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Research Article

Interactive Design of Museum Display Space Based on Virtual and Reality Technology

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Virtual reality technology has brought new vitality to the display of museum exhibits. With the vigorous development of virtual reality technology, the application of virtual reality technology is becoming more and more frequent. Now, the application of virtual reality technology can be seen in many museums. This paper is aimed at using virtual reality technology to study the exhibition space and interaction design of museums. This paper proposes a virtual space display technology based on the octahedral projection method and hemisphere projection method and investigates and analyzes the application of virtual reality technology. Although the realism of the virtual display is not as good as that of the traditional display, it can be improved in terms of technology and other aspects in the future.

1. Introduction

The history of virtual reality technology is short; with the birth of the computer, it was only widely concerned in the 1980s. However, it is still at a relatively early stage, with poor computer processing power and high costs. At that time, it was impossible to enter the life of the public, and there were few examples of its application in art. Virtual reality technology is also known as the next technological change to change human vision and cognition. This is a revolutionary technology that will affect the way we transmit information, receive knowledge, and think in the future. Based on this new technology, the expression is extended and becomes more free and flexible.

Due to the rapid development of the times, in addition to undertaking the basic mission of acquiring, storing, and promoting collections, museums also need to effectively establish and spread civilization. On the basis of deepening its educational functions, it also pays attention to its interactivity and entertainment. This allows the audience to use their hands and brains together during the exhibition, stimulate their perception of language, and lay the foundation for effective access to information. Because of the rapid growth of science and technology, the speed of information transmission has increased rapidly, and the changes in communication carriers have also brought new ones. As a result, the form of information dissemination also shows an unprecedented diversification trend. With the rapid improvement of the economic level and the abundance of material existence, people began to pay attention to the improvement of spiritual and ideological aspects. People's need for access to information and culture has become increasingly urgent, driving the emergence of a large number of new industries. As a place for civilized education, museums have also begun to actively explore the growth path of the new era. Under the influence of subjective and objective reasons, the optimization appeal of exhibition expression is stronger. Under this influence, the museum's display ideas and methods of information transmission are also extremely different, and the main body of the museum has changed from exhibits to audiences. As for the interactive design expression language that came into being, it is more integrated into the museum exhibition design. Thanks to the development of the times and the advancement of science and technology, museums can apply many theoretical and technical achievements. It adapts to the needs of the audience in a more diverse manner. It completes the communication between the subject and the object during the exhibition process by upgrading the display mode and enhances the display effect of the museum. Therefore, it is necessary to study the interaction design of museum display space based on virtual and reality technology.

For the research on museum exhibition space, this paper mainly has the following two innovations: (1) For the display rules of virtual and reality technology, the projection method is improved in this paper, and improvements are made based on the eight-sided projection method and the spherical projection method. This makes the audience interaction more realistic when performing 3D projection. (2) It designed a questionnaire for the application of virtual and reality technology in museum exhibition space. It is divided into four aspects: sensory, interactive, emotional, and cognitive experience of the audience. This paper fully reflects whether the application of virtual reality technology in museum display is recognized by the audience through such an investigation.

2. Related Work

At present, there are not many relevant literatures on the study of virtual reality museum displays. Most of them generally introduce the development situation of virtual reality and future art and put forward some ideas. Maples-Keller et al. believed that virtual reality allows the delivery of sensory stimuli to be controlled by the therapist and is a convenient and economical treatment method. Their study focused on the existing literature on the effectiveness of incorporating virtual reality into the treatment of various psychiatric disorders, with a particular focus on exposure-based interventions for anxiety disorders [1]. Mai et al. explored the effect of somatosensory interaction technology combined with virtual reality technology on upper limb function and activities of daily living in patients with cerebrovascular disease. They selected 80 patients with cerebrovascular disease who were admitted from January 2019 to December 2019 and were randomly divided into the control group (40 cases) and the observation group (40 cases). The control group received conventional rehabilitation therapy for 40 minutes a day. The observation group received conventional rehabilitation therapy and virtual reality technology for 20 minutes a day. Their experimental results show that the somatosensory interaction technology combined with virtual reality technology is beneficial to improve the upper limb function and daily living ability of patients with cerebrovascular disease [2]. Hyun et al. believed that EEG plays an increasingly important role in the development of brain-computer interface (BCI) technology. Through their experiments, they observed statistically significant changes in event-related potentials. The results of these few related studies are considered meaningful basic statistics in medicine [3]. Hughes et al. argued that although virtual reality technology has been used as a tool to address health issues in older adults, it is underrepresented. Therefore, they made an exploration in this area and introduced the application of the currently known virtual reality technology in the elderly group [4]. Liang et al. believed that the rapid development of computer technology pointed out a new direction for the protection and cultural inheritance of traditional villages. Virtual reality technology plays an important role in reconstructing ancient buildings and perceiving the cultural connotation of buildings. They conducted research on value identification and traditional village protection [5]. Min et al. explored the challenges and strategies for promoting Korean culture through museum exhibitions in the United States. Through research, they believed that the results of this research will play a role in promoting culture [6]. Luo et al. proposed an energy-efficient local ventilation system. Their experimental results demonstrate that local ventilation systems provide an energy-saving strategy for environmental control in funeral pits. This system can be used to control the local preservation environment of burial pits separated from large space exhibition halls [7]. In general, research on virtual reality technology mainly focuses on its application, and there are not many articles displayed in cemetery museums.

3. Virtual Reality Technology and Museum Space Display

3.1. The Concept of Virtual Reality Technology. Virtual reality technology is currently divided into narrow and broad senses. In a narrow sense, it means "virtual reality is a high-end human-machine interface. It includes real-time simulation and real-time interaction through multiple sensory channels including sight, hearing, touch, smell, and taste." In a broad sense, it refers to the "simulation of both virtual imagination (three-dimensional visualization) or the real three-dimensional world." In short, the narrow sense is more complex and more real. In terms of feeling, it seeks to achieve a real sense of existence, and it can be simulated visually [8, 9]. The emphasis in this paper is in a narrow sense, for example, by simulating a real 3D vision in a real environment. It can also see the action feedback of the hand in the window, giving people an immersive and real experience. Virtual reality is also divided into two categories: VR (virtual reality) and AR (augmented reality). AR is developed on the basis of VR. The two concepts are similar, but also easy to confuse. Although both are virtual reality devices, they are based on different core concepts. VR is an immersive virtual experience, completely shielded from the external environment. AR is half of the reality and generally virtual, which constitutes the difference in use between the two.

3.2. 3I+M Features of Virtual Reality Technology. The characteristics of virtual reality technology represent the advantages of virtual reality technology, and understanding its characteristics will help us to sort out the influence with sculpture [10, 11]. Some scholars put forward a triangle of virtual reality technology in their research in 1983. As for the representation of virtual reality technology, it has the following three prominent characteristics: immersion

(Immersion), interactivity (Interactivity), and imagination (Imagination). These three points are extremely important and are also known as the 3I characteristics. In addition to the 3I characteristics, contemporary researchers believe that virtual reality technology also has MultiPerceives, which is now collectively referred to as 3I+M. This mutual support and assistance constitute a complete virtual reality experience, which completely immerses people's bodies and minds [12, 13].

3.2.1. Immersion. Immersion is the feeling that virtual reality technology simulates the real environment through algorithms on human auditory, visual, and tactile organs. It allows the experiencer to have an immersive reproduction feeling. The current VR virtual devices are still based on devices such as head-mounted display devices and data clothing. But its on-the-spot effect is already very realistic. Future nanobrain interface technology or the development of future VR virtual reality equipment may make virtual equipment invisible to the experiencer. It achieves natural interaction and does not require a large number of devices such as data clothes. The device accepts your every movement and stillness and provides real-time feedback, so that it is difficult to tell the difference between the virtual and the real.

3.2.2. Interactivity. Interactivity is the linkage between us and the environment in the virtual world. It captures the movements of the experiencer through sensors, and the virtual reality world also changes, achieving the same illusion as the real world. This is based on the latest developments in human-computer interaction. The early stages of human-computer interaction are divided into four stages. The first is the early batch approach. It is operated through the control panel through the interaction of punched paper with the computer. Early typewriters connected to the keyboard were relatively simple interactions. Secondly, in computers and general programming languages, it makes a computer execute a specific program through specific program code. Thirdly, the graphical user interface, in order to facilitate memory and processing, mouse, keyboard, and screen came into being. It realizes human-computer interaction through the screen manipulation image interface. This is also a common way of interaction in modern times. For example, today's Windows computer operating system is representative of the graphical user interface interaction.

3.2.3. Conceptual. Conceptuality is also called fantasy and creativity. It means that virtual reality technology can bring huge imagination space and develop people's imagination ability, because a lot of information in the virtual environment can be simulated by computer. In the virtual world, it can do things that are impossible in the real world through commands. This in turn changes the perception of the world, thereby expanding the imagination and creating a more creative world. Immersion, interaction, and conception together constitute the great potential of virtual reality.

3.2.4. Multisensory. Multisensitivity refers to the breadth and depth of sensory channels and information obtained by virtual reality systems. These sensations are achieved through a variety of highly sensitive and high-precision sensors, simulating the sense of substitution in the virtual world as in reality. In addition to simulating feelings in the real dimension, these sensors can also give virtual objects a "life force." It provides a more diverse and richer sensory experience than reality. For example, in the real world, sculpture works are often static, and dynamic sculpture can only simply repeat the actions under certain programs. But with the implantation of sensors and the blessing of AI, the sculpture can also interact with the viewer similar to that between people.

3.3. System Types of Virtual Reality Technology. There are many classification standards for virtual reality systems. One of the most commonly used classification methods is the classification method according to both the immersion system and the user scale. It is roughly divided into desktop virtual reality systems, immersive virtual reality systems, augmented reality or mixed reality systems, and distributed virtual reality systems. However, according to the presentation method, it is currently only divided into two types: VR and AR. Its development in the field of artistic creation is also based on these two [14].

3.3.1. Immersive Virtual Reality System. Immersive virtual reality systems are one of the most familiar and complete interactive experiences. It allows the experiencer to have a sense of immersion fully integrated into the virtual space. It is further divided into helmet display, cave automatic environment, projection VR, and remote virtual reproduction [15, 16]. (1) The helmet display is to make the participants highly simulate the real feeling in the virtual reality experience through the corresponding virtual reality helmet, positioning equipment, and sensing equipment. The virtual device produced by Oculus in Figure 1 can be operated in a virtual space by packing two sensors, and it can be seen with a special head-mounted display. (2) The cave is an automatic virtual environment. The cubic projection space composed of several screens can accommodate about 10 people. With LCD stereo glasses, the operator will lead the observer to experience in the virtual world. (3) The projection immersion system captures the experiencer through the camera and treats the experiencer as part of the virtual environment. The experiencer can control their own perspective to participate in the virtual environment through the device. Projection-style immersion may not be so strong, but the equipment is simple and can be shared by multiple people. (4) The remote virtual reproduction system is to quickly integrate the remote real environment into a realistic virtual environment through the computer through high-speed cameras and a high-speed network and then transmit it to the experiencer. The experiencer can control the camera platform in the remote environment by manipulating the device to obtain the real-time scene and perspective, so as to obtain a sense of presence.

3.3.2. Desktop Virtual Reality System. Desktop virtual reality is also called a simple virtual reality system. It controls the window of the display through computer operation to

Figure 1: Display of some virtual reality equipment.

achieve 360-degree observation of the virtual environment, as shown in Figure 2. If people wear stereoscopic glasses, they can experience a strong sense of immersion, and the operation is similar to traditional computer operation. It requires low equipment and is a good choice for operators to develop simple virtual technologies, such as desktop virtual reality systems such as QuickVR, virtualRealityModelingLanguage, and VRML.

3.3.3. Augmented Virtual Reality System. Augmented virtual reality systems superimpose virtual objects in the real world. In addition to reducing the computing power and equipment required by the computer, it can also be combined with the real world. It achieves an experience that is both true and false and integrates with the real world. It combines the advantages of immersive and desktop virtual systems to a certain extent. In the program "The Strongest Brain" on March 10, 2017, it allowed players to see floating text fragments over the stage through MR glasses and operate as needed. This is not possible with entity props. This is a large-scale stage-enhanced virtual system developed and designed by NetDragon Network Company in Fujian [17, 18].

3.3.4. Distributed Virtual Reality System. The rapid development of 5G technology and the speed of data transmission have promoted the development of the synchronous information industry. High-speed transmission speed brings lower latency. Distributed virtual reality system is developed from the combination of virtual technology and information technology. In general virtual reality systems, fixed locations or high-performance equipment conditions are often required. However, in the highly developed stage of communication technology, virtual devices are only used as sensing devices for information reception and action. The super-powerful cloud computer in the remote process processes the received data into graphics and transmits it to the virtual side. This reduces the structure and weight of virtual end devices and integrates data from multiple users together. In this way, each user can interact with each other and experience together. Its simulation system structure is shown in Figure 3.

3.4. Enhanced Display Effect of Virtual Reality Technology on Exhibits

3.4.1. Enhancing the Expressiveness of the Exhibits. VR technology has the form of 3D modeling, through 3D images, texture shaping, and so on. It can be seen in the early stage of design that the effect of the shape will be presented. And some other special effects functions in virtual technology, such as lighting, environment, crowd, building, weather, and other simulation effects, can enhance the effect expression of exhibits placed in the environment. It expands from traditional offline two-dimensional shaping and three-dimensional shaping to multidimensional shaping. Virtual technology can further improve the performance of exhibits, make the exhibits more lively, and better meet the needs of the public. In the design process, the designer can pay attention to the expression of the artistic power of the work at any time and express the imagination space of artistic thinking more [19, 20].

As shown in Figure 4, the Lyon Light Festival in France is the third largest light festival in the world. Every year, the lighting design is very design effect. In the city's public buildings, designers compete, constantly innovating and designing unique lighting effects. They incorporate computer virtual reality technology into their creative process by developing their own software. As designers of exhibitions and visuals, they add a lot of visual elements to their designs. The work in Figure 4 is the application of laser technology, 3D special effects, and sound and light effects in the current virtual reality technology to the design of the work, which changes the appearance of traditional lantern art. Its lighting works presented by virtual reality technology make the flat and still buildings become smart. It is coupled with the effects of light and sound, which greatly enhances the expressiveness of the exhibits. This brings a shocking and extreme experience to the audience.

3.4.2. Increasing the Interaction between the Exhibits and the Public. Different from the real space, the content and setting of the space can be freely developed by the creator, rather than a dead theme as traditionally prescribed. The expressions and related spatial elements in the space can be modified and shaped. Artists create various required elements in the virtual space through the settings of the software. They superimposed different angles and special effects and immediately changed the presentation of the work from two-dimensional to three-dimensional and multidimensional. It

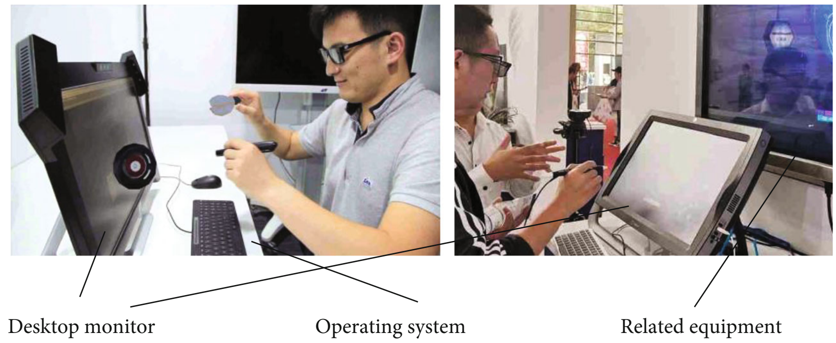

Figure 2: Desktop virtual reality system.

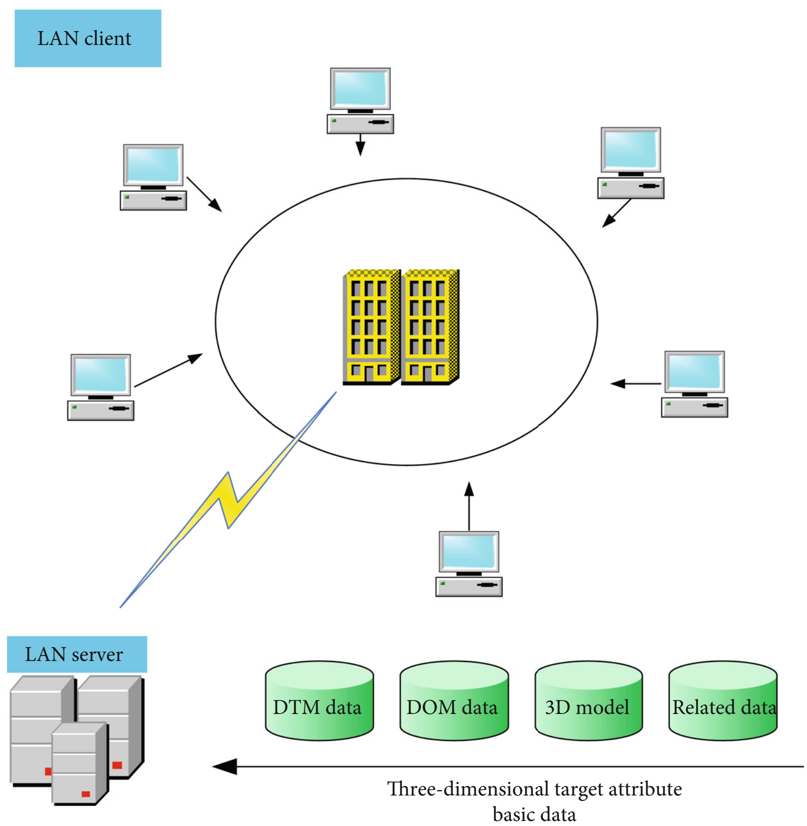

Figure 3: Distributed coordination virtual simulation system.

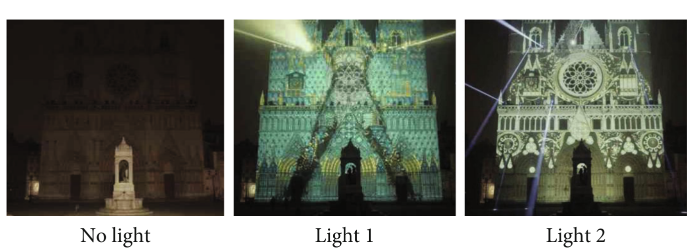

Figure 4: The Festival of Lights.

transforms the static display of the work into a dynamic effect and pulls the distant view to a close observation, which can form different viewing effects. Moreover, the creation basis of all this is more convenient and easier than real creation. And based on the convenience of the Internet, the creation and sharing of works can also be synchronized in real time. It can better meet the psychological characteristics of the public and strengthen the interaction between the works and the audience.

In terms of visual perception, virtual reality technology can also allow the audience to obtain a better visual experience. There are various interaction methods under virtual reality technology. It can interact through various sensing methods such as touch, smell, and hearing. It can also interact with this through body movements such as motion or gesture tracking. And it can also realize interaction according to the thinking direction feedback and so on. Different interaction methods can give the audience a different experience. The application of this technology in the process of exhibit design enables the audience to obtain these perceptions and feelings that they have never had before. It creates the corresponding sensory experience deep in human memory and accumulated experience in the real space, which is more intuitive, as shown in Figure 5.

3.4.3. Expanding the Dissemination of Exhibits and the Public. During the display of exhibits, digital virtual reality technology continues to provide a new expression language for exhibits. It greatly expands the traditional visual image perception of the exhibits and promotes the public's understanding and thinking of the exhibits. Virtual reality technology transforms the past monotonous appreciation or text interpretation into an immersive exploration of the audience in a virtual space environment, and the appeal of the artwork is enhanced. The cultural connotation behind it is also perceived and recognized in such a dynamic three-dimensional system. A thousand readers are a thousand Hamlet, and the deeper meaning behind the work is also enriched and expanded by the different interpretations of the public. In this way, the original creative purpose and expected effect of the exhibits can be demonstrated. As a cultural communication medium in public space, exhibits have greatly increased their communication power with the support of virtual reality technology.

4. VR Museum Display Space Projection Algorithm

4.1. Octahedron Projection Method. The octahedron projection method is also a kind of spherical video projection method, which belongs to the geometry projection. Existing optimal layout methods for octahedral projection still cannot guarantee good continuity between geometric patches. To improve the continuity of planar video after projection, this chapter proposes a new layout method called continuous octahedral projection.

Then the two-dimensional coordinates (u, v) and three-dimensional coordinates (X, Y, Z) of each point on the triangular surface can be calculated with the help of the information of the surface in the three-dimensional space. As shown in Figure 6, the coordinates of the three vertices of the equilateral triangle are known, and the upper left vertex of the circumscribed rectangle is identified by Q. $\vec{q}_0$ is the basis vector of the horizontal side where the Q point is located, 2 is the basis vector of the vertical side where the Q point is located, and point O is the origin of the three-dimensional space coordinate. Then it (that is, the coordinates of the point Q) can be calculated by formula (1):

$$\overrightarrow{OQ} = \overrightarrow{OV}_i + \frac{\overrightarrow{OV}_j - \overrightarrow{OV}_k}{2}. \quad (1)$$

The basis vector can be calculated by formulas (2) and (3):

$$\vec{q}_0 = \frac{\overrightarrow{V_j V_k}}{\left\|\overrightarrow{V_j V_k}\right\|} = \frac{\overrightarrow{OV}_k - \overrightarrow{OV}_j}{\left\|\overrightarrow{OV}_k - \overrightarrow{OV}_j\right\|}, \quad (2)$$

$$\vec{q}_1 = \frac{\overrightarrow{V_j V_k} + \overrightarrow{V_i V_k}}{\left\|\overrightarrow{V_i V_j}\right\| + \left\|\overrightarrow{V_i V_k}\right\|} = \frac{\left(\overrightarrow{OV}_j - \overrightarrow{OV}_i\right) + \left(\overrightarrow{OV}_k - \overrightarrow{OV}_i\right)}{\left\|\left(\overrightarrow{OV}_j - \overrightarrow{OV}_i\right) + \left(\overrightarrow{OV}_k - \overrightarrow{OV}_i\right)\right\|}. \quad (3)$$

Then, the normal vector $\vec{n}$ of the surface can be calculated from two basis vectors, as shown in formula (4):

$$\vec{n} = \frac{\vec{q}_0 \times \vec{q}_1}{\left\|\vec{q}_0 \times \vec{q}_1\right\|}. \quad (4)$$

It uses P' to represent a point on one face of the octahedron. Based on the above data, the conversion between its two-dimensional (u, v) and three-dimensional coordinates (X, Y, Z) can be carried out smoothly. Specifically, for the conversion from a point in a two-dimensional plane to a point in three-dimensional space, it can be calculated by formula (5):

$$\overrightarrow{OP'} = \overrightarrow{OQ} + \overrightarrow{QP'}. \quad (5)$$

It uses (X_Q, Y_Q, Z_Q) to represent the coordinates of the Q point and $(\overrightarrow{V_X}, \overrightarrow{V_Y}, \overrightarrow{V_Z})$ to represent the X, Y, and Z values of vector $\vec{V}$. Therefore, the coordinate values X, Y, and Z of point P (i.e., $\overrightarrow{0p}$) can be calculated by formulas (6)–(8):

$$X = X_Q + \left(\mu \times \vec{q}_0\right)_X + \left(\nu \times \vec{q}_0\right)_X, \quad (6)$$

$$Y = Y_Q + \left(\mu \times \vec{q}_0\right)_Y + \left(\nu \times \vec{q}_0\right)_Y, \quad (7)$$

$$Z = Z_Q + \left(\mu \times \vec{q}_0\right)_Z + \left(\nu \times \vec{q}_0\right)_Z. \quad (8)$$

For the conversion from a point in the three-dimensional space to a point in the two-dimensional space, the point $P(X, Y, Z)$ on the sphere is firstly obtained from the point P' which is mapped to the geometry. It then converts its two-dimensional coordinates from the three-dimensional coordinates of the point P'. It first uses the following formula to determine the index of the patch to which

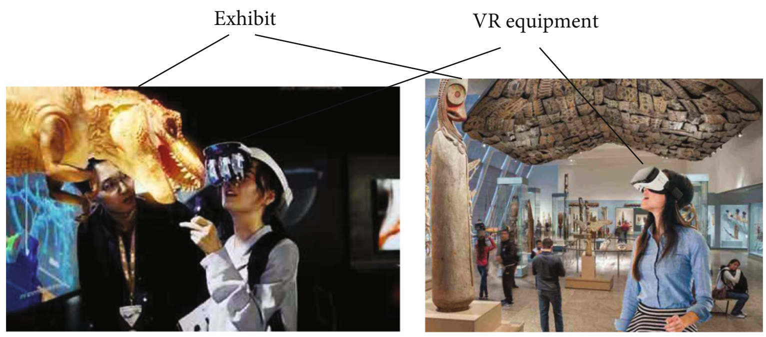

Figure 5: Museum virtual reality interactive display.

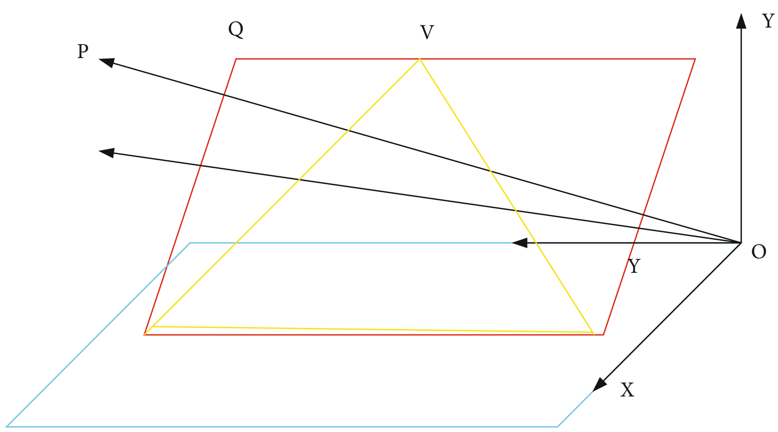

Figure 6: Coordinate definition of triangular faces in the octahedron.

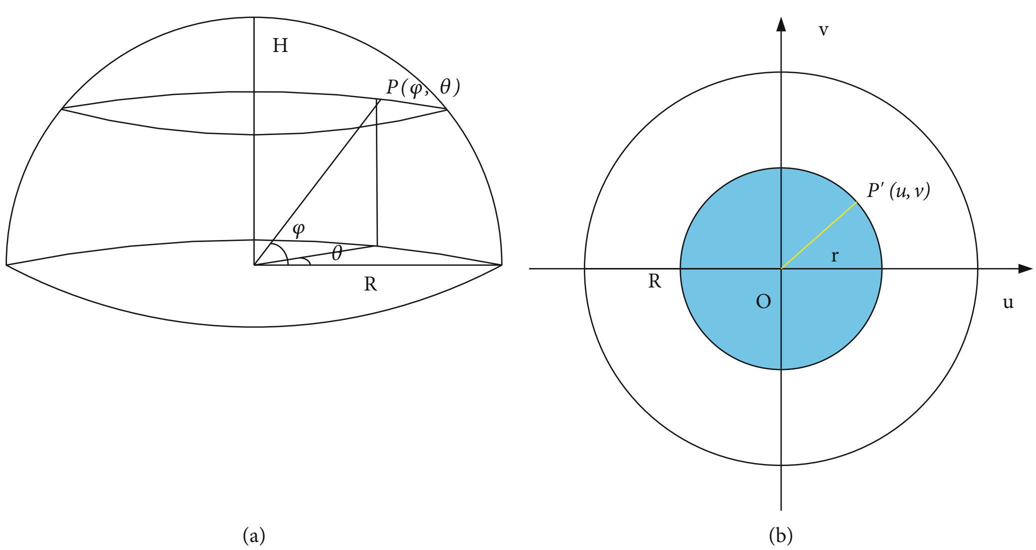

Figure 7: Schematic diagram of the hemispherical area-reserved area mapping to a plane circle.

the point P' belongs on the geometry, as shown in formula (9):

$$f = \arg\max\left(\overrightarrow{OP} \times \vec{n}_i\right), i = [0, 7]. \quad (9)$$

Among them, the argmax$(f(i))$ function represents the value of the variable i corresponding to the maximum value of $f(i)$. Then, the projection point P' is on the surface f, and its three-dimensional coordinates can be obtained from the similar triangle theorem to formula (10):

$$\overrightarrow{OP'} = \frac{\overrightarrow{OQ} \times \vec{n}_f}{\overrightarrow{OP'} \times \vec{n}_f} \times \overrightarrow{OP}. \quad (10)$$

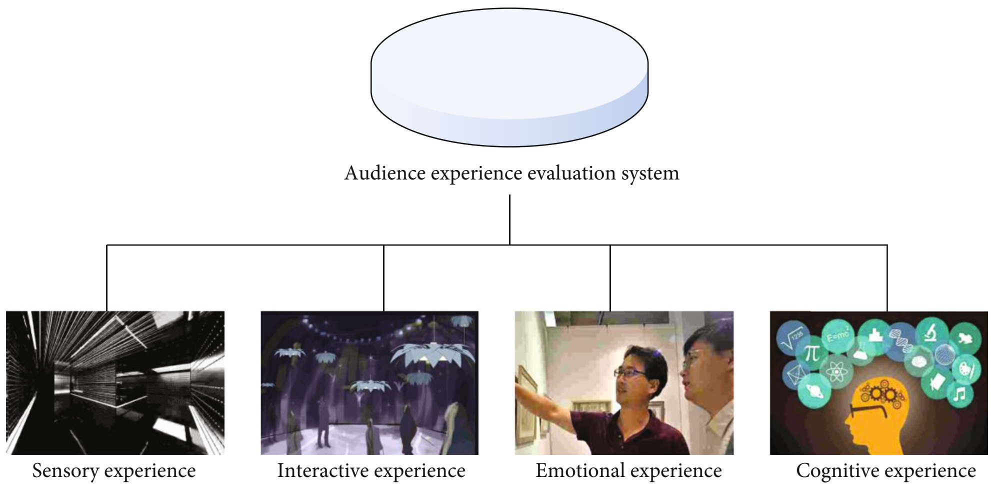

Figure 8: Elements of audience experience evaluation indicators.

Table 1: Composition of the assessment questionnaire.

Audience evaluation system	Subject	Very different	Disagree	Unclear	Agree	Very much agree
Sensory experience	The display of exhibits has a strong sense of hierarchy.	1	2	3	4	5
	The visual effect of the display makes people feel very comfortable.	1	2	3	4	5
	The information transmission of exhibits is intuitive and clear.	1	2	3	4	5
	The spatial layout of exhibits is reasonable.	1	2	3	4	5
	The exhibits and the environment are very real.	1	2	3	4	5
Interactive experience	The interaction between exhibits and the environment can present exhibits well.	1	2	3	4	5
	The interaction of signage information on exhibits here is very rich.	1	2	3	4	5
	The interaction between audience and exhibits is very strong.	1	2	3	4	5
Emotional experience	This kind of exhibits has a strong feeling of being on the spot.	1	2	3	4	5
	This kind of display form is easy to satisfy people.	1	2	3	4	5
	This kind of display form makes you happy to learn the costume culture.	1	2	3	4	5
	The environment where such exhibits are located makes people feel very vivid.	1	2	3	4	5
Cognitive experience	There are scenes in the process of obtaining exhibit information.	1	2	3	4	5
	Exhibits can transmit a large amount of exhibit information.	1	2	3	4	5
	The environmental layout here is helpful for the in-depth understanding of exhibits.	1	2	3	4	5

Table 2: Reliability analysis table of the questionnaire.

Dimension	Cronbach's alpha	Number of entry
Total table	0.965	15
Sensory experience	0.849	5
Interactive experience	0.847	3
Emotional experience	0.955	4
Cognitive experience	0.926	3

So the two-dimensional coordinates (u, v) can be calculated by the projection of vector $\overrightarrow{QP}'$ on the basis vector, such as formulas (11) and (12):

$$u = \left(\overrightarrow{OP'} - \overrightarrow{OQ} \right) \times \vec{q}_0, \quad (11)$$

$$v = \left(\overrightarrow{OP'} - \overrightarrow{OQ} \right) \times \vec{q}_1. \quad (12)$$

Table 3: Path coefficient table between latent variables.

Subject	Coefficient of regression	Standard error	t	P
Sensory experience	0.861	0.071	11 355	***
Interactive experience	0.98	0.073	11.129	***
Emotional experience	0.997	0.063	16.385	***
Cognitive experience	0.981			

4.2. Preserving Area Uniform Projection Method. As shown in Figure 7, projecting a panoramic video into a flat video format is to project the upper and lower hemispherical surfaces of the unit sphere into two flat circles, respectively. This is for the northern hemisphere as an example, as shown in Figure 7. The ratio of the surface area of the hemisphere S_{hemi} to the area of the plane circle S_{disk} is formula (13):

$$\frac{S_{hemi}}{S_{disk}} = \frac{2\pi R^2}{\pi R^2} = 2. \tag{13}$$

This sets the area of the gray spherical cap on the hemisphere to be S_1 and the height to be H. The area of the small gray circular area inside the corresponding plane circle after its projection is S_2, and its radius is r. The surface area formula of the spherical crown is $s=^{2\pi RH}$; then

$$\frac{S_1}{S_2} = \frac{2\pi RH}{\pi r^2} = \frac{2\pi R \times (R - R \sin \phi)}{\pi r^2} = \frac{2R^2 \times (1 - \sin \phi)}{r^2}. \tag{14}$$

Considering the area-preserving projection from the hemisphere to the plane circle, according to the area-preserving mapping property, the ratio of the area of any area on the sphere to the area of the corresponding area after being mapped to the plane circle is guaranteed to be constant. Therefore, according to formula (13), the ratio of area S_1 to S_2 can be obtained as 2; then formula (15) can be obtained by combining formula (14):

$$\frac{S_1}{S_2} = \frac{2\pi RH}{\pi r^2} = \frac{2R^2 \times (1 - \sin \phi)}{r^2} = 2. \tag{15}$$

The square of the radius of the small circle after projection is $r^2 = u^2 + v^2$. If $R = 1$, the corresponding point $P'(u, v)$ on the plane can be obtained according to formula (15), as shown in formula (16):

$$\phi = \arcsin\left(1 - \left(u^2 + v^2\right)\right). \tag{16}$$

Longitude uses a simple equiangular uniform mapping. That is, the longitude value θ of any point P on the spherical surface is equal to the angle between OP'; then formula (17) is obtained:

$$\theta = \arctan \frac{v}{u}. \tag{17}$$

The area of the differential unit at any point $P(\phi, \theta)$ on the sphere $d\theta d\varphi$ is shown in formula (18):

$$\delta S(\theta, \phi) = \cos(\phi)|d\theta d\phi|. \tag{18}$$

The area of the differential unit $dudv$ at the corresponding point $P'(u, v)$ is expressed as $dS(u, v) = |dudv|$. The relationship between the two microareas is formula (19):

$$d\theta d\phi = J(u, v)dudv, \tag{19}$$

where $J(u, v)$ represents the Jacobian determinant, which can be derived by combining formulas (18) and (19). Finally, the area stretch ratio of the two differential elements can be calculated as formula (20):

$$SR(u, v) = \frac{\delta S(\theta, \phi)}{\delta S(u, v)} = \cos(\phi)J(u, v). \tag{20}$$

The area ratio $SR(u, v)$ of the differential element of the area-preserving uniform projection method proposed in this paper is 2. That is, the stretch ratio of the differential area projected from the hemisphere to the plane circle is constant, so the projection process is uniform area preserving.

5. Comparison of the Differences between Traditional Display and Virtual Display Experience of Exhibits

5.1. Traditional Display and Virtual Display

5.1.1. Traditional Display. Traditional displays are based on physical museums presenting cultural relics or collections to the audience. Traditional displays are also known as physical displays. It refers to the display and exhibition of collections, based on cultural relics and specimens. It cooperates with appropriate auxiliary exhibits and displays cultural relics in a combination of certain themes, sequences, and art forms.

5.1.2. Virtual Display. The virtual display uses computer technology to simulate the real display environment on the basis of the traditional display to realize the interaction between the audience and exhibits. It is an immersive and realistic virtual museum or exhibition space that is not limited by time and space. Virtual display is a new display form produced and applied along with virtual reality technology, which breaks the closed static display method in the traditional sense. It uses various information technologies to integrate text, graphics, sound, and other information into the virtual display space. This creates an interactive display environment full of artistic appeal and character.

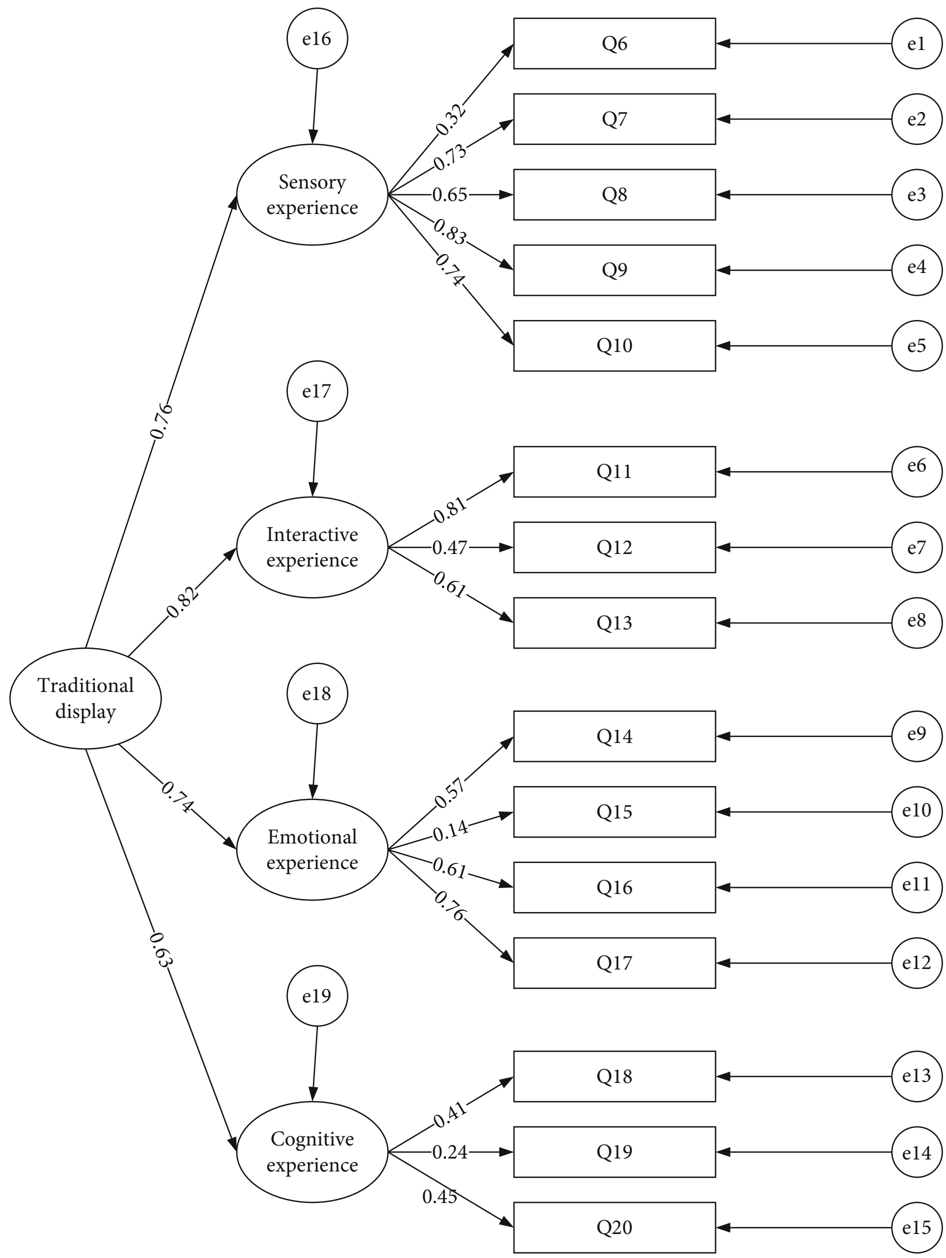

Figure 9: Traditional display path model coefficient diagram.

5.2. Audience Experience Evaluation Indicator System. The 21st century is the era of design that focuses on user experience. User experience is a subjective psychological feeling established by users in the process of using a product or service. As far as the museum display experience is concerned, the user experience is the audience experience. It is a process of perception, interaction, emotion, and cognition between the audience and the exhibits.

The indicators for evaluating the display form of museum clothing are mainly composed of the four basic elements of the audience's senses, interaction, emotion, and cognitive experience, as shown in Figure 8. The details of the questionnaire are shown in Table 1.

5.3. Audience Experience Data Collection. The questionnaire survey mainly involves the following links: setting of questionnaire options, preinvestigation of questionnaires, modification of questionnaire options, distribution of questionnaires, and collection of questionnaires. The measurement table of audience experience in this study mainly includes four dimensions: sensory experience, interactive experience, emotional experience, and cognitive experience. The test items of these questionnaires are mainly obtained through interviews with audiences and field research in museums.

Reliability mainly evaluates the accuracy, stability, and consistency of the scale, that is, the degree of variation of

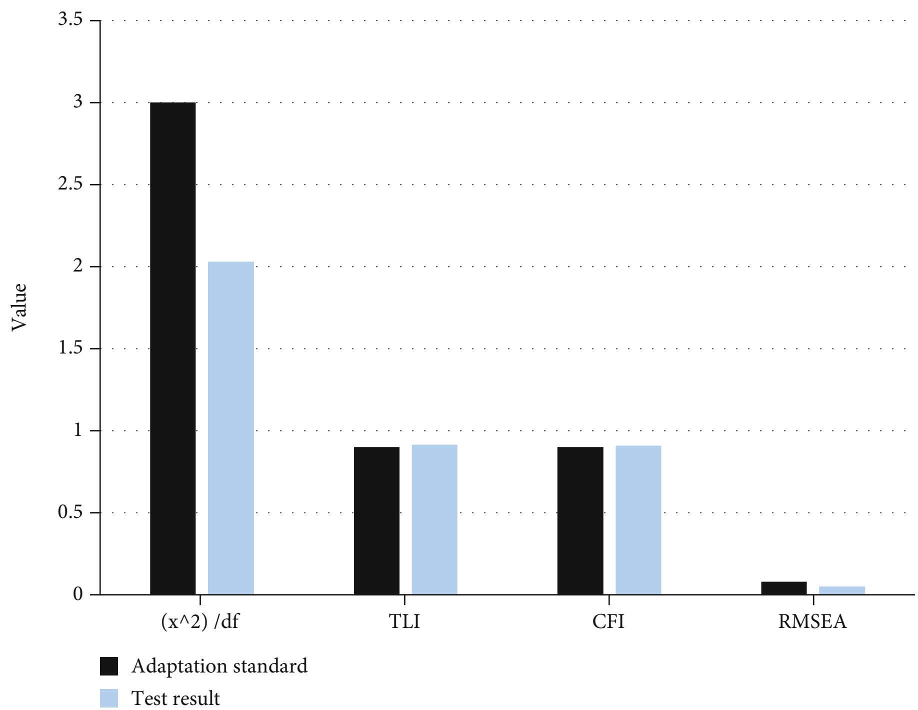

FIGURE 10: Traditional display model fitting results.

TABLE 4: Virtual display model fitting results.

Verification index	$(x^2)/df$	TLI	CFI	RMSEA
Adaptation standard	<3.00	>0.90	>0.90	<0.08
Test result	2.073	0.952	0.961	0.084
Adaptive judgment	Ideal	Ideal	Ideal	Approach

the measured value caused by random errors in the measurement process. Questionnaire reliability means that the survey results reflected are consistent or stable with the actual situation, and it is also an indicator to detect the authenticity of the surveyed object.

In this study, Cronbach's alpha was used to measure the reliability of the data. First, the questionnaire data obtained from the virtual display and the traditional display audience experience are imported into SPSS, and the results are shown in Table 2. The reliability coefficient of the total scale obtained by the operation is 0.965, indicating that the reliability of the questionnaire is very good. The value of Cronbach's alpha for each index is between 0.847 and 0.955. The reliability coefficient of sensory experience is 0.849, the reliability coefficient of interactive experience is 0.847, the reliability coefficient of emotional experience is 0.955, and the reliability coefficient of cognitive experience is 0.926. All of them are greater than 0.8, and the reliability of the data has passed the test.

The path coefficient table between the latent variables can more intuitively draw the conclusion of whether the path coefficient is significant. The path coefficient between the two variables in the test results passed the significance test, indicating that the variables are related. The path coefficients between the latent variables of the audience's experience in the virtual display of the exhibits pass the significance test and the conclusions are shown in Table 3.

5.4. Audience Experience Data Analysis. The structural formula model is referred to as SEM (full name, structural formula modeling). On the basis of the measurement model, the causal relationship between variables is further assumed, so it is a synthesis of the measurement model and the causal model. SEM is a multivariate data quantitative analysis method that integrates path analysis, factor analysis, and other techniques. It has the functions of theoretical verification and factor relationship quantification. It is also a statistical method integrating a conceptual model and mathematical model. It realizes the deep combination of quantitative analysis and qualitative research. The museum visitor experience data analysis is a confirmatory analysis of traditional and virtual displays based on structural formula modeling. It compares the differences between the two types of clothing display forms in detail from the four dimensions of sensory experience, interactive experience, emotional experience, and cognitive experience.

The confirmatory analysis of the audience experience of the traditional display mainly uses the structural formula model to explain the relationship between them from four variables: sensory experience, interactive experience, emotional experience, and interactive experience. As shown in Figure 9, the path coefficients of the total audience experience and the latent variables of the audience experience are as follows: The path coefficient between it and "sensory experience" is 0.76, and the path coefficient between it and "interactive experience" is 0.82. The path coefficient between

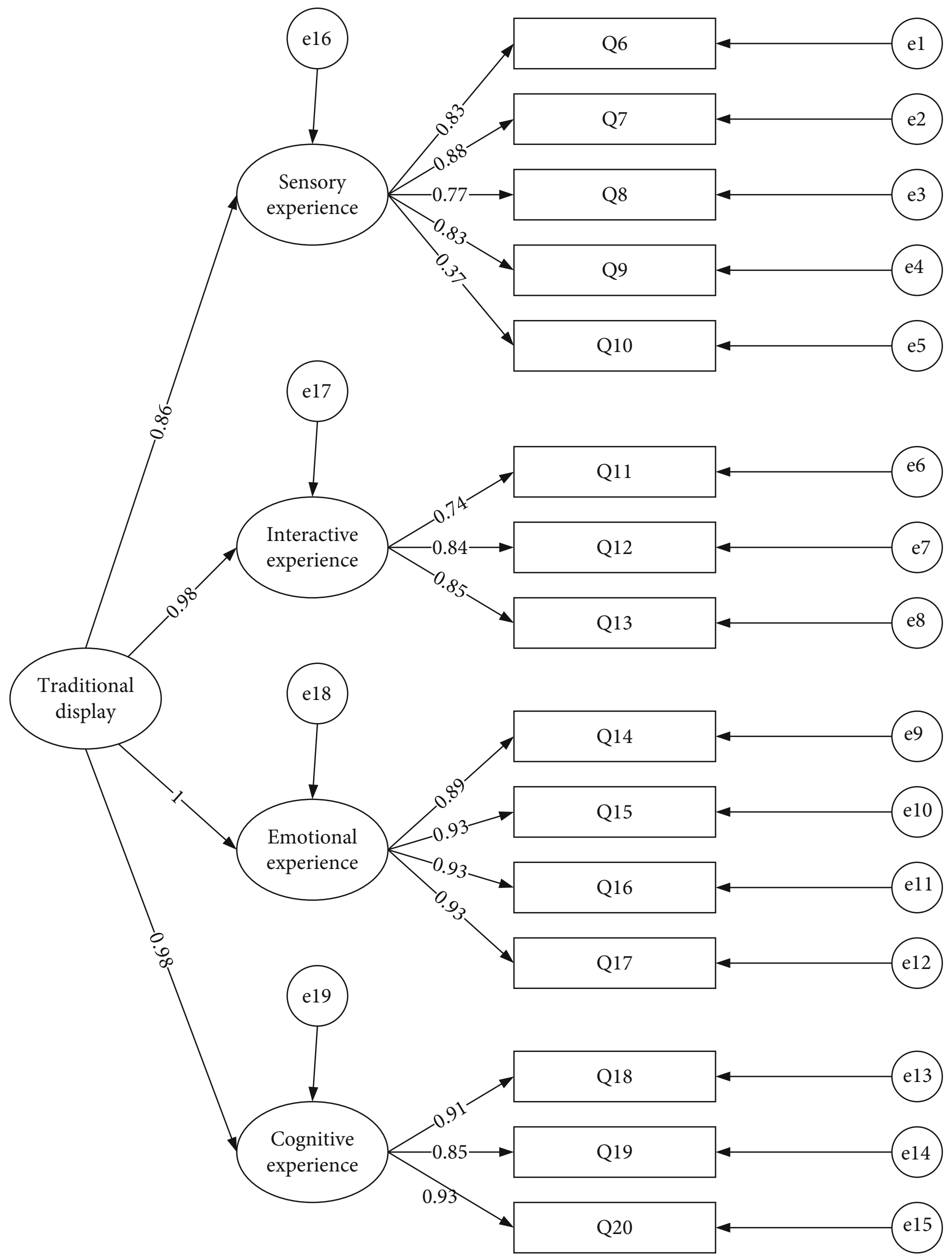

Figure 11: Virtual display path model coefficient diagram.

it and "emotional experience" is 0.74, and the path coefficient between it and "cognitive experience" is 0.63. This shows that the direct relationship between audience experience and audience experience latent variables is mainly as follows: The direct relationship between the audience experience of the traditional display of exhibits and the "interactive experience" is greater than the direct relationship between the other three experiences. (2) The direct relationship between the audience experience of the traditional display of exhibits and the "sensory experience" and the direct relationship with the "emotional experience" are strong and relatively close. (3) The direct relationship between the audience experience and the "cognitive experience" of the traditional display of exhibits is weaker than the other three experiences.

The audience experience of traditional clothing display mainly selects four fitting indices of x^2/df, TLI, CFI, and RMSEA to test the fit of the model. The audience experience of the traditional display shows that the following four indices $x^2/df < 3.00$, TLI > 0.90, CFI > 0.90, and RMSEA < 0.08 are all within the acceptable range in the model fitting results. The fit of the model is ideal and the fitting is good, as shown in Figure 10.

Table 4 shows the results of the model fitting of the audience experience of the virtual display of the exhibits. Table 4 shows that, except for RMSEA, which is close to the ideal value, all other fitting indices are within the acceptable range, and the audience experience model is ideally fitted and well fitted.

The confirmatory analysis of the virtual display under the structural formula model is shown in Figure 11. The path coefficients of the total audience experience and the potential variables of the audience experience are as follows: The path coefficient between it and "sensory experience" is 0.86, and the path coefficient between it and "interactive experience" is 0.98. The path coefficient between it and "emotional experience" is 1, and the path coefficient between it and "cognitive experience" is 0.98. This shows that the direct relationship between audience experience and audience experience latent variables is mainly as follows: (1) The direct relationship between the audience experience and the "emotional experience" of the virtual display of exhibits is the strongest. (2) The direct relationship between the audience experience of virtual display of exhibits and the "cognitive experience" is consistent with the direct relationship with the "interactive experience." (3) The direct relationship between the audience experience and the "sensory experience" of the virtual display of exhibits is the weakest compared with the other three experiences.

To sum up, there are certain differences between the virtual display of exhibits and the traditional display. Although the realism of the virtual display is not as good as that of the traditional display, it can be improved in terms of technology and other aspects in the future. From the overall evaluation point of view, the form of virtual display is more helpful for nonprofessional audiences to appreciate the exhibits. As far as the digitalization trend of museums is concerned, the combination of virtual reality technology and the display of exhibits has enriched the display methods of museums to a certain extent and created a new relationship between exhibits and audiences.

6. Conclusion

VR video is still in the stage of ordinary monocular panoramic video and stereoscopic binocular panoramic video. The third stage can only be achieved by a computer. Panoramic video production is low cost and time-consuming, and having huge video content in a short period of time is its advantage over 3D technology. This paper believes that in terms of the digital trend of museums, the combination of virtual reality technology and exhibits has enriched the display methods of museums. It creates a new relationship between the exhibits and the audience, but the technology in all aspects is not mature, so there are many areas for improvement. With the increase of freedom from panoramic video, the road to the third stage of VR video is even more arduous. Therefore, further research on this situation will be carried out in the follow-up research.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

We confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

Conflicts of Interest

There are no potential competing interests in our paper. And all authors have seen the manuscript and approved the submission of this paper.

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