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Optimization of Interactive Experience of Multimedia Technology in Exhibition Design of Art Museums

Abstract: - This paper adopts VR technology in multimedia technology, combined with Unity3D development, to construct the virtual roaming system of art museum exhibition. The virtual exhibition environment is simulated through the steps of field scene acquisition, plane production and model construction. While simplifying the operation, it enhances the content degree and provides a multi-dimensional perceptual experience to enhance user interactivity and immersion. The RBM model is used to analyze the user interaction behavior and get the audience preference characteristics. By training the audience preference perception model, the higher-order nonlinear relationship of audience interest is captured to optimize the user interaction experience of art museum exhibitions. In the control accuracy test, the control accuracy of this paper's method is stable at more than 99.5%, much higher than the original method's 88.49%, and with little fluctuation, which is excellent and stable. The interaction experience score of multimedia technology is between 3.22-4.64, which indicates that this paper's method performs better in interaction real-time, and can provide users with more rapid and timely interaction response to enhance user experience.

Keywords: multimedia technology; VR technology; art museum exhibition meter; interactive experience; RBM modeling

1. INTRODUCTION

In the context of the growing demand for public culture, people's diversified requirements for cultural consumption and aesthetics have surpassed any previous period [1]. The arrival of the digital era has made science and technology encircle and sweep many aspects of human life, which has given rise to many emerging multimedia technologies such as somatosensory devices, interactive technology, holograms and other innovative design means used in the design field [2-3]. In exhibition design, multimedia technology as one of the design means fits the overall trend of social development [4-5]. It not only makes it possible to design from the one-way output of the main body to the public's consumption feedback, but also allows the diversity and recyclability of multimedia equipment to meet the different needs of exhibition design, thus optimizing the consumption of resources and providing more diversified dissemination methods in the specific design process [6-7].

Summarizing the relevant studies, it is found that the rapid development of modern multimedia technology provides a new way for visual communication and design creativity. The innovative use of multimedia technology in the exhibition design of art museums can, to a certain extent, expand the design dimension through video technology, and break through the limitations of physical space in spatial design to create different attributes of scene experience for the public. In this paper, we take the interactive experience of public exhibition as the entry point to explore the expression of VR technology in the exhibition space of art museums in design. Combining imaginative intelligence and modern technology, it breaks through the constraints of physical space and creates a new multi-dimensional perception scene for the public, so as to better enhance the dissemination of exhibition information and the sense of interactive experience. The RBM model is used to

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analyze the audience interaction behavior and get the audience preference characteristics. By training the audience preference perception model, the higher-order nonlinear relationship of audience interest is captured to optimize the user interaction experience of art museum exhibitions.

2. RELATED WORKS

With the development of science and technology and the iterative updating of media, the communication era is in constant transformation, and each communication era has its own unique media form. The dominant medium that triggers revolutionary changes, with the progress of science and technology, today's society has rapidly entered the interactive digital communication era [8-9]. At present, most of the research on the exhibition design of multimedia art focuses on the use of technical research level, and lacks hierarchical discussion on the research of the comprehensive artistic effect of multimedia technology.Wu, X et al. studied the online museum of intangible cultural heritage, which has become a bridge connecting the history and the public through virtual interactive animation. The design integrates virtual interactive technology to break the time and space barriers, allowing the public to enjoy an immersive experience without leaving home. The design not only showcases the essence of heritage, but also deepens understanding through interaction, revitalizing traditional culture. In principle, 3D modeling, motion capture and other technologies are used to build realistic scenes and dynamic displays to enhance user participation. Eventually, the design realizes the transformation from static viewing to dynamic exploration, which makes the inheritance and promotion of intangible cultural heritage more vivid and extensive [10]. Z Zou, N et al. proposed to create hierarchical experience and build a closed loop of VRME experience. Through the literature review, they summarize the technical trends and interaction difficulties, and propose the rose model to explain the subtle relationship between technology, senses, experience levels and human-computer interaction, which provides a new perspective for VRME design. And the model revelation is discussed in depth to promote the refinement of VRME interaction design [11]. Sun, H et al. argue that in the era of new technology, museum exhibitions focus on emotional design. Image emotion semantic analysis is integrated with VR and AI to lead the new direction of exhibition digitization. Analyze the technical development and emotional needs, clarify the necessity and feasibility of image emotion semantic analysis in museums, put forward the analysis strategy and application method, and realize the display effect of intermingling space, emotion and scene. The experiment proves that image emotion semantic analysis effectively improves the visiting experience and meets the new needs of the times [12]. Zhao, L focuses on VR and deep learning, designs a personalized medical museum exhibition system, integrates multimedia and multimodal perception, and strengthens the performance of VR framework. Tested and verified, the system effectively promotes the digital display of cultural heritage resources and opens up new paths for cultural heritage protection [13]. Liu, L researches the interactive display of mobile non-heritage, integrates context-awareness and machine learning, and proposes design principles based on the theories of digital display, education, embodied cognition and gamification. Ontology is used to construct a user model, combined with multi-context analysis to optimize the recommendation algorithm. The experiment proves that the algorithm still performs well when the data is sparse. Meanwhile, exploring the application of AR in folk art appreciation class, designing practice cases, solving teaching challenges, analyzing feedback and looking forward to the future [14]. Yi, J. H. et al. research covers design, analysis, synthesis and evaluation. Six viewing experiences are defined, integrating the three elements of presence, flow, and natural interaction of MR to create a customized MR experience for artifacts. Evaluations show that users highly value the new experience. Technology implementation requires prior insight into the application domain and in-depth user analysis. This study provides a system development guide for cross-domain applications of wearable MR [15]. Tsita, C et al. concluded that VR museums help cultural heritage communication and deepen public understanding through interactive experiences. Applied to a contemporary art museum, a VR environment was designed to promote interactive learning for abstract art. Evaluation showed positive user experience with good sense of control, usability, and entertainment. Users valued the educational value and were willing to explore heritage content and recommend applications.VR technology opens new paths for cultural heritage communication [16]. Durmuş, U et al. proposed a model incorporating VR technology to strengthen design communication and enhance stakeholder engagement. Through case tests with museum experts, VR effectively facilitates the comprehensive presentation of multimedia, lighting and other elements to enhance design communication. Studies have shown that VR can significantly reduce costs and improve quality in the exhibition construction phase, providing innovative solutions for exhibition production [17]. Analyzing the above studies, it is found that VR technology has certain advantages in the design of fine art exhibitions.

3. APPLICATION OF MULTIMEDIA TECHNOLOGY

The development of human civilization is a continuous process of exhalation of the past and incorporation of the new, and the limitations of information dissemination in each era form different cultural ideologies in different technological environments. Nowadays, people's pursuit of technology has reached a level unparalleled in any previous period, and the issue of technology has thus become the core issue of social competition. Technological innovation extends new communication media and changes users' habits and ways of thinking, therefore, new communication carriers are needed to satisfy users' needs, and art pavilions are the new communication carriers spawned by digital media technology and cultural expectations.

3.1 VR technology

VR is a kind of computer simulation technology and behavior of the simulation system, so that the user immersed in the generated three-dimensional dynamic visual environment of the technology [18]. VR technology is the most important feature is to be able to give the user to experience the sense of immersion, VR technology needs to experience the user to wear a full wrap-around type of headset, when the experience of the user's head in different directions when the head is rotated, the virtual world will be seen with the angle of its line of sight is constantly changing, the user will feel that The user will feel that the situation is exceptionally real. With the rapid development of digital technology in the field of exhibition display, art museum exhibition began to utilize new media technology to promote. With the innovation of visual design, the new media technology makes a piece of precious and fragile artwork have a richer form of display, so that visitors can get great visual satisfaction.

In this paper, Unity3D is used as the design basis to develop virtual roaming VR software for art museum exhibitions, which applies VR technology to build art exhibition halls and virtually reconstructs the art scenes for users to roam in [19]. Through the flexible use of materials, the scene is designed in the scene modeling function of Unity3D, and the corresponding script is applied to optimize the environment of the experience, so that the viewer can have a better visual interactive experience [20].

3.1.1 Software development

The main software for program development includes Microsoft visual studio, Unity 3D, 3D Studio Max, Adobe Photoshop and so on.

The program as a whole is divided into two major modules, including Baimei Village Pavilion Module and the real scene module, the production content is divided into the field picking, plane production, modeling, Unity code framework writing, post-rendering, the project packaging several parts, the software development process is shown in Figure 1. Software development is divided into six parts, as follows:

(1) The field scene acquisition is carried out with three kinds of equipment: plane camera, panoramic camera,

and drone.

(2) Plane production will be organized after the collection of material, put into the Adobe Photoshop CC2018 software for modification, interface UI design, throughout the project's overall style control, and finally imported into the Unity3D.

(3) Through 3dsMax2017 for grid, line layout, through the material ball, mapping, lighting fusion to form a colorful model.

(4)The Unity framework is written with U manager, sound manager, event manager, and resource manager.

(5)Post-rendering of the main scene of the light rendering, Unity under the model for lighting settings, material ball filling, and finally rendering.

(6)Project packaging is the production of scripts and 3D models through mono compiled into a resource, and then through Unity to select the corresponding platform for packaging, and ultimately into an exe file that can be run on the windows platform.

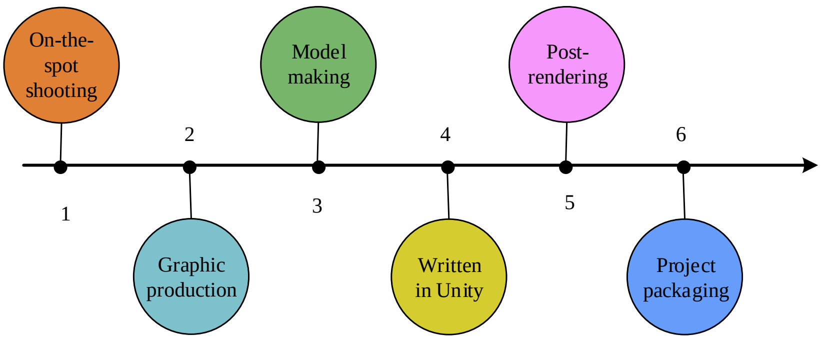

Figure 1 Software development process

3.1.2 Software architecture

The development language is mainly based on C#, and Figure 2 shows the architecture. It can be seen that the real mode is completed through the production of real-life shooting. The real scene of Baimei Village is shot by the panoramic shooting equipment, and then processed into Unity's jpeg format through the post retouching software, the information of the picture, such as the name, format, scene name is stored in accordance with the prescribed format, and the picture data is loaded into the customized configurator. Unity loads the image information through resource.load and displays it on the screen, and reads the configuration table through System.IO.StreamReader, the information Unity reads is a string. StreamReader, Unity reads the information as a string, so it parses the content of the configuration table by parsing the string information, and then displays the read content into the screen in order. Button event is added to each scene by using UnityEngine.UI.Button to give each button the logic to be executed when it is pressed, so that the content to be displayed can be shown.

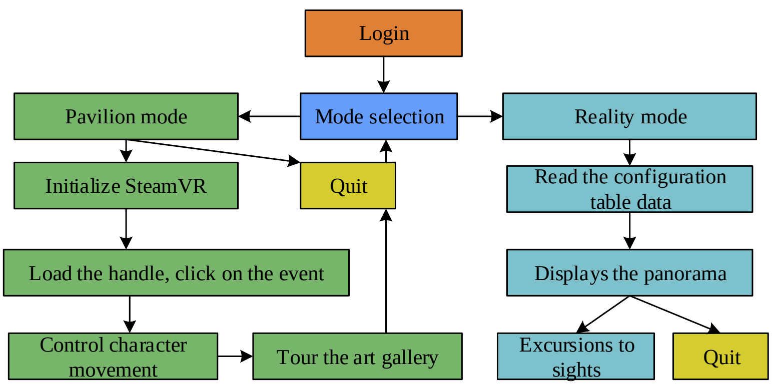

Figure 2 Software Architecture

3.2 Exhibition Environment Design for Art Museums

As an art form of contemporary cultural social presentation, with the development of cultural consumption, communication and modern science and technology, exhibition shows unprecedented vitality and vitality in visual communication and scene experience. The growth of cultural demand will inevitably promote the continuous development of exhibition art, while the innovation of new technology will also enrich the innovation of design thinking, making design and technology in this development trend towards integration and symbiosis, and derive new ideas. In the optimization of interactive experience of multimedia technology in art museum exhibition design, the use of multimedia technology is the current research hotspot. Emerging technologies enable the exhibition space to break through the limitations of physical transformation, maximize the availability of space, and construct a high-tech space that completely simulates or transcends the natural environment, featuring low-energy and low-consumption, rich in content, wide dissemination, and strong sense of immersion. With the continuous development of multimedia technology and the breakthrough of creative intelligence dimension, the cooperation between creative design and science and technology will be more and more close, and will also give birth to more new design objects.

The optimization of the interactive experience of multimedia technology in art museum exhibition design is to meet the needs of visitors for art appreciation and knowledge acquisition. Therefore, when designing, VR technology is utilized to design from the consideration of visitors' use perspective [21-22]. The specific design principles are as follows:

(1) The system should be simple and easy to operate means to design a beautiful and extremely easy to operate system interface, so that visitors can easily get started.

(2) The system should be realistic, the requirements of a more close to the reality of the art works on display situation, and enrich the display model, to provide visitors with a more realistic experience of the exhibition.

(3) The system content should be rich and diverse, providing visitors with visual, auditory, physical, tactile and other multi-directional perception, so that visitors in the emotional resonance to understand the connotation of art.

(4) The system interactivity should be strong, to optimize the system interface interaction function, so that visitors can operate the audio-visual materials, text introduction, art works, etc. in the venue, to enhance the user's experience of the exhibition [23].

The environmental design of the art exhibition hall of VR technology is shown in Figure 3, and in terms of the optimization of the interactive experience of multimedia technology in the exhibition design of the art museum, a professional and relevant experience room can be opened. However, instead of equipping each person with a computer, it is only necessary to configure a two-channel stereoscopic projection system with about four high-brightness projectors, about two high-performance PCs, and then a central control PC and corresponding multimedia equipment such as data gloves, helmets or stereo glasses [24]. It has the advantages of ultra-wide screen and large viewing angle, which can bring a more stunning experience.

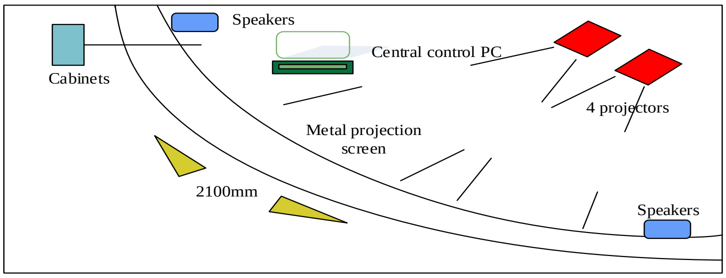

Figure 3 Environment design of art gallery with VR technology

3.3 Based on the user interaction behavior preference perception model

In the process of optimizing the interactive experience of multimedia technology in the exhibition design of art museums, the uncertainty and dynamics of audience preferences are taken into account, and the audience generation data are fully explored to analyze the development and evolution of the audience's interests and preferences, to establish an audience preference perception model that expresses the audience's needs and preferences, and to extract the characteristics of the audience's preferences, so as to provide services for the personalized design and recommendation of the exhibition of the art museums [25-26].

The task of interactive experience optimization for multimedia technology in art museum exhibition design is to search for optimization goals that meet the potential needs and personalized interest preferences of the audience in the dynamic evolutionary feasible domain space composed of massive multi-source and heterogeneous audience generation data, so as to make personalized exhibition recommendations for the audience, i.e., it is essentially a kind of complex dynamic qualitative index optimization problem. Here, the objective function $f_u(x)$ of the multimedia technology-oriented interactive experience optimization problem in art museum exhibition design is defined as:

$$\begin{cases} f_u(x) \\ s.t. u \in U, x \in X \end{cases} \tag{1}$$

Where $U = \{u_1, u_2, \cdots u_{|U|}\}$ denotes the set of viewers, $|U|$ denotes the number of visitors to the art exhibition, and $X = \{x_1, x_2, \cdots x_{|X|}\}$ denotes the set of exhibition items in the art museum. Usually X is very large and sparse, $|X|$ represents the number of exhibition items, and the exhibition item solution x_i contains n decision variables, denoted as $x_i = \{x_{i1}, x_{i2}, \cdots x_{in}\}$. The degree of preference of the audience u for the exhibition items x is $f_u(x)$, which can not be accurately expressed by a specific mathematical function, but is determined by the audience's u cognitive experience and interest preference, and may change dynamically during the process of optimization of the interactive experience.

According to the audience's historical interactive behavior data, screening the collection of items containing current audience preferences constitutes the dominant group D, if the audience's evaluation or attention to an exhibition item is higher than the threshold, which usually means that the audience likes the item, the item is classified into the dominant group. If the audience stays at an exhibition item to browse, the item that gets longer browsing time is categorized into the dominant group. The dominant group D is used as the initial population $Pop(0) = \{x_i, i = 1, 2, \cdots, |D|\}$ under the EDA evolutionary optimization framework, and the population size is $|D|$.

Regarding the coding of the evolved individuals in the population, the exhibition item (individual) x is described by n attributes, denoted as the binary coding of the decision variable $x = \{x_1, x_2, \cdots x_n\}$. Where the i th decision variable x_i takes the value of 1 or 0, with 1 indicating that the item has the attribute, and 0 indicating that it does not have the attribute. Individuals of exhibition items contain the interest preferences of viewers, and evolving the ith decision variable $x_i = 1$ of individual x indicates that viewers are interested in exhibition items that contain attribute i.

Based on the attribute distribution information of the decision variables of the dominant group in the search space, the higher-order nonlinear relationship between the decision variables of the qualitative indicators based on the audience interaction behavior is fitted by using the implicit expression ability and feature extraction ability of the RBM model, and the RBM audience preference perception model is constructed to capture the audience preference features. Figure 4 shows the structure of the RBM user preference perception model. The RBM user preference perception model based on user interaction behavior has a two-layer network structure. Visible layer v contains n visible units, which represent n attributes of the individual items, and v_i represents the state of the ith visible unit. Hidden layer h contains m hidden units representing user preference features, and h_j represents the jth hidden unit state. Both visible and hidden units are binary variables.

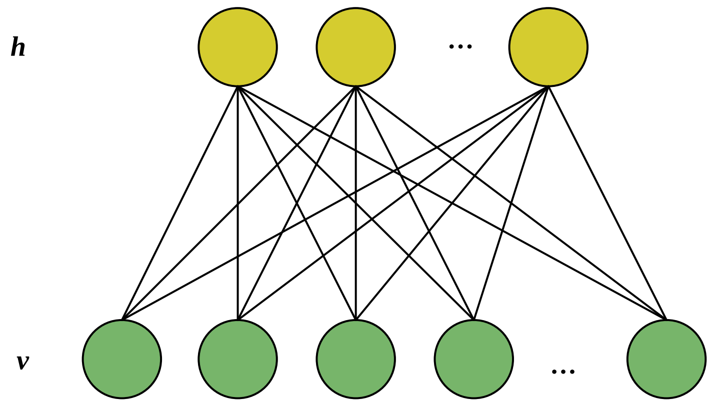

Figure 4 Structure of RBM user preference perception model

The operational formulas for the conditional distribution probabilities of visible and hidden cells are as follows:

$$P_\theta\left(v_i = 1 | h\right) = \sigma\left(a_i + \sum_j W_{ij} h_j\right) \tag{2}$$

$$P_\theta\left(h_j = 1 | v\right) = \sigma\left(b_j + \sum_i v_i W_{ij}\right) \tag{3}$$

where W_{ij} represents the connection weight between visible unit i and hidden unit j, and a_i and b_j represent the bias of visible unit i and hidden unit j, respectively.

For a given set of states (v, h), the system energy function of the RBM user preference perception model based on user interaction behavior is:

$$E\left(v, h | \theta\right) = -\sum_{i=1}^{n} \sum_{j=1}^{m} v_i W_{ij} h_j - \sum_{i=1}^{n} a_i v_i - \sum_{j=1}^{m} b_j h_j \tag{4}$$

Where $\theta=\{W,a,b\}$ denotes the model parameters, all of which are real numbers.

Through the RBM model CD learning algorithm, the binary genetic code $x=\{x_1,x_2,\cdots x_n\}$ of evolved individuals in the population is used as the training dataset $T=\{(x_i, f(x_i)), i=1,2,\cdots|D|\}$. Input into the visible layer unit $v=\{v_1,v_2,\cdots v_n\}$ of the RBM audience preference perception model based on the audience interaction behavior, train the audience preference perception model, capture the higher-order nonlinear correlation relationship of the audience preference information, and obtain the RBM model parameter that contains the excellent solution of the gene distribution feature representation $\theta=\{W,a,b\}$. Combining the above, the complete the interaction experience optimization design.

4. INTERACTION EXPERIENCE OPTIMIZATION RESULTS ANALYSIS

4.1 Parameters and test methods

In order to ensure that the two solutions for optimizing the interactive experience of multimedia technology in the exhibition design of art museums can run smoothly in a unified experimental environment, it is necessary to design the test environment and the equipment required for the test. The test will be carried out in an art gallery, and the test equipment, in addition to the traditional computing equipment, also adds a small amount of central control equipment. In order to ensure the effectiveness of this design, set the parameters of the hardware and software development environment designed in the test, and Table 1 shows the parameters of the experimental environment. Basic hardware design, combined with VR technology to complete the overall construction of the test platform. The VR hardware equipment used during this test contains modeling equipment, 3D visual display equipment, sound equipment and human-computer interaction equipment.

Table 1 Experimental environment parameters

Serial number	Parameter	Detailed information
1	Operating System	Windows 10
2	Database	SQL Server 2016
3	Operating Environment	NET Framework 3.5
4	Web server	IIS 6.0
5	Configuration Management	CVS (Concurrent Version System)
6	Data Planning	PowerDesigner R 9.5
7	3D Presentation Language	VRML 2.0 (Virtual Reality Modeling Language)
8	CPU	Intel
9	Memory /GB	16
10	Cache /GB	4
11	Input Devices	Digital board
12	NIC	Wireless LAN card

In this test, the interaction between the original method and the design method in the text will be tested. On the one hand, the interaction between the original method and the design method in the text will be tested in real time, and on the other hand, the accuracy of the display control of the two methods will be tested. Both tests are for the details of the product display, so in this test, the interaction between the original method and the design method in the text will be tested. On the one hand, the interaction between the original method and the design method in the text is tested in real time, and on the other hand, the display control accuracy of the two methods is tested. Both tests are for the details in the product display, this test is a total of 20 groups, need to display goods as test samples, in order to facilitate the acquisition of test results.

4.2 Interaction real-time test results

The results of the interaction real-time test are shown in Table 2, for the original method, the time consumed by the action is between 27ms and 74ms, which all meet the delay requirements. For the original method, the time consumed is between 27ms and 74ms, which meets the delay requirement. The time consumed by this method is generally lower than that of the original method. In the original method, the longest time consumed is 74ms, while the longest time consumed by this method is 50ms. In several test numbers, the time consumed by this method is significantly reduced, in the art exhibit 1, the original method is 27ms, while this method is 20ms; in the art exhibit 3, the original method is 45ms, while this method is 34ms. The above data shows that the method of this paper is much better in the real-time performance of interaction. The overall performance is better. This shows that in the interactive experience of art museum exhibitions, the method in this paper can provide more rapid and timely response to the audience, reduce the waiting time, and thus significantly improve the interactive experience of the audience.

Table 2 Interactive real-time test results

Art Exhibit Serial No.	Original Method Action Time/Ms	Compliance with delay requirements	Method action time consumed in this paper/ms	Compliance with time delay requirements
1	27	Y	20	Y
2	30	Y	26	Y
3	45	Y	34	Y
4	21	Y	15	Y
5	64	Y	49	Y
6	25	Y	20	Y
7	74	Y	47	Y
8	65	Y	50	Y
9	34	Y	30	Y
10	51	Y	40	Y
11	45	Y	35	Y
12	41	Y	36	Y
13	52	Y	32	Y
14	63	Y	31	Y
15	45	Y	35	Y
16	37	Y	36	Y
17	42	Y	32	Y
18	40	Y	35	Y
19	49	Y	34	Y
20	50	Y	38	Y

4.3 Control accuracy test results

The control accuracy in this test refers to the accuracy of the human-computer interaction of the audience during the exhibition display in the art museum. Table 3 shows the results of the control accuracy test. For each art exhibit, the control accuracy of the original method ranges from 81.07% to 88.49%, while the control accuracy of the method in this paper ranges from 99.54% to 99.78%. The control accuracy of the original method is relatively low and the values fluctuate greatly. The control accuracy of the original method for Art Exhibit 13 is only 82.08%, while that of the original method for Art Exhibit 3 reaches 88.43%. In contrast, the control accuracy of the method in this paper is excellent and stable. No matter which art exhibit, its control accuracy is above 99.5%. This fully demonstrates that the method in this paper is significantly better than the original method in controlling the art exhibits, which can provide more accurate and reliable display effects for art museum exhibitions and enhance the viewing experience of the audience.

Table 3 Control accuracy test results

Art Exhibit Serial No.	Original method to control accuracy	The methodology in this paper controls the precision
1	85.36%	99.62%
2	87.39%	99.60%
3	88.43%	99.61%
4	86.16%	99.66%
5	85.20%	99.66%
6	87.37%	99.61%
7	88.25%	99.66%
8	87.42%	99.68%
9	86.46%	99.68%
10	87.16%	99.66%
11	88.49%	99.67%
12	85.14%	99.62%
13	82.08%	99.78%
14	81.07%	99.56%
15	86.41%	99.72%
16	87.43%	99.60%
17	85.20%	99.58%
18	84.20%	99.54%
19	85.30%	99.58%
20	86.45%	99.56%

4.4 Evaluation of Interaction Experience

In order to further assess the optimization effect of multimedia technology in the exhibition design of art museums, the evaluation results of interactive experience are shown in Figure 5. The closer the rating is to the score, the more satisfied the exhibitors are with the interactive experience. The box in the figure shows the evaluation interval between multimedia-based and traditional design, the center axis is the mean value, and the left and right horizontal lines are the maximum and minimum ratings. The rating of multimedia technology is between 3.22-4.64, which indicates that multimedia technology can create personalized and humanized interactive experience, which in turn improves visitors' satisfaction, and creates and retains high-quality clientele for the art museum. The rating of traditional design is between 2.10-2.98, which indicates that the visitor's interactive experience is unsatisfactory or does not meet the expectations, then long will be involved in the subsequent visit, making the exhibitor's experience plummet, and may even lose the customer.

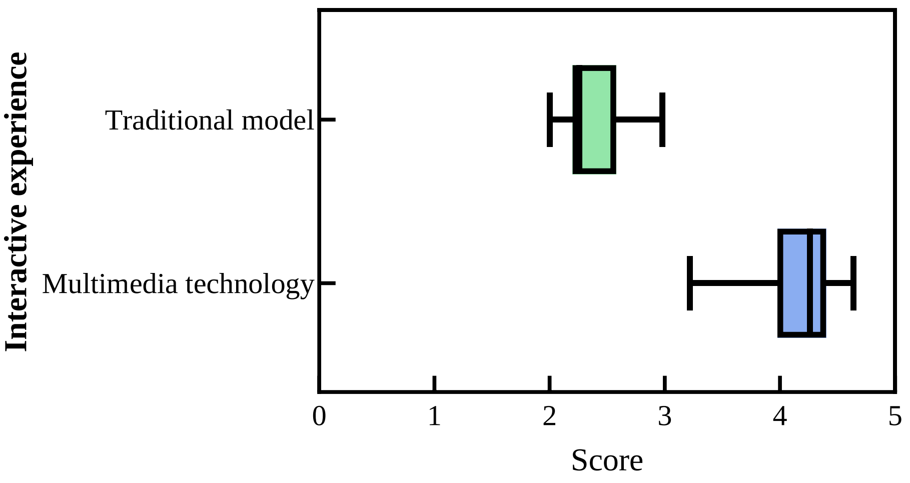

Figure 5 Interactive experience evaluation results

5. CONCLUSION

This paper adopts VR technology in multimedia technology, combined with Unity3D development, to realize the virtual roaming system of the art museum exhibition, and conducts research on the optimization of the interaction experience of multimedia technology in the exhibition design of the art museum. The audience interaction behavior is analyzed by RBM model, and the RBM audience preference perception model is constructed to capture the audience preference characteristics, which provides support for personalized exhibition recommendation and optimizes the interaction experience. The research results show that:

(1) In terms of interactive real-time, the time consumed by the method in this paper is generally lower than that of the original method, with the time consumed by the original method ranging from 27ms to 74ms, and that of the method in this paper ranging from 15ms to 50ms, which can provide the audience with a more rapid and timely response and enhance the interactive experience.

(2) In terms of control accuracy, the control accuracy of the original method fluctuates between 81.07% and 88.49%. The control accuracy of the method in this paper is between 99.54% and 99.78%, which is excellent and stable, and can provide more accurate and reliable display effect for the exhibition in the art museum.

In summary, the method in this paper has significant advantages in the optimization of interactive experience of multimedia technology in the exhibition design of art museums, which can meet the needs of visitors for art appreciation and knowledge acquisition, and shape a new multi-dimensional perception scene for the public.

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