User Interface Design and Interactive Experience Based on Virtual Reality

Ying Sun[1] and Jiao Li[2]

[1]School of Artificial Intelligence, Zhengzhou Railway Vocational and technical college, Zhengzhou, Henan 451460, China, 10330@zzrvtc.edu.cn
[2]School of Artificial Intelligence, Zhengzhou Railway Vocational and technical college, Zhengzhou, Henan 451460, China, 11388@zzrvtc.edu.cn

Corresponding author: Ying Sun, 10330@zzrvtc.edu.cn

Abstract. With the continuous development of computer simulation technology, various simulation platforms constructed based on Virtual Reality (VR) technology have greatly developed. At present, hardware devices from many manufacturers emerge in endlessly, but the devices have not formed a standardized interaction mode. Many VR products still use the two-dimensional interface design method for their interactive interfaces, resulting in poor user experience. The interaction design method of VR environment needs further research. This article introduces CAD technology into an art and design interactive platform built in virtual reality to enhance the interaction between the platform and users. The results show that the platform can extract and recognize color features of murals, effectively recognize user gestures, and achieve 3D modeling of images through VR technology, providing reliable technical and data support for platform interaction modules. The analysis of experimental user data information shows that the interaction design, operation and layout of the CAD platform can meet the needs of most users in cognition, perception and interaction, stimulate their interests and improve their sense of experience. This article not only verifies and analyzes the usability test results on the virtual command system, but also tests the effectiveness of user experience and improves user feedback needs.

Keywords: CAD Technology; Virtual Reality; Multimedia Technology; Interactive Platform
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1 INTRODUCTION

In the daily simulation process of creating 3D dynamic scenes, it is very important to use CAD computers for environmental simulation. By interactively constructing a multi-source information model of the environment, a simulation and construction system can generate a virtual world. This system provides a reference for the construction of dynamic scenes. In the UI (User Interface) design of virtual reality systems, there are currently two commonly used UI design methods. One method is to select an area with the line of sight and confirm it through a peripheral device. The other method is to read the seconds after selecting the area with the line of sight, and when the time is up, the confirmation operation is executed. The first method, using peripherals, will prevent users from fully immersing themselves in VR (Virtual Reality) scenes, disrupting the sense of immersion. The second method can interfere with the user's experience. Sometimes, just wanting to see clearly what is in that area, they start the second reading confirmation operation, which affects the user experience and increases mis-operation. In summary, the user interface interaction method based on the current UI design method of virtual reality systems has a high error rate and poor immersion when users operate virtual reality systems.

Based on this, it is necessary to provide a user interface interaction method and system for virtual reality systems to address the problem of high mis-operation rates and poor immersion when users operate virtual reality systems. A user interface interaction method for a virtual reality system, comprising the following steps: displaying multiple virtual reality models in the user interface. Among them, each virtual reality model is associated with at least one interactive object, and the initial state of the display attributes of each interactive object is set to an invisible state. Detect the user's line of sight interaction signal, and set the display attribute of the first interaction object associated with the first virtual reality model to a visible state when the line-of-sight interaction signal is detected to move to the area where the first virtual reality model is located in the virtual reality model. When the line-of-sight interaction signal is detected and the first interaction object is selected, the operation corresponding to the first interaction object is executed. A user interface interaction system for a virtual reality system, including a display module for displaying multiple virtual reality models on the user interface. Among them, each virtual reality model is associated with at least one interactive object, and the initial state of the display attributes of each interactive object is set to an invisible state. The first setting module is used to detect the user's line of sight interaction signal. And when the visual interaction signal is detected to move to the area where the first virtual reality model in the virtual reality model is located, the display attribute of the first interaction object associated with the first virtual reality model is set to a visible state. An execution module is used to perform operations corresponding to the first interaction object when detecting the line-of-sight interaction signal and selecting the first interaction object.

2 RELATED WORK

Chylinski et al. [1] analyzed the results of user marketing strategies and practices for augmented reality. The combination of augmented reality technology and gamified elements can attract more users to participate in marketing activities. For example, brands can use augmented reality technology to engage customers in brand interactive games in the virtual world, thereby increasing brand awareness and loyalty. Hamilton et al. [2] compared the quantitative learning results of I-VR based on HMD with less immersive teaching methods such as computer-aided learning. The results indicate that the use of immersive virtual methods in educational environments has a very strong level of significance. Huang and Lee [3] explored user 3D model learning in virtual reality environments. The availability factors in virtual reality were investigated through principal component analysis. Jin et al. [4]. Evaluated the model construction performance of participants in the VR environment. Jeong et al. [5] proposed an asymmetric virtual reality user environment experience. It has designed an improved system with an asymmetric interface for multi view interaction, achieving a perfect integration of distinguishing user experience and interface programs. Kharoub et al. [6] proposed immersive virtual reality desktops in different interaction modes. The proposed user interface can interact between multiple screens. At the same time, conduct quantitative and qualitative analysis on the interaction between different users. Koyachi et al. [7] validated the use of computer-aided design for scanning image surgical evaluation. The results indicate that there is no statistical deviation at any point on any axis in the postoperative repeatability plan, indicating that the method used can reproduce with high accuracy. Makransky et al. [8] analyzed the effectiveness of immersive virtual reality (VR) as a medium for providing laboratory security training. Through the test of different self-efficacy feelings of the testers, the significant difference effect of computer-assisted immersive virtual reality was compared.

Malik et al. [9] analyzed and explored the framework driven approach of human centered virtual reality technology in event simulation. Using the same simulation to produce device interactions in virtual reality simplifies the user experience production system for immersive environments. Miller et al. [10] analyzed the task performance value of augmented reality. Examined the patterns of specific users' performance in different tasks. Compared to individual tasks, participation has greatly improved the technology of augmented reality. Noghabaei et al. [11] analyzed and evaluated the current status of AR/VR technology in the AEC industry, and significantly improved the technical status analysis of institutions. Assembly process design in virtual environment refers to the process of simulating and optimizing the assembly process design of products using computer simulation and virtual reality technology in virtual reality environment. Qiu et al. [12] conducted assembly process design in a virtual environment, which improved the accuracy and efficiency of the design, and reduced the manufacturing cost and time of the product. Reski and Alissandrakis [13] compared the scale issues between different input technologies in interactive virtual reality (VR) environments. Visualize and analyze online data sources from multiple sources, enabling users to immerse themselves in browsing and exploration. Sagnier et al. [14] conducted perceptual testing on the variable features of the model. The results indicate that users' acceptance of virtual reality decreases significantly under the stimulation of personal personality traits. Tastan et al. [15] studied model construction and collection of data encoding based on screen size. Its immersive and efficient application of virtual environments promotes efficient model construction in computer-aided 3D environments.

3 BUILD AN INTERACTIVE INTERFACE DESIGN SYSTEM BASED ON VIRTUAL REALITY TECHNOLOGY

3.1 Design of CAD Design Art Interactive Platform

CAD design art interaction platform refers to a platform based on CAD design software that provides interactive experience in art design. The platform has designed a user interface as an interface for users to interact with products. Designing user interfaces for interactive platforms requires consideration of factors such as ergonomics, user needs, and visual effects. Design the functional modules of the platform based on user needs and product positioning. Each module should have clear functions and roles, and be reasonably associated with other modules. The process and methods of interactive CAD virtual display design based on user experience were emphasized. Display design is a comprehensive and interdisciplinary art discipline. Display design aims to use space as a medium to transmit information and spread culture in exhibition activities, commercial product displays, cultural promotion, and social activities. Its function and significance are not only the aesthetic aspect of artistic expression, but also a fusion of commercial, social, and technological attributes. Display design is accompanied by social development and plays an increasingly important role and significance in social and cultural life and commercial activities.

Therefore, the design of CAD interactive platforms should fully consider physical environmental factors and user psychological factors. The interactive interface of the platform should demonstrate good user friendliness. Help users obtain the required information in a short period of time, master the corresponding functional operations, and reduce their learning costs. At the same time, it is also necessary to reduce the single form of content display, such as a large number of textual descriptions. We should combine multimedia technology with diverse and multi angle display content to create an immersive atmosphere and artistic design display content. Based on this, Figure 1 shows the interactive content that the art and design interactive platform can achieve.

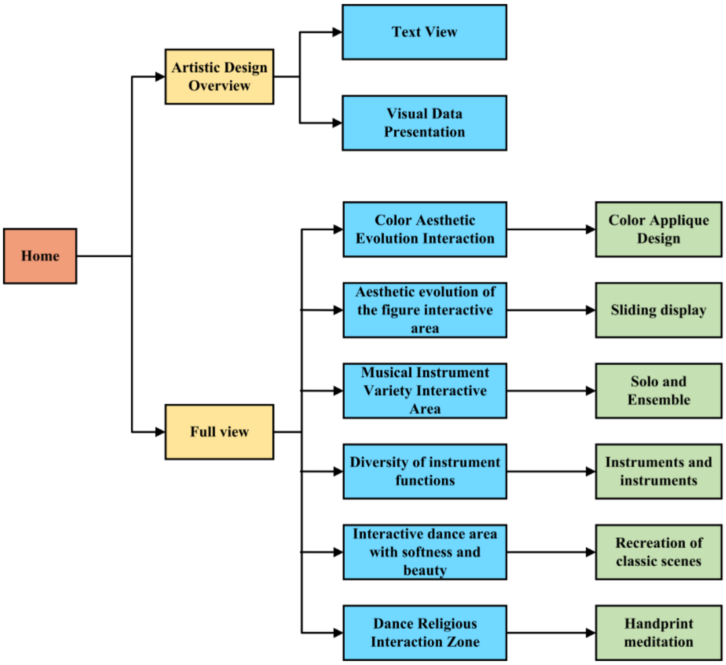

Figure 1: Interaction content that the art design interaction platform can realize to run.

In order to establish an interactive relationship between display design works, display space, audience, and designers, and achieve the purpose and significance of meeting user needs.

The first layer is the main interactive interface of the interactive platform, providing users with basic platform information, services, and options for the next layer. The second layer mainly includes two modules: art design overview and panoramic appreciation. The overview module mainly introduces the content through text and visual data display, and provides users with more basic information through various visualization methods. The panoramic viewing module is the main field of human-computer interaction, which can provide users with various forms of interaction and content. Such as content sliding display, art design color interaction design, diversified instrument interaction, etc. That is to extract a part of art and design content, achieve interaction with users, and deepen users' understanding of the content. Different levels and modules can be converted through interface fast channels. Users can also achieve corresponding goals through multiple gesture operations, but learning and practicing operations requires more time and effort.

3.2 Calculation of CAD Technology in User Experience Interactive Platforms

Virtual reality creates a realistic virtual reality environment that requires a large amount of 3D graphics computation and generally requires computer support. In recent years, the performance of computers has rapidly improved, and virtual reality research and application of CAD/CAM can be carried out on microcomputers. The pursuit of a sense of realism and virtuality beyond reality, as well as the establishment of a multidimensional information system in which individuals can immerse themselves and interact, has driven the application and development of virtual reality technology in CAD/CAM. The virtual reality technology of CAD/CAM involves various disciplines of CAD/CAM, and has shown its practicality, enormous technical potential, and broad application prospects.

The sliding display, color interaction design, and musical instrument interaction in the interaction platform all require the extraction of feature information and classification recognition of the corresponding content by the corresponding algorithm, based on which the content and form of interaction are designed. The image is composed of several color pixel points, among which the pixel points of the main color appear most frequently. Let there be m data points in the initial data set, randomly select g data points as the comparison target, and obtain the data with the highest similarity from the remaining data points and form a new cluster. The degree of similarity can be described by the distance between the data, and the calculation formula is shown in (1).

$$l = \sqrt{(x-x_1)^2 + (y-y_1)^2 + (z-z_1)^2} \tag{1}$$

The corresponding value of the color pixel point in the spatial coordinates is expressed as x, y, z .

The computer display color space is RGB, which presents a certain gap between the colors and the colors seen by the human eye. HSV color space is used to express colors through three indicators: chroma, nominal and saturation, which is closer to the effect of human visual perception, as shown in Figure 2.

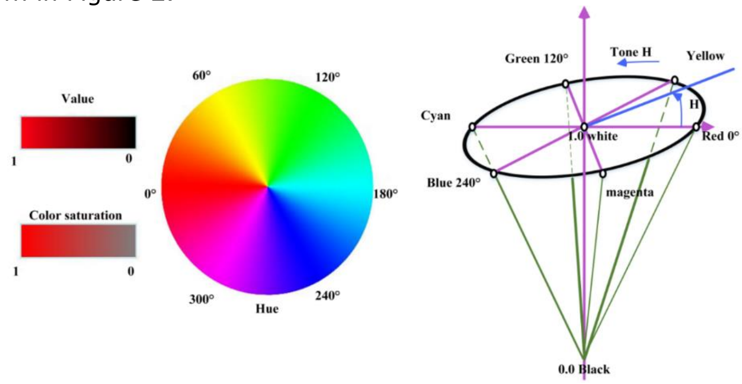

Figure 2: HSV color space diagram.

The image color acquired by the interactive platform is RGB color data, which needs to be converted into HSV color image as shown in equations (2)-(4).

$$h = \begin{cases} \arccos \dfrac{2r-g-b}{\sqrt[2]{(r-b)^2+(r-b)(g-b)}} & (b \le g) \\ 2\pi\text{-}\arccos \dfrac{2r-g-b}{\sqrt[2]{(r-b)^2+(r-b)(g-b)}} & (b > g) \end{cases} \tag{2}$$

$$s = \frac{\max(r,g,b) - \min(r,g,b)}{\max(r,g,b)} \tag{3}$$

$$v = \frac{r+g+b}{3} \tag{4}$$

Where $r, g, b \in [0,255]$, $h \in [0,360]$, $s, v \in [0,1]$.

As shown in Equation (5) for the HSV spatial yellow-green features and color vividness features calculation equation.

$$x_{gy} = \frac{x_h}{150}, when\ x_h \in [0,150] \tag{5}$$

The yellow-green feature is noted as x_{gy} and the color vibrancy feature is expressed as x_h .

The image contrast is shown in Equation (6).

$$C = \sum_{\varphi} \varphi(m,n)^2 P_{\delta}(m,n) \tag{6}$$

where the grayscale difference of neighboring pixels is described as $\varphi(m,n)$, $\varphi(m,n) = |m-n|$, and its distribution is denoted as $P_{\varphi}(m,n)$.

According to equation (7), the picture chroma can be calculated as follows.

$$IS = \frac{M_q}{M} \times 100\% \tag{7}$$

The number of extra pixels above the saturation threshold is M_q and the total number of pixels is M .

The multi-gesture operation in the interaction platform can increase the user operability and interactivity, in fact, combined with VR technology and Kinect to realize the gesture 3D modeling and recognition. Its need to realize the transformation between image translation and projection in different coordinate systems through 3D registration technology. Let $W = (w_x, w_y, w_z, 1)^T$ describe the world coordinate system and its projection in the plane is represented as $W_X = (w_X, w_Y, 1)^T$, according to equation (8) the relationship can be expressed as follows.

$$W_X = PW = \alpha KMW = \alpha K \begin{bmatrix} r_1 & r_2 & r_3 & r_4 \\ 0 & 0 & 0 & 1 \end{bmatrix} W \tag{8}$$

The internal parameters of the camera are represented as K and the external parameters as M .

When W is in the table real plane, $w_z = 0$, the above equation can be further transformed as shown in equation (9).

$$W_X = \begin{bmatrix} w_X \\ w_Y \\ 1 \end{bmatrix} = \alpha K \begin{bmatrix} r_1 & r_2 & r_3 & r_4 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} w_x \\ w_y \\ 0 \\ 1 \end{bmatrix} = \alpha K \begin{bmatrix} r_1 & r_2 & T \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} w_x \\ w_y \\ 1 \end{bmatrix} = W_H \begin{bmatrix} w_x \\ w_y \\ 1 \end{bmatrix} \tag{9}$$

The implementation of 3D registration requires extracting and projecting its 3D coordinates into the observation 2D coordinate system based on the natural feature points in the actual environment, and estimating the positional information based on the single-strain matrix of each image frame. The radiometric reconstruction technique can calculate the positional information, i.e., let the affine coordinate point be noted as $m = (h,k,l,1)^T$, the 2D plane coordinates in different views are described as $m^1 = \{h^1, k^1, 1\}, m^2 = \{h^2, k^2, 1\}$, and the position calculation formula is shown in (10).

$$\begin{bmatrix} h^1 \\ k^1 \\ h^2 \\ k^2 \end{bmatrix} = \begin{bmatrix} h_1^1 - h_0^1 & h_2^1 - h_0^1 & h_3^1 - h_0^1 & h_0^1 \\ k_1^1 - k_0^1 & k_2^1 - k_0^1 & k_3^1 - k_0^1 & k_0^1 \\ h_1^2 - h_0^2 & h_2^2 - h_0^2 & h_3^2 - h_0^2 & h_0^2 \\ k_1^2 - k_0^2 & k_2^2 - k_0^2 & k_3^2 - k_0^2 & k_0^2 \end{bmatrix} \begin{bmatrix} h \\ k \\ l \\ 1 \end{bmatrix} = r_{4*4} \begin{bmatrix} h \\ k \\ l \\ 1 \end{bmatrix} \tag{10}$$

The current projection of the point is Eq. (11).

$$\begin{bmatrix} h \\ k \\ 1 \end{bmatrix} = \begin{bmatrix} h_1 - h_0 & h_2 - h_0 & h_3 - h_0 & h_0 \\ k_1 - k_0 & k_2 - k_0 & k_3 - k_0 & k_0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} h \\ k \\ l \\ 1 \end{bmatrix} = m_{3*4} \begin{bmatrix} h \\ k \\ l \\ 1 \end{bmatrix} \tag{11}$$

The pixel coordinate system and the random pixel points in the imaging plane coordinate system can be transformed relationally according to Eq. (12).

$$\begin{bmatrix} h \\ k \\ 1 \end{bmatrix} = \begin{bmatrix} 1/di & 0 & h_0 \\ 0 & 1/dj & h_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} i \\ j \\ 1 \end{bmatrix} \tag{12}$$

Where the physical size of the pixels are expressed as di, dj respectively.

4 APPLICATION EXPERIMENT OF USER DESIGN INTERACTIVE PLATFORM BASED ON CAD VIRTUAL TECHNOLOGY

The application of CAD virtual technology in user design mainly refers to the user interface design based on computer aided design (CAD) software, also known as human-computer interaction design. The widespread application of CAD software in engineering and product design has made user interface design increasingly important. CAD software provides various tools and functions. These functions can help users engage in design thinking and creativity. In user design, virtual technology can help designers better utilize these tools and functions to create a better user experience.

This article takes Dunhuang murals as the object of artistic design display and interaction, and tests the application of the interactive platform. In the color extraction experiment module of the interactive platform, the test involves extracting women's clothing colors from different periods of the same dynasty, providing accurate data information for displaying changes in women's clothing colors and corresponding interactions. The results are shown in Figure 3 and Figure 4.

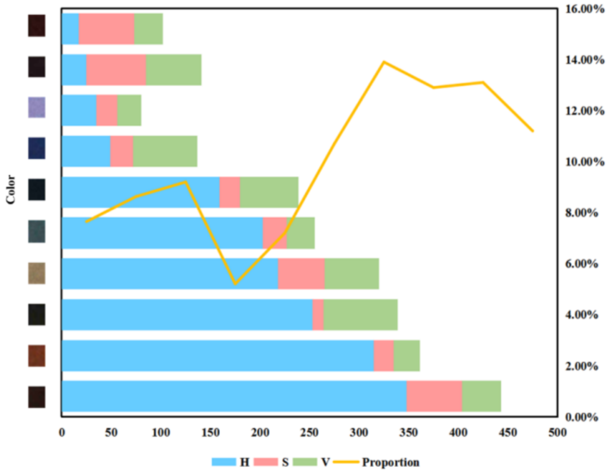

Figure 3: Extraction of main color features and percentage results of mid-Tang female dress.

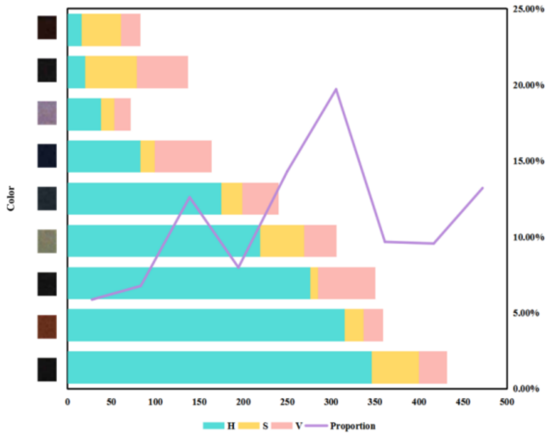

Figure 4: Results of extracting and accounting for the main color features of women's clothing in the late Tang Dynasty.

The results in the figure indicate that the machine learning algorithm in the interactive platform can effectively extract the main color features of clothing in different periods. Simultaneously obtain the corresponding hue, brightness, and saturation values for each color based on the color space. Due to the environmental factors of Dunhuang murals and the background color of the murals, there may be some deviations in the extraction results of the primary color, but the impact on the overall display and interaction is relatively small. The primary color spatial data and percentage extracted by CAD can provide a data basis for the corresponding clothing evolution display. Provide users with a more comprehensive and multi-dimensional presentation of Dunhuang women's clothing and the color change process, improving the operability and design of color interaction.

The recognition results of user gestures on the interactive platform are shown in Figure 5. The results in Figure 5 (a) indicate that the interaction platform can effectively track and recognize user gestures through Kinect and VR technologies to ensure the possibility of corresponding gesture operations. Figure 5 (b) shows the recognition results of the augmented reality system. Users can zoom in, out, and rotate the 3D model at any angle in the interactive platform, viewing and observing the recognized targets in the image from multiple angles, improving the user's sense of realism and immersion.

(a)Gesture recognition effect (b)Recognition effect

Figure 5: Results of gesture recognition and image target recognition based on Kinect and VR technology.

It can be seen that the interactive platform designed in this article can effectively identify targets and display artistic content to users in various ways and angles. At the same time, interactive platforms can increase the platform's operability and interactivity through VR technology, providing users with a better experience environment. Provide strong technical and data information support for subsequent user experience experiments.

In the user experience experiment of user designed interactive platforms, 10 users were randomly selected for the experiment. According to the survey results, none of the participating users have a deep understanding of Dunhuang mural art. Figure 6 shows the statistical results of user experience time participating in the experiment using a user art design interaction platform.

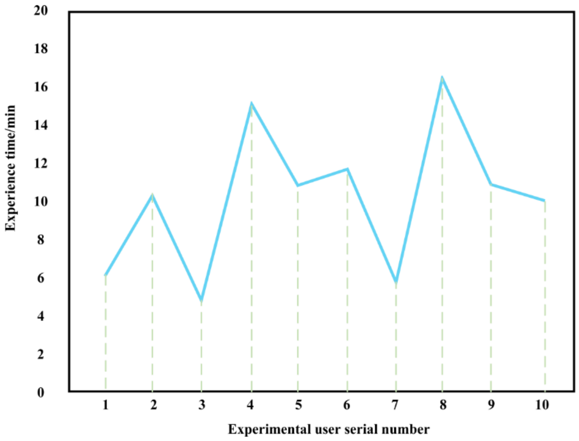

Figure 6: Experimental users' experience time statistics of using the art design interaction platform.

The results in the figure show that the number of users whose experience time exceeded ten minutes was seven, and two of them had an experience time higher than 15 minutes. This indicates that the interface design of the art design interaction platform can basically meet the basic needs of users' visual and operational needs, and reduce the phenomenon of lowering users' interest due to sensory and operational problems. In addition, the feedback from users whose experience time was less than 10 minutes indicated that the interaction process would generate certain negative emotions due to matching errors and other reasons, and the end of the interaction session was somewhat abrupt and lacked corresponding prompts. The statistical results provide a basic data basis for the measurement of the immersion effect and fun effect of the interaction platform later.

The corresponding user experience evaluation results are calculated based on the evaluation metric information after the experimental users complete the interactive platform experience, and the calculation formula is shown in (13).

$$E = \frac{\sum [Z_i \times C_i]}{5 \times \sum Z_i} \tag{13}$$

The serial number of the current evaluation item is expressed as i, the value of the user experience score is expressed as C, and the item importance score is expressed as Z. The results of the interactive platform experience metrics for the 10 experimental users are shown in Figure 7. From the figure, it can be seen that the overall experience provided by the three aspects is good for the users. Among them, the experimental users have the lowest rating in sensory experience. Combined with the feedback from the users in the experience time statistics session, the interface design of the art design interactive platform in this paper can meet the operation needs of most people, the visual effect is well presented, and the overall style matching is maintained in a good state. After analysis and further information collection, it is concluded that users rely more on sensory experience in using the interaction platform, focusing on whether the operation is easy and smooth, and seldom understand the style of elements, distribution planning and operation logic behind. Further analysis showed that the experimental users gave positive comments on the images, music, and presentation of the interactive platform, which provided good conditions and environment for users to read and browse.

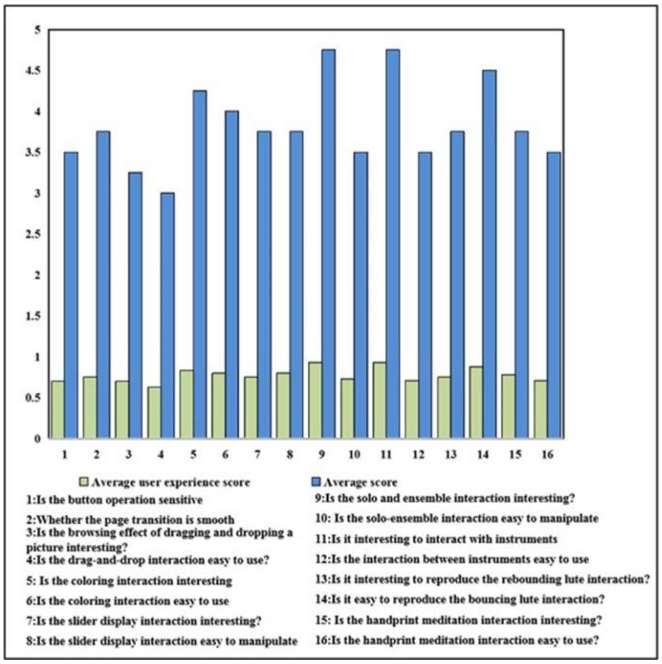

Figure 7: Experimental user sensory experience metric results.

In summary, an art and design interactive platform based on CAD virtual technology can provide users with a good interactive environment. By transmitting the content and information of art design through users' multiple senses, it meets the needs of users' perception, cognition, and interaction. However, according to feedback from relevant users, there are still shortcomings in the application of interactive platforms, such as content classification and interactive triggering. The layout of interactive interface design elements is unreasonable, without highlighting the key points, and the appeal to users is limited.

5 CONCLUSION

The adoption of CAD virtual technology further enhances the interactive experience of art design and enhances its application value. Making the development and application of art and design more possible. User design not only needs to showcase the connotation and emotions that the design wants to express, but also needs to pay attention to the emotions and personalized needs of users. Therefore, the user experience in art and design interaction is an integral part that cannot be ignored. In the past, art and design were unable to interact well with users due to objective reasons, resulting in relatively poor user experience. Therefore, this article introduces multimedia technology into the art and design interaction platform, and enhances the interactivity and operability of the interaction platform through machine learning, VR, and other technologies. Performance tests have shown that the art and design interaction platform based on multimedia technology can effectively recognize and extract color features from Dunhuang murals, and obtain corresponding color space data information and scales through classification. At the same time, the platform can recognize user gestures, enhance image authenticity, and increase the operability and visibility of interactive sessions for users. The analysis of experimental user data shows that the interface and interaction modules of the platform are designed to meet the basic needs of users, which has aroused the majority of users' interest in Dunhuang murals. The final user experience evaluation results show that the majority of users have a positive attitude towards the platform's interactive performance and the display of artistic design content. This can help users efficiently and easily understand the artistic features of Dunhuang murals in a short period of time. Effectively reducing user time costs and creating a good experience space for users. However, there are still issues in platform design such as unreasonable layout of operational elements, difficulty in interaction, and sudden cessation of interaction, which require further optimization. The art design display content has issues such as insufficient focus and inconsistent elements, which reduces the attractiveness and experience for users.

Ying Sun, https://orcid.org/0000-0002-5071-7224
Jiao Li, https://orcid.org/0009-0004-8331-6920

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