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Computer-Aided Design AND APPLICATIONS

Virtual Reality-Based Interactive Visual Communication Media Design and User Experience

Yuanyuan Sun[12] and Lina Ke[34]

[1]College of Marxism, Northeastern University, Shenyang, Liaoning 110819, China, 1910491@stu.neu.edu.cn
[2]Academy of Drama Arts, Shenyang Normal University, Shenyang, Liaoning 110000, China, 1910491@stu.neu.edu.cn
[3]College of Journalism and Communication, Heilongjiang University, Harbin, Heilongjiang 150080, China, 2020005@hlju.edu.cn
[4]College of Chinese Language and Literature, Harbin Normal University, Harbin, Heilongjiang 150025, China, 2020005@hlju.edu.cn

Corresponding author: Lina Ke, 2020005@hlju.edu.cn

Abstract. The traditional visual communication method lacks the product of modern fusion, and the development trend is gradually aging and rigid. In order to improve the user experience and communication efficiency of media in the information age, this article studies media design and user experience based on interactive visual communication in virtual reality. This study designed the application and potential of virtual reality technology in visual communication media design, and explored the advantages and limitations of virtual reality in design. Use CAD virtual reality technology to improve the quality and effectiveness of design through real visual communication cases. This study constructed a visual communication system framework using three-dimensional digital graphics and analyzed the characteristics of image elements. The experiment used visual user quantitative analysis design to construct a real-world interaction system for visual communication. The research results indicate that the user experience under visual analysis has high interactivity, high efficiency, and fast corresponding functions.

Keywords: Virtual Reality Technology; CAD Technology; 3D Image Reconstruction; Visual Communication Design; User Experience
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1 INTRODUCTION

The media industry is undergoing a transformation and upgrading from traditional two-dimensional media to visual communication media. Virtual reality technology, as an emerging media, has an immersive experience and interactivity, which can better meet users' needs for media experience. The current design industry is developing towards diversification, digitization, and innovation.

Virtual reality technology, as a digital technology, can bring new design ideas and manifestations to the design industry, further promoting the innovative development of the design industry. With the popularization of the Internet and intelligent terminals, users' demand for media experience is increasing. Virtual reality technology can provide users with a more realistic and immersive experience, enabling them to better perceive the design intent of visual communication media. The application scenarios of virtual reality technology are constantly expanding, involving multiple fields such as gaming, entertainment, education, healthcare, and industry. The design of visual communication media needs to be combined with different application scenarios to achieve corresponding design effects through virtual reality technology. In summary, the application background of virtual reality technology in visual communication media design is mainly influenced and promoted by various aspects such as the media industry, design industry, user experience, and application scenarios. This is an important direction for the innovation and transformation and upgrading of visual communication media design.

The concept of media design has been closely related to science since ancient times. With the advancement of technology, the development and scale of the media design industry have also undergone dynamic updates and changes. Studying the application and possible design methods of virtual reality technology in visual communication media design can explore the advantages and limitations of virtual reality technology in design. It can analyze how to use virtual reality technology to improve the quality and effectiveness of design. Ahmed et al. [1] conducted computer-aided 3D printing material structure design. Traditional print media design has gradually lost its position in the historical trend, bringing with it the three-dimensional visual design concept brought by computer technology. Digital twins refer to the digitization of various characteristics and behaviors of actual objects or systems through digital technology. Burghardt et al. [2] conducted modeling and virtual robot programming simulation on digital models. Create realistic scenes and interactive experiences in virtual space through technologies such as computer technology and graphics. It simulates the collision situation of actual objects in robot collision testing, thereby assisting the robot in simulation and training. Its research shows that virtual reality technology can help robots navigate autonomously and plan their paths by creating environments and obstacles around them in virtual space. Dzardanova et al. [3] view CAD virtual reality (VR) as an emerging communication medium. It can help us better understand the role of CAD software in the design and manufacturing process. VR technology can provide designers and engineers with an immersive experience, enabling them to better understand the performance of design solutions in actual manufacturing. In addition, VR can provide users with a more intuitive way to explore and experience CAD software, thereby better understanding its functions and operations.

2 RELATED WORK

Immersive natural interaction is an interaction mode that combines virtual reality (VR) and natural user interface. It allows users to interact with the virtual environment through natural ways such as natural gestures, voice and sight. Immersive natural interaction can interact with the virtual environment through natural means such as user gestures, voice, and line of sight, making the interaction process more natural and smoother. Through VR technology, immersive natural interaction can bring users a more immersive experience, allowing them to fully immerse themselves in the virtual environment. Immersive natural interaction can improve interaction efficiency, enabling users to interact more efficiently with virtual environments. Immersive natural interaction can use various natural methods to interact with virtual environments, such as gestures, speech, and line of sight, making the interaction methods more diverse. In short, immersive natural interaction is a very promising way of interaction with broad application prospects. Through this approach, users can interact more naturally and smoothly with the virtual environment, thereby obtaining a better experience. Immersive natural finger interaction is a technology that utilizes natural gestures for interaction. The core idea is to combine human natural gestures with VR interaction to achieve a more natural and intuitive user experience. In the

immersive natural finger interaction, Fechter et al. [4] conducted interactive operation control between fingers and VR environment. This interaction method does not require any additional devices or controllers, making it more natural and intuitive. In virtual reality environments, three-dimensional (3D) virtual models are usually located in front of real-world objects. This is because virtual reality environments require the display of virtual objects in the user's field of view, and real-world objects are the main content in the user's field of view. Product models are usually stored in 3D CAD systems. 3D CAD system is a software system used to establish, edit, and present 3D digital models, widely used in manufacturing, architectural design, electronic engineering, mechanical manufacturing, and other fields. Han et al. [5] used different tools to create and edit 3D digital models. These tools can help designers and engineers create and modify 3D digital models to achieve the desired design effects. Therefore, in order to make virtual objects more prominent and easier to recognize, they need to be located in front of the user's field of view. In order to provide a more realistic virtual reality experience, Jin and Lee [6] analyzed the geometric shape, texture, and color attributes of virtual models that are the same as real-world objects. In order to better present the true appearance and feel of virtual objects in a virtual reality environment. Kikuchi et al. [7] developed a digital twin method of CAD outdoor augmented reality using the detailed 3D model of the city to block the first person and aerial view. Kozinets [8] collected some trained 3D CAD model data. It preprocesses the collected data, including converting the model from 2D images to 3D point clouds and removing some noise points. The development of deep learning has been achieved through immersive network 3D CAD model diagrams. Lee et al. [9] proposed a deep learning model. This model can capture the features of 3D CAD models. This may involve using some pre trained deep learning models. Use the collected data to train the deep learning model so that it can learn the representation of 3D CAD models. Liu and Liu [10] simplify user operations and improve system availability. Although the common result of CAD modeling is design documentation, researchers believe that CAD modeling can support conceptual design. Shih and Sher [11] used CAD multi view stereo to achieve more accurate depth estimation. Before applying the multi view depth estimation model, it underwent a high level of computational resources and data processing capability analysis. In order to improve the effectiveness of visual communication art design, Yu [12] combined virtual reality technology to have a quantitative impact on the design of visual communication art. It has semi covered virtual reality graphics that can achieve changes in artistic effects through user interaction with the virtual environment, thereby improving user engagement. Half coverage virtual reality graphics can immerse users in the virtual world, experiencing the combination of reality and virtuality, thereby enhancing their visual experience. Experimental research shows that the visual communication design system based on virtual reality technology proposed in this article has good design performance and can effectively improve the effectiveness of visual communication art design. Zhang et al. [13] combined the features of each view with their corresponding depth estimation values, and trained the entire model using a multi view depth estimation model to obtain more accurate depth estimation values. Zhao [14] used scene rendering and clipping technology to optimize the design of garden landscapes. It uses computer graphics technology to cut and process images to optimize rendering effects and performance. In landscape design, the use of scene rendering and clipping technology can cut and process images to achieve better visual effects and higher performance. Zhang and Kou [15] conducted an analysis of the application value of digital 3D panoramic technology images. Through the application, it has carried on the virtual reality panorama image campus design stitching. By innovating the art form of visual communication, it collects and estimates the spectral reflectance of the object's three-color channels, separates the specular reflection component and the diffuse reflection component. Finally, it describes the method of making panoramic images and the main function modules of the roaming system in detail.

3 RESEARCH ON INTERACTIVE VISUAL COMMUNICATION DESIGN AND USER EXPERIENCE BASED ON VIRTUAL REALITY TECHNOLOGY FOR 3D IMAGE RECONSTRUCTION

3.1 Research on 3D Display of Image Reconstruction

3D image reconstruction based on virtual reality technology is an advanced technology that can simulate realistic 3D scenes through computers and achieve real-world simulation. This technology can be applied in multiple fields, such as game development, education and training, and urban planning. In game development, 3D image reconstruction technology can achieve realistic 3D scenes, bringing users a richer gaming experience. In education and training, 3D image reconstruction technology can simulate various complex environments and objects, helping students better understand and master knowledge. In urban planning, 3D image reconstruction technology can simulate the future urban landscape, helping urban planners better anticipate the direction of urban development. Overall, 3D image reconstruction based on virtual reality technology is a very useful technique that can bring convenience and benefits to multiple fields. In the development of modern media communication, computer image processing, data processing, image design, virtual technology, etc. are indispensable. Therefore, in order to achieve ideal design solutions and effects in visual communication, multiple concepts and technologies need to be effectively combined. Applying virtual reality technology in visual communication media design to make image elements, sound elements, color elements, and environmental elements more concrete, visualized, and realistic. So, in the early stages of design, we need to conform to the following characteristics: firstly, the element image of visual communication media design is more in line with immersive needs, and one of the main goals of our strategy is to immerse ourselves in the design work. Secondly, achieve interactive design interaction, and incorporate the concept of communication between people and the environment in the visual communication process. As a designer, it is also necessary to incorporate automated methods of natural laws to update various objects in the virtual environment in real-time. Connect the user to the virtual environment through wearable devices and experience screens. At the same time, it is also necessary to ensure that the impact of dynamic data is positive in data collection and processing. Finally, in the design of visual communication media, it is necessary to meet the combination of sensibility and science. By utilizing the core technologies of the corresponding modules, combining virtual environments with reality can satisfy and stimulate designers' thinking inspiration. We conducted statistical and quantitative analysis on the changes in the research results of visual communication media design in different countries, as shown in Figure 1.

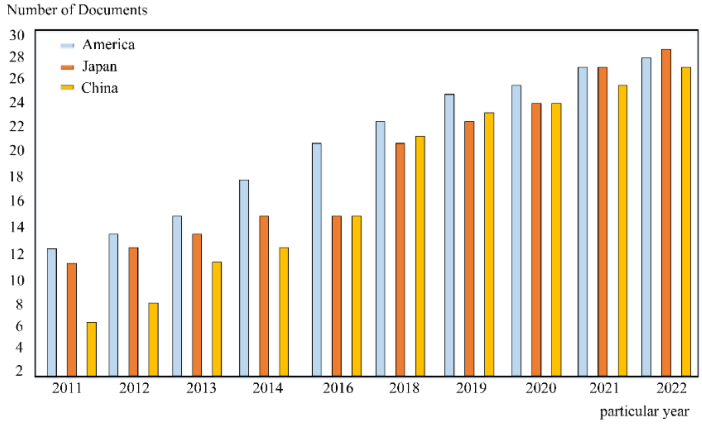

Figure 1: Changes in research achievements of visual communication media design in various countries.

As shown in Figure 1, the United States and Japan are in a leading position in research on visual communication media design. Since 2012, there has been a significant increase in the number of studies in this area in China. The above results are related to the speed of development in computer and virtual technology in each country. When using virtual reality technology for computer vision communication design, several requirements should be met. The first is the three-dimensional visual effect, which adopts the principle of three-dimensional digital design. Propose various elements of reference design from the design database, count and process them to form a brand-new design work. During the process, there will be problems in converting two-dimensional planes to three-dimensional solids, from designing patterns to geometric changes, and then to adjusting the material selection and application of design works. So, we design dynamic and realistic virtual scenes tailored to different visual communication media needs. The second is to use the concept of numerical functions, using the range and space of data feature points included in the design concept as the basic information source for mathematical function calculations. This processing method needs to be based on selecting computer preparation software based on the spatial environment in a virtual reality environment. Fully incorporate various information that meets the design requirements of visual communication media, while simplifying three-dimensional mathematical models. In the visual communication design process supported by virtual reality technology, many design images and feature points need to be faced. Analyzing graphics and image processing algorithms is also our main research direction. From literature research, it has been found that non localized views based on molecular analysis and high-precision reconstruction algorithms, as well as adaptive algorithms for array feature point images, are effective algorithms for completing 3D modeling. However, most algorithms in virtual reality technology systems focus more on using advanced sensing and interaction devices, which brings great pressure to research and experiments. The above algorithms simultaneously ignore issues such as user experience, design quality, and interaction between people and design works. We randomly selected from multiple collections of works and compared the quality of traditional graphic design works with 3D communication design works supported by virtual reality technology, as shown in Figure 2:

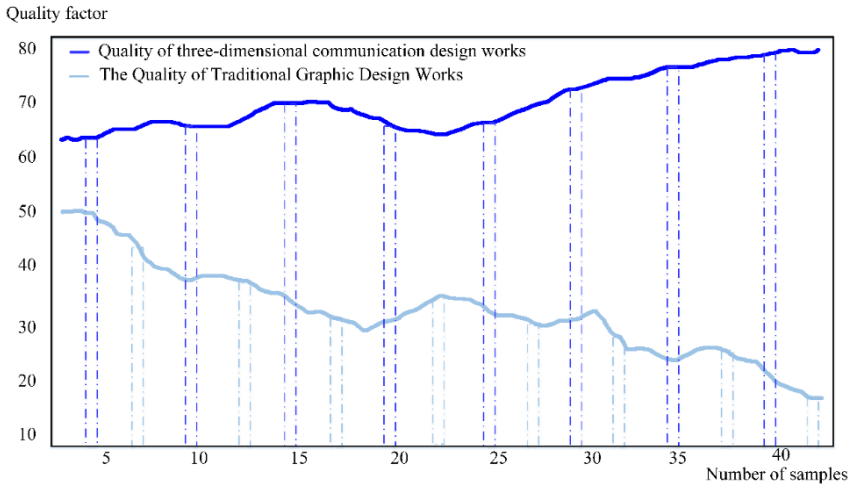

Figure 2: Comparison between the quality of traditional graphic design works and 3D communication design works supported by virtual reality technology.

As shown in Figure 2, the quality of traditional graphic design works shows a negative change with the increase of collected samples. Under the transformation, the quality of visual communication design still maintains the advantages of high accuracy and resolution. In this study, virtual reality

technology for three-dimensional image reconstruction is added to improve design efficiency and interactive applicability. We organized the 3D image feature recombination framework as shown in Figure 3:

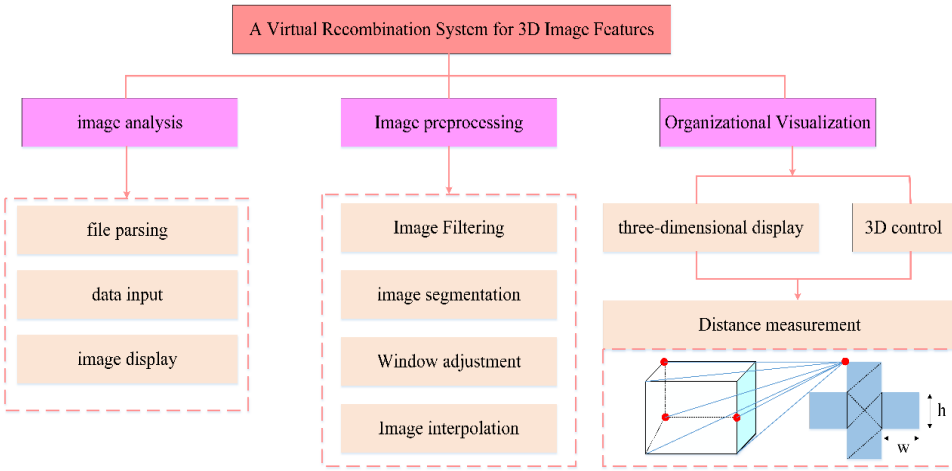

Figure 3: 3D image feature recombination framework.

As shown in Figure 3, in the 3D image feature virtual recombination system, the functions of image feature analysis, preprocessing, and visualization are analyzed as three major modules. The hardware equipment selects materials that are compatible with dynamic data transmission for the bus and device interface. Due to the differences between the visual characteristics and sensory symbols of the human body and the actual situation of visual communication, factors such as three-dimensional spatial perception, motion perception, and visual difference all have certain interference effects. 3D design works differ from real objects in terms of spatial distance and volume size, therefore, attention needs to be paid to the accuracy of the data in the process of reconstructing feature points. We start from the combination of image feature sequences and randomly select a set of design images as a reference, adding those that have not undergone threshold filtering to the same feature group. The calculation methods are as follows:

$$V(P)=\left\{I \mid n(p)\cdot\frac{c(p)O(I)}{c(p_i)O(I_1)}>\cos\eta\right\} \tag{1}$$

$$V(P)=\left\{I \mid I\in V(P), h(p,I,R(P))\le a\right\} \tag{2}$$

In the formula, P represents the horizontal plane coordinate, a represents the feature adjustment coefficient and represents the reference image of the design. Continue to perform 3D reconstruction function metrology calculation:

$$g(P)=\frac{1}{|V(P)/R(P)|}\sum_{i,V(p)/R}h(p,i,r) \tag{3}$$

$$g^{*}(P)=\frac{1}{|V^{*}(P)/R(P_0)|}\sum_{i,V(p)/R}h(p) \tag{4}$$

In order to better reflect the design effect of feature point recombination, we use the following formula for detail filtering:

$$|V^*(P^{'})|(1-g(p))<\sum_{p\in U(P)}(1-g(p)) \tag{5}$$

In the formula, V^* represents all useless data information that does not conform to feature details. Define a physical model of a visual communication media design work, incorporating reconstructed image features. The interval coordinate function of the model is:

$$\Phi(P)=\begin{Bmatrix}1,P\in M\\0,P\notin M\end{Bmatrix} \tag{6}$$

Determine the interval range based on the function value to dynamically adjust the reference design information. This three-dimensional design is based on virtual feature reconstruction, and virtual reality technology provides core processing assistance for advanced simulation scenes. We also present visual communication media design works from a multi-dimensional perspective, using computer vision feature analysis to obtain the edge description formula for three-dimensional design products:

$$p=(X^{(cs2)},\theta^*,P^*) \tag{7}$$

Construct a visual feature point distribution vector for visual communication media design works, and represent the fused model formula in spatial coordinates:

$$I_e=\frac{p}{\sqrt{\ln(x,y)}} \tag{8}$$

Among them, $\sqrt{\ln(x,y)}$ represents the coordinates of feature points. By combining visual communication rendering technology, establish three-dimensional work feature parameters in virtual scenes, and obtain the expression after image fusion output:

$$C(X,Y)=\frac{\sqrt{(\Delta x,\Delta y)^T(x_i,y_i)}}{I_e} \tag{9}$$

Among them, C representing the image quality resolution of 3D works in visual design, (x_i,y_i) represents an interface anchor point. Using a feature point database as the information resource library for the design work, combined with embedded equations, the spatial distribution formula for the three-dimensional display of the work is obtained:

$$I_{X,Y}=\frac{\left[C(x,y)-1\right]^2}{p^*} \tag{10}$$

Finally, we added feature elements for automatic tracking and recognition to the interactive visual communication design work in virtual reality scenes, and used adaptive fusion methods to provide visual enhancement effects for the virtual environment.

3.2 Research on Visual Communication Design Optimization and User Experience Based on Virtual Reality and CAD Assisted Technology

Visual communication media design not only includes artistic elements but also information technology elements. Art design is also an imitation and reference of nature and longing for people. The design requirements in visual communication are purposeful activities, and we use virtual reality technology to handle special design ideas to create more digital design works. The study of user experience in visual communication media design also summarizes users' feelings in the appreciation and use of works from a subjective perspective, which is reflected in the evaluation after the initial results of visual communication design are obtained. The user experience can include emotional changes, preference trends, cognitive evaluation, psychological

and behavioral reactions, and other aspects. We only explore user sensory experience, interactive experience, and authenticity experience in the visual communication media design effects supported by virtual reality scenes. When we use virtual reality technology to optimize visual communication design, we often encounter situations such as delayed dynamic data updates, low communication efficiency, and poor image quality. Therefore, we optimize and improve the above defects by quantifying and enhancing quality pixels. Using infrared spectral feature texture technology to map images into a virtual environment. Firstly, it is necessary to calculate and extract the spatial scale of spectra and design works, while aggregating and preprocessing feature points, and using Analytic Hierarchy Process to enhance the experience of virtual reality scenes. This spectral texture processing method, combined with virtual reality technology, has the advantages of clear edges, high quality resolution, and high clarity. We also need to perform dimensionality reduction and analysis on the feature data to make the layered data filtered by the adaptive algorithm more in line with the design requirements. Compare the visual communication effect of spectral feature texture using virtual reality technology with the visual communication design effect of ordinary spectral feature texture, as shown in Figure 4:

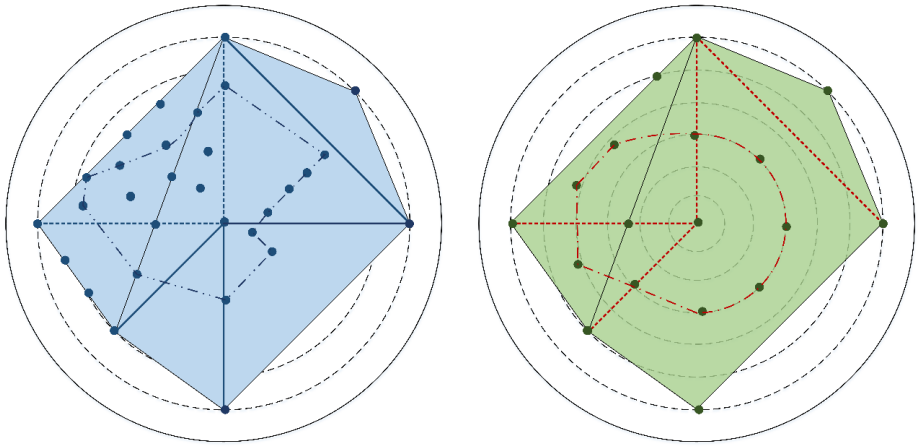

Figure 4: Comparison of visual communication design effects between two technologies.

As shown in Figure 4, based on the changes in feature points, the spectral texture visual effect using virtual reality technology is clearer. The design effect of visual transmission of ordinary spectral features and textures is significantly weaker. Therefore, we need a virtual reality environment for spectral image mapping and feature extraction. Firstly, it is set that the collected infrared data points in the design image can form a multidimensional matrix, and the intensity mapped by each pixel is shown in the following formula:

$$x(n)=\left[x_1(n),x_1(n),...,x_k(n)\right] \tag{11}$$

$$X=\left[\sum_{i=1}^{k} xi(1),\sum_{i=1}^{k} xi(2),...,\sum_{i=1}^{k} xi(N)\right] \tag{12}$$

In the above formula, we mark the constant as X ,collection frequency is $xi(N)$. For the three-dimensional resources in visual communication media design, we also need to construct a high-amplitude virtual space. Set feature images in virtual space as variable coefficients:

$$L(x,y,\sigma)=G(x,y,\sigma)^{*}I(x,y) \tag{13}$$

In the formula, $I(x,y)$ multiple design forms representing virtual scale spaces. When choosing a space size, it is important to meet the diverse needs of visual communication media design, as different size definitions may have limitations on the design work. Assuming the Gaussian dimension of space is calculated as follows:

$$G(x,y,\sigma)=\frac{1}{2\pi\sigma^2}e \tag{14}$$

In the formula, after obtaining the coordinates of the dimension space, represented by constants. Simultaneously set the resolution module in the image to label and integrate the distributed pixel points:

$$D(x,y,\sigma)=L(x,y,k\sigma)-L(x,y,\sigma) \tag{15}$$

After combining feature elements, cluster analysis is conducted to ultimately form an image scheme for visual communication design. Finally, we utilized CAD technology to digitize the visual communication design system for packaging. CAD technology varies with the media, and the changes reflected in visual communication forms are also more diverse. By utilizing its functions of data information analysis and visual feature symbol collection and transmission, the packaging visual communication design effect can better meet user needs and experience expectations. We conduct functional analysis on the visual module of the visual communication design system based on CAD technology, as shown in Figure 5:

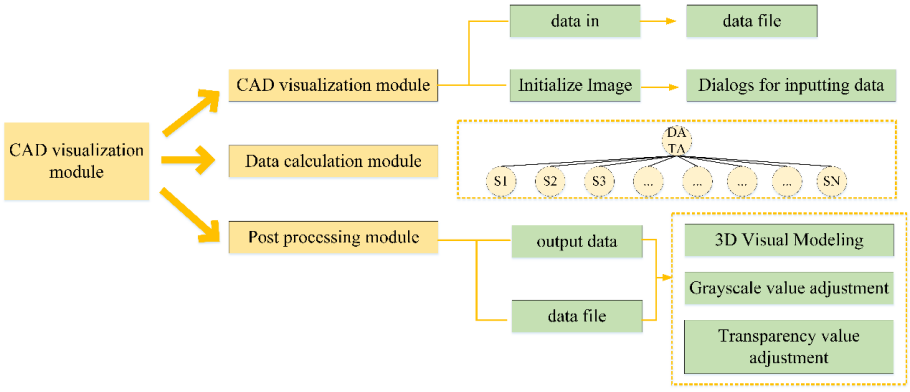

Figure 5: CAD technology visual communication design system module distribution.

As shown in Figure 5, the visualization module includes pre and post processing modules, which form an initialization design scheme after inputting image feature data. Both the calculation module and the output data module can be reflected in the 3D visual design, and the quality of the design image can be adjusted to form the design data file.

4 ANALYSIS OF RESEARCH RESULTS ON INTERACTIVE VISUAL COMMUNICATION DESIGN AND USER EXPERIENCE BASED ON VIRTUAL REALITY TECHNOLOGY FOR 3D IMAGE RECONSTRUCTION

4.1 Analysis of Research Results on 3D Display of Image Reconstruction and Visual Communication Design Based on Virtual Reality Technology

Traditional visual communication design teaching is often constrained by the limitations of physical teaching aids, which cannot provide students with a broader design space. Virtual reality technology can provide students with more diverse design scenarios and materials through virtual

reality environments, stimulating their design inspiration and creativity. Integrating virtual reality technology into visual communication design is a trend, which will bring more possibilities and richer design effects to visual communication design. We incorporated a virtual reconstruction process of 3D image feature points in the experimental process to ensure that the visual communication design quality meets the various needs of users. Firstly, capture feature image points, compare similar information from the designed data source, and independently extract useful information. Analyze the feature point elements input into the 3D modeling of the virtual reality system, and complete preprocessing and other classification operations during the data analysis process. Finally, the original two-dimensional platform information is analyzed and processed to transform the single-layer plane image into a multi-dimensional image. In order to verify the effectiveness of 3D images in visual communication design using virtual technology, we will use 3DMAX as the system platform and verify the effectiveness of 3D display of visual communication design works. Using the underlying architecture to model the virtual simulation scene of the design work, we use stereo image parameters as the parameter variables for feature recognition. The impact of sample size and complexity on virtual reality interactive presentation in test design is shown in Figure 6.

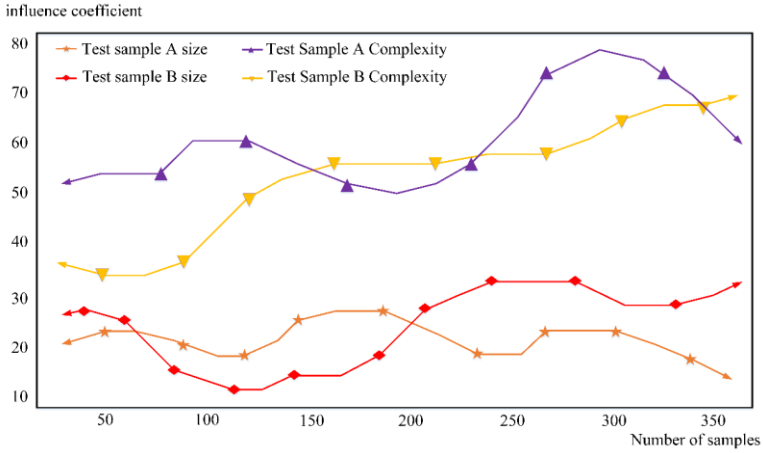

Figure 6: The Influence of sample size and complexity on virtual reality interactive demonstration.

From Figure 6, it can be seen that the total number of design samples participating in the test is 350, and the sample content is all valid graphic design information. Based on the changes in the trend chart, we found that the size of works under virtual reality technology has no significant impact on the interactive coefficient. The complexity of design samples has a significant impact on the interactive effect, so the difficulty of generating design samples determines the efficiency of system operation in 3D simulation display. Finally, from the perspective of correlation, virtual reality technology has a significant help in visual communication media design. After achieving feature image point space matching and recombination, it can enhance the feasibility of the design scheme.

4.2 Analysis of Research Results on Visual Communication Design Optimization and User Experience Based on Virtual Reality and CAD Assisted Technology

Virtual reality technology has great application prospects and effectiveness in visual communication media design. It can bring better design effects and user experience by enhancing visual effects, increasing user engagement, improving user experience, and expanding application areas. It can provide users with more freedom and participation, allowing them to have a deeper understanding of products and services. In advertising design, the use of virtual reality technology

can allow users to more intuitively experience the characteristics and advantages of the product, improve user engagement and purchasing desire. Virtual reality technology can improve users' user experience by optimizing design processes and improving design efficiency. In media design, adopting virtual reality technology can help designers better understand user needs and market trends, improve design quality and efficiency. Although the similarity of design feature images increases with the increase of matching coefficients, the update speed of dynamically obtained external image information can fully compensate. We randomly selected 12300 users as virtual reality interactive visual communication designers and collected their evaluation indicators for the design results, as shown in Figure 7.

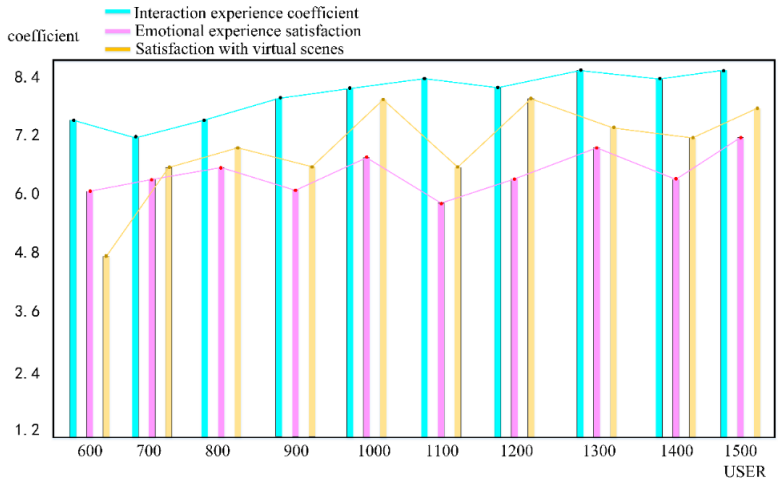

Figure 7: Changes in user reviews.

As shown in Figure 7, it can be seen from the three directions of user interaction experience coefficient, emotional experience satisfaction. In the process of optimizing the interface packaging of the CAD technology system, functions such as real-time communication and communication, directional selection of user connections, and collaborative data distribution were achieved. From the perspective of visualization, the visual communication design system is validated, and the display of three-dimensional digital works has advantages such as high clarity and obvious visualization effects.

5 CONCLUSION

In order to solve the problems of poor user experience and low interactivity in visual communication design, this article proposes virtual reality technology, 3D feature image reconstruction, and CAD visual communication system packaging solutions. Firstly, the design requirements for visual communication media were analyzed, and functional hardware suitable for three-dimensional construction was selected based on image elements, sound elements, and perceptual interaction elements. Combining the concept of visual communication design, analyze the quality of works and hidden influencing factors involved in 3D image feature recombination and display. Utilize numerical filtering and feature point set analysis to optimize virtual recombination design under three-dimensional sequences. Adopting a virtual reality platform as the basic architecture of the system, and utilizing CAD technology to package the visual display interface. Establish a virtual reality environment, use spectral texture enhancement to design image pixel features, and map them to a virtual place to obtain the visual communication work of the design. Finally, multiple sensory analysis of user experience is used as a multifaceted indicator to validate

the experimental results. The research results indicate that visual communication media design optimized using virtual reality technology and CAD technology has obvious excellent effects in terms of interactivity, user experience, communication design performance, and design image quality.

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Yuanyuan Sun, https://orcid.org/0000-0002-2592-7801
Lina Ke, https://orcid.org/0009-0006-4996-2229

REFERENCES

[1] Ahmed, K.-S.; Ibad, H.; Suchal, Z.-A.; Gosain, A.-K.: Implementation of 3D printing and computer-aided design and manufacturing (CAD/CAM) in craniofacial reconstruction, Journal of Craniofacial Surgery, 33(6), 2022, 1714-1719. https://doi.org/10.1097/SCS.0000000000008561

[2] Burghardt, A.; Szybicki, D.; Gierlak, P.; Kurc, K.; Pietruś, P.; Cygan, R.: Programming of industrial robots using virtual reality and digital twins, Applied Sciences, 10(2), 2020, 486. https://doi.org/10.3390/app10020486

[3] Dzardanova, E.; Kasapakis, V.; Gavalas, D.; Sylaiou, S.: Virtual reality as a communication medium: a comparative study of forced compliance in virtual reality versus physical world, Virtual Reality, 26(2), 2022, 737-757. https://doi.org/10.1007/s10055-021-00564-9

[4] 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

[5] Han, Y.-S.; Lee, J.; Lee, J.; Lee, W.; Lee, K.: 3D CAD data extraction and conversion for application of augmented/virtual reality to the construction of ships and offshore structures, International Journal of Computer Integrated Manufacturing, 32(7), 2019, 658-668. https://doi.org/10.1080/0951192X.2019.1599440

[6] Jin, Y.; Lee, S.: Designing in virtual reality: a comparison of problem-solving styles between desktop and VR environments, Digital Creativity, 30(2), 2019, 107-126. https://doi.org/10.1080/14626268.2019.1608264

[7] Kikuchi, N.; Fukuda, T.; Yabuki, N.: Future landscape visualization using a city digital twin: Integration of augmented reality and drones with implementation of 3D model-based occlusion handling, Journal of Computational Design and Engineering, 9(2), 2022, 837-856. https://doi.org/10.1093/jcde/qwac032

[8] Kozinets, R.-V.: Immersive netnography: a novel method for service experience research in virtual reality, augmented reality and metaverse contexts, Journal of Service Management, 34(1), 2023, 100-125. https://doi.org/10.1108/JOSM-12-2021-0481

[9] Lee, H.; Lee, J.; Kim, H.; Mun, D.: Dataset and method for deep learning-based reconstruction of 3D CAD models containing machining features for mechanical parts, Journal of Computational Design and Engineering, 9(1), 2022, 114-127. https://doi.org/10.1093/jcde/qwab072

[10] 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

[11] Shih, Y.-T.; Sher, W.: Exploring the Role of CAD and its Application in Design Education, Computer-Aided Design and Applications, 18(6), 2021, 1410-1424. https://doi.org/10.14733/cadaps.2021.1410-1424

[12] Yu, M.: Analysis of the Quantitative Impact of Virtual Reality Technology on Visual Communication Art Design, Applied Artificial Intelligence, 37(1), 2023, 2204599. https://doi.org/10.1080/08839514.2023.2204599
[13] Zhang, Y.; Yang, J.; Liu, Z.; Wang, R.; Chen, G.; Tong, X.: Virtualcube: An immersive 3d video communication system, IEEE Transactions on Visualization and Computer Graphics, 28(5), 2022, 2146-2156. https://doi.org/10.48550/arXiv.2112.06730
[14] Zhao, X.: Application of 3D CAD in landscape architecture design and optimization of hierarchical details, Computer-Aided Design and Applications, 18(S1), 2020, 120-132. https://doi.org/10.14733/cadaps.2021.S1.120-132
[15] Zhang, G.; Kou, X.: Research and implementation of digital 3D panoramic visual communication technology based on virtual reality, International Journal of Communication Systems, 35(5), 2022, e4802. https://doi.org/10.1002/dac.4802