of pinhole imaging, let's denote the measured object size as Y, the image height as y, the object distance (from the object to the lens centre) L, the lens focal length f, the distance between adjacent pixels as d, and the number of pixels occupied by the image height as N, with $y = Nd$. Using the lens imaging formula, we can derive:

$$Y = \left(\frac{L}{f} - 1\right) Nd \quad (7)$$

If the positioning area of each anchor node forms a hollow sphere with a thickness 2ε, the positioning area of the unknown node corresponds to the intersection A_p of the positioning areas of four anchor nodes. Provided that ε is not substantial, the component plane A_p can be approximated as a flat plane. In this scenario, the four sets of opposing planes A_p must be parallel, separated by a distance 2ε, and A_p must encompass an inscribed sphere R with a radius of ε:

$$R = \left\{ (x, y, z) \,\middle|\, x^2 + y^2 + z^2 = \varepsilon^2 \right\} \quad (8)$$

As the number of anchor nodes grows, A_p exhibits an increase in sections, resulting in A_p becoming closer to R. A smaller R leads to a smaller location area for unknown nodes, resulting in higher location accuracy. R represents the absolute error area of unknown nodes.

Firstly, this method extracts the features of images from each perspective to get their feature points. Then, through the feature-matching algorithm, the corresponding feature points between images from different perspectives are found. To improve the matching accuracy, the matching strategy based on distance and descriptor is adopted, and the mismatching points are eliminated by combining the RANSAC algorithm. Then, using the principle of triangulation, the 3D coordinates of the object are calculated according to the matched feature points. To further improve the accuracy and robustness of 3D reconstruction, multi-view geometric constraints and optimization algorithms are used to fine-tune 3D coordinates. Finally, through 3D modelling technology, the calculated 3D coordinates are converted into a visual 3D model, which provides an intuitive space display for NMA creation and teaching.

4.2 Experimental Design

To assess the performance of the proposed NMA teaching system in the experimental environment and dataset, and to explore its potential for computer-aided creation and teaching, a series of experiments were designed to evaluate the accuracy of image feature detection, 3D reconstruction, and user satisfaction.

In the experimental environment, a VR-based laboratory was built, equipped with high-performance computers, VR equipment and related software to simulate the real NMA teaching scene. In terms of the data set, six groups of images with different sizes and textures were collected as test samples, covering two different types of surfaces, smooth and deep textures, and different colour schemes, to comprehensively evaluate the performance of the system.

During the experiment on feature detection accuracy, the performance of the CNN-based feature detection algorithm proposed in this article was compared to other commonly used methods (SIFT, SURF). The experiment involved extracting features from test samples and calculating the error rate between the extracted features and the actual features. By comparing the error rates of different methods, the feature detection accuracy of this algorithm is evaluated, and its application potential in computer-aided creation and teaching is explored.

In the experiment of 3D reconstruction accuracy, the 3D reconstruction algorithm based on stereo vision proposed in this article is used to reconstruct the test samples and compare them with other stereo vision systems. During the experiment, first, feature detection and matching are carried out for images from each perspective, and then the 3D coordinates of the object are calculated by the triangulation principle, and the 3D model is generated. Finally, by comparing the error rate between the reconstructed 3D model and the real object, the 3D reconstruction accuracy of this algorithm is evaluated.

In the experiment of user satisfaction and teaching effect, 50 teachers and students majoring in NMA were invited to participate in the test, and their experiences of 3D reconstruction and computer-aided creation using this system and other stereoscopic vision systems were evaluated.

5 EXPERIMENTAL RESULTS AND ANALYSIS

With the digital advancement of the intelligent era, virtual reality has provided new directions for the development of virtual reality art, and the addition of intelligent features can promote the level of interactive experience in virtual reality art. There is also an illusory imagination that transcends reality, and this interplay of both real and illusory perceptions often leads people to endless thinking about what art carries. Human artistic creation originates from the author's genuine perception and conscious imagination of the world, and with the help of virtual reality technology, all the creator's ideas can be virtually reproduced. Intelligence will become a new important feature of future virtual reality art. The expressive tension of virtual reality art largely depends on the creator's imagination, and the object of artistic expression is not just a reflection of reality. Deepening the simulated perception of the immersive world also broadens the creator's understanding of the boundaries of the fantasy world. Conceptuality is another significant artistic feature of virtual reality art.

5.1 Experimental Setup

In this experiment, six sample groups were set up, and each sample group contained images with different sizes and textures, as shown in Table 1.

Sample No.	*Size (mm×mm×mm)*	*Resolution (dpi)*	*Texture*	*Color Scheme*
1	60×60	168	Smooth	Dark
2	120×120	326	Smooth	Dark
3	160×160	395	Smooth	Dark
4	200×200	221	Deep Texture	Normal
5	260×260	256	Deep Texture	Normal
6	320×320	288	Deep Texture	Normal

Table 1: Sample reconstruction results.

5.2 Experimental Results

Figure 4 illustrates the accuracy of image feature detection achieved by different methods. Upon comparing the experimental data, it is evident that our proposed method attains an average accuracy of 92.3% with a standard deviation of 1.2%. This is in contrast to other commonly used methods, such as the SIFT algorithm, which has an average accuracy of 85.4% and a standard deviation of 2.7%, and the SURF algorithm, with an average accuracy of 87.6% and a standard deviation of 2.3%. Our method exhibits higher accuracy and stability.

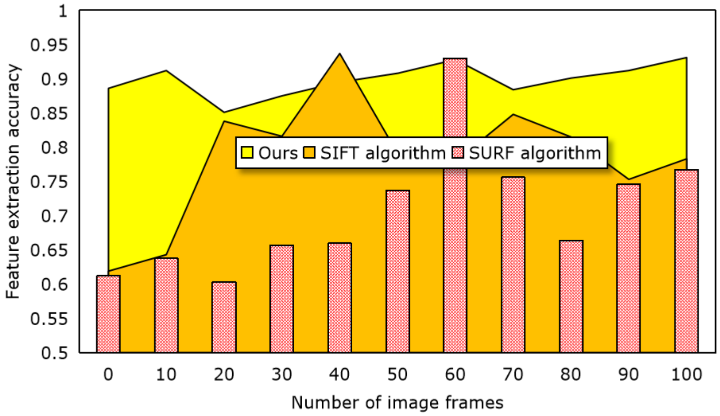

Figure 4: Comparison of feature detection accuracy.

Different methods were tested, and the variation of VR modelling time with image size was compared, as shown in Figure 5. The modelling time required by our method does not exhibit significant changes with increasing image size. It has an average modelling time of 1.5 seconds and a standard deviation of 0.2 seconds, which is notably lower than that of two conventional methods, such as the SIFT algorithm (average modelling time of 3.2 seconds, standard deviation of 0.7 seconds) and the SURF algorithm (average modelling time of 2.9 seconds, standard deviation of 0.5 seconds).

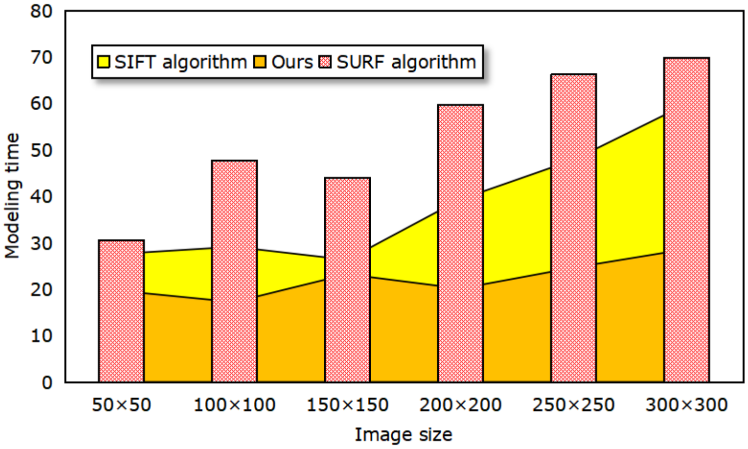

Figure 5: VR modelling time varies with size.

The system presented in this article, along with the stereo vision systems proposed in references [13] and [18], were utilized to reconstruct the artistic image in 3D. The reconstruction accuracy and user satisfaction were evaluated, as depicted in Figure 6 and Figure 7.

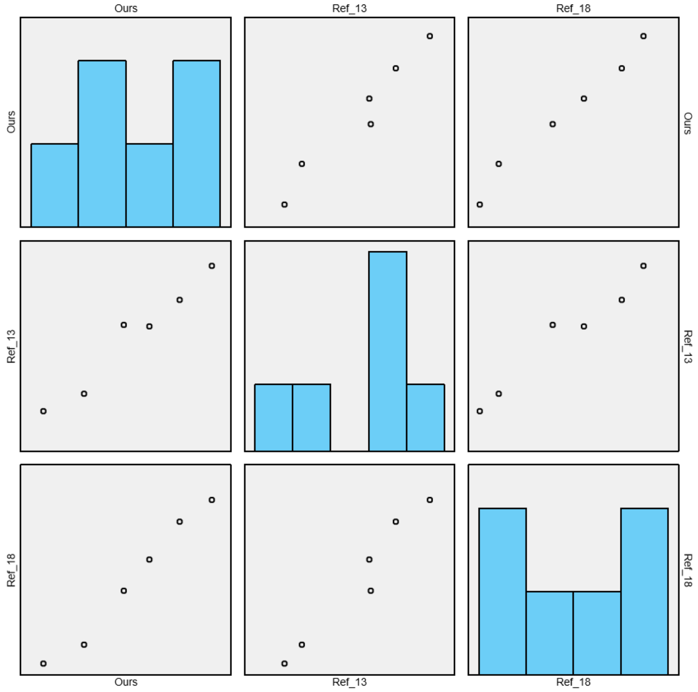

Figure 6: Comparison of reconstruction accuracy.

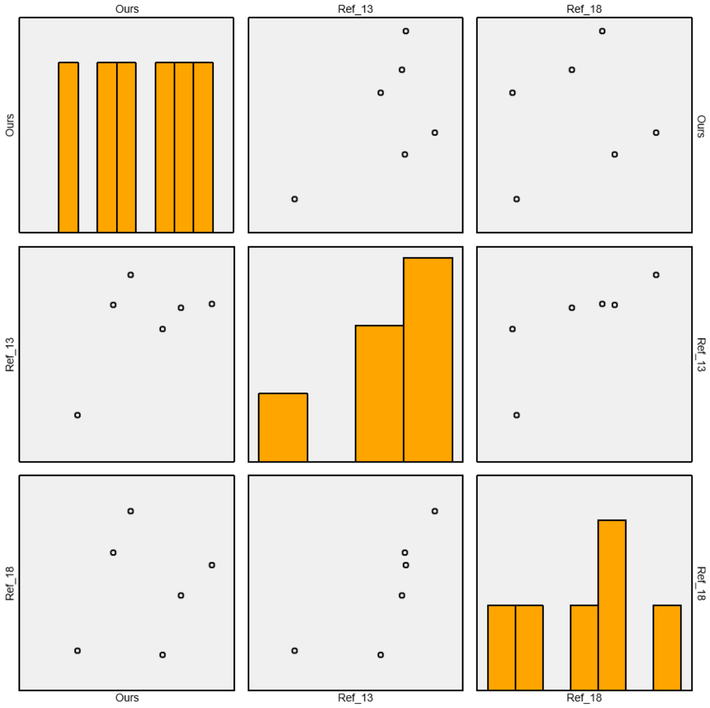

Figure 7: Comparison of user satisfaction.

From the results of VR reconstruction accuracy, the average reconstruction accuracy and standard deviation of the NMA teaching system designed in this article are 95.8% and 0.9%, which are almost the same as those of reference [13] and reference [18]. However, in terms of user satisfaction, the average satisfaction of the system in this article is 90.4% and the standard deviation is 3.1%, which is more advantageous than the average satisfaction of reference [13] of 82.1%, standard deviation of 4.5% and reference [18] of 84.7% and standard deviation of 3.9%. The results show that the system has good reconstruction accuracy and efficiency.

The test sample comprises six groups of images, but due to image distortion during preprocessing, only four groups were successfully matched. Figure 8 illustrates the matching results of the system designed in this article compared to the original system.

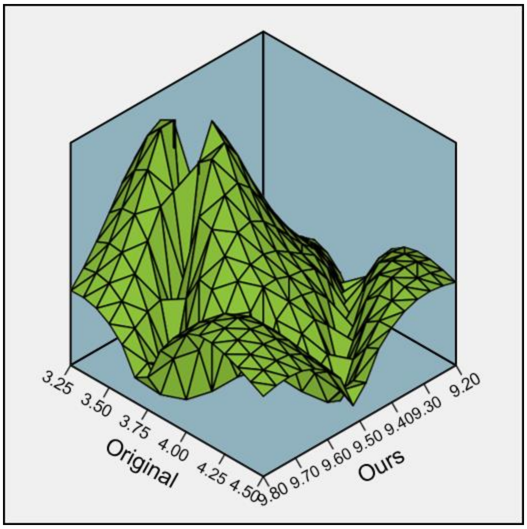

Figure 8: Image matching error rate.

Upon comparison, it is evident that the original system has an average matching error rate of 9.1% with a standard deviation of 0.6%, whereas the system designed in this article exhibits an average matching error rate of 4.3% and a standard deviation of 0.8%. The lowest error rate of the original system is 8.2%, while the highest error rate of our system is 5.6%.

Comparative experiments and data analysis reveal that the NMA teaching system designed in this article excels in image feature detection accuracy, VR modelling time, 3D reconstruction accuracy, and user satisfaction. Notably, in terms of user satisfaction and image-matching error rate, our system demonstrates clear advantages over other methods. This indicates that the NMA teaching system designed in this article possesses high feasibility for practical application and can provide robust support for NMA teaching.

6 CONCLUSIONS

The computer-aided creation and teaching system of NMA based on VR has brought innovative teaching and creation methods to the NMA field. Through in-depth research and experimental verification, this article fully demonstrates the remarkable advantages of the system in image feature detection, 3D reconstruction and user interaction experience.

In terms of image feature detection, the CNN algorithm based on deep learning employed in this article significantly enhances accuracy and stability. The results indicate that the algorithm maintains high feature detection accuracy across images of varying sizes and textures. Regarding

3D reconstruction, the stereo vision-based algorithm proposed here successfully achieves high-precision 3D reconstruction of NMA images, demonstrating superior performance in accuracy and efficiency compared to other common methods. User satisfaction experiments further validate the feasibility and effectiveness of the system in practical application. User feedback highlights the system's ease of operation, and realistic and interactive reconstruction effects, which can greatly enhance the teaching and creative experience of NMA.

Overall, the VR-based computer-aided creation and teaching system for NMA holds broad application prospects in the NMA field and offers novel ideas for teaching and research in related areas. Future work will focus on optimizing and refining the system to further enhance its role in NMA teaching and creation.

Mengyuan Fu, https://orcid.org/0009-0005-9598-1650
Mingyu Jiang, https://orcid.org/0009-0007-4046-6605

REFERENCES

[1] Cabero, A.-J.; Roig, V.-R.: The motivation of technological scenarios in augmented reality (AR): Results of different experiments, Applied Sciences, 9(14), 2019, 2907. https://doi.org/10.3390/app9142907

[2] Fan, M.; Antle, A.-N.; Warren, J.-L.: Augmented reality for early language learning: A systematic review of augmented reality application design, instructional strategies, and evaluation outcomes, Journal of Educational Computing Research, 58(6), 2020, 1059-1100. https://doi.org/10.1177/07356331209274

[3] Fechter, M.; Schleich, B.; Wartzack, S.: Comparative evaluation of WIMP and immersive natural finger interaction: A user study on CAD assembly modeling, Virtual Reality, 26(1), 2022, 143-158. https://doi.org/10.1007/s10055-021-00543-0

[4] Fleury, S.; Poussard, B.; Blanchard, P.; Dupont, L.; Broekema, P.-M.; Richir, S.: Innovative Process for Furniture Design: Contributions of 3D Scan and Virtual Reality. Computer-Aided Design and Applications, 19(5), 2022, 868-878. https://doi.org/10.14733/cadaps.2022.868-878

[5] Gong, Y.: Application of virtual reality teaching method and virtual reality technology in digital media art creation, Ecological Informatics, 63(1), 2021, 101304. https://doi.org/10.1016/j.ecoinf.2021.101304

[6] Hamzah, M.-L.; Rizal, F.; Simatupang, W.: Development of augmented reality application for learning computer network device, International Journal of Interactive Mobile Technologies, 15(12), 2021, 47-64. https://doi.org/10.3991/ijim.v15i12.21993

[7] Ho, L.-H.; Sun, H.; Tsai, T.-H.: Research on 3D painting in virtual reality to improve students' motivation of 3D animation learning, Sustainability, 11(6), 2019, 1605. https://doi.org/10.3390/su11061605

[8] Hui, J.; Zhou, Y.; Oubibi, M.; Di, W.; Zhang, L.; Zhang, S.: Research on art teaching practice supported by Virtual Reality (VR) technology in the primary schools, Sustainability, 14(3), 2022, 1246. https://doi.org/10.3390/su14031246

[9] Kaimal, G.; Carroll, H.-K.; Berberian, M.; Dougherty, A.; Carlton, N.; Ramakrishnan, A.: Virtual reality in art therapy: a pilot qualitative study of the novel medium and implications for practice, Art Therapy, 37(1), 2020, 16-24. https://doi.org/10.1080/07421656.2019.1659662

[10] Lei, Y.; Su, Z.; He, X.; Cheng, C.: Immersive virtual reality application for intelligent manufacturing: Applications and art design, Mathematical Biosciences and Engineering, 20(3), 2023, 4353-4387. https://doi.org/10.3934/mbe.2023202

[11] Liu, L.; Liu, G.: Intelligent Teaching Method of Interdisciplinary Art Design and CAD, Computer-Aided Design and Applications, 19(S8), 2022, 96-104. https://doi.org/10.14733/cadaps.2022.S8.96-104

[12] Liu, P.; Phongsatha, S.: Application research on enhancing the cognitive ability of art appreciation of senior high school students in chengdu through virtual reality technology, International Journal of Innovative Research and Scientific Studies, 5(3), 2022, 236-248. https://doi.org/10.53894/ijirss.v5i3.676
[13] Sansom, M.; See, Z.-S.: Translating performative mediated art into virtual reality: A case study, Virtual Creativity, 11(1), 2021, 53-65. https://doi.org/10.1386/vcr_00042_1
[14] Shi, H.; Niu, D.: Application research of virtual reality technology in ocean environmental art design, Journal of Coastal Research, 104(SI), 2020, 296-301. https://doi.org/10.2112/JCR-SI104-054.1
[15] Zhao, B.; Zhan, D.; Zhang, C.; Su, M.: Computer-aided digital media art creation based on virtual reality, Neural Computing and Applications, 35(35), 2023, 24565-24574. https://doi.org/10.1007/s00521-023-08584-z