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Research Article

Application of Virtual Reality Based on Multisensor Data Fusion in Theater Space and Installation Art

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The application of Virtual Reality (VR) in theater space and installation art is the general trend, and it can be seen in large stage plays and installation art exhibitions. However, as the current VR is not mature enough, it is difficult to perfectly fulfill the exhibition requirements of large theaters, so this paper aims to change this situation by using VR based on multisensor data fusion. In this paper, a data fusion algorithm based on multisensors is designed, which improves the data transmission efficiency and delay of the VR system, so that VR can have a better viewing experience in theater space and installation art. And, through the questionnaire survey and actual interview, the actual feelings of VR audience in theater space and installation art are investigated and studied. Through the experimental analysis of this paper, the algorithm in this paper has high reliability and can improve the experience of using VR. The interview results and results show that the main application of VR in theater space is manifested in three aspects: multiangle and all-round viewing, multiroute viewing, and man-machine interaction in art galleries. The application of VR in installation art is mainly reflected in the perception of installation materials.

1. Introduction

All the activities of the theater are "fake," and making fake is really the premise of theater art activities, and this premise is a hypothesis, which exists in every part of theater art. Hypothesis in theater space design is an important feature that distinguishes it from many art forms such as movies, television, painting, etc. It creates an illusion for the space and gives the audience imagination. The assumption in the theater space design is mainly reflected in the coexistence and transformation of "virtual and real" among various elements in the space. Taking the traditional stage space as an example, the framed stage space, with a desk and two chairs and an old-fashioned background, creates a fantasy virtual space through the actors' substantive movements and language, breaking through the limitation of theater space and creating imagination. Compared with the traditional theater space, the design of multimedia theater space has become more flexible and free in space transformation. Many rigid physical props or scenes can be replaced by virtual images, which makes the transformation between visual elements more convenient. At the same time, it can accommodate more art forms, expand the boundaries of theater space design, and enhance the artistic conception expression. The addition of electronic multimedia makes the virtual and real expression of space richer, expands the "assumption" principle of theater, and increases the artistic appeal of theater and the audience's aesthetic interest. With the weakening of the "text" center and the improvement of the status of stage art, the coexistence and transformation between "virtual reality" tend to be diversified in both the form and content of space construction. It gives the audience more initiative to find the points of interest and imagine.

Art has always been the expression of a human's rich spiritual world. Now, the form of art has also changed, and many scholars have studied it. Malone D did research on

virtual reality exhibition of public space in Albanian National Theater [1]. Helena used the blockchain technology to arrange the articles in the exhibition space by referring to the transmission mode of blockchain and achieved good results [2]. Lopez-Aguilar et al. [3] aim to create an interactive space for testing. Its main goal is to react to the emotional state of users in order to modify the environment until it reaches the appropriate stage for users to enter the state [3]. Duarte-Garcia and Wilde [4] discussed the relationship between the art of sound installation and the occupation of public space in Latin American cities [4]. It can be found that VR is applied in many display scenes, and some scholars have optimized its display principle, but there is little research on VR communication optimization.

Because VR needs better interaction through multisensor networks, it needs better algorithms to support data fusion, which is also studied by many scholars. Jiang et al. [5] studied the optimal state estimation of asynchronous multirate multiscale sensors with unreliable measurement and correlated noise [5]. Bouain et al. [6] proposed an embedded design of multi-sensor data fusion (MSDF), which is used for vehicle perception by a stereo camera and LIDAR sensor. A modular and extensible architecture based on Zynq-7000 SoC was designed [6]. Di Rosa et al. [7] compared the data of single mode and fusion method to classify different Sicilian honey varieties. Combining the potential electronic tongue with the computer vision system, a satisfactory recognition rate is achieved [7]. GrohnFeLdt [8] extends the sparse image fusion algorithm to Joint Sparse Image Fusion (JSparseFI) algorithm by making use of the possible signal structure correlation between different multispectral channels [8]. Weidong and Zhenwei [9] proposed a gait phase recognition method based on fuzzy logic [9]. Careful analysis will reveal that most of the research on data fusion focuses on data clustering but lacks the analysis of clustering, fusion, communication, and so on.

For installation art, digital materials can bring more vivid expression to it. 209 samples tend to have the same cognition about digital materials and traditional materials. After analysis, although the influence of nonmaterial factors will be deliberately excluded when selecting material pictures, people's favor for digital materials will be more obvious. This shows that in the exhibition space and installation art, VR can make the exhibits have richer senses through digital materials. It proves that VR has good application prospects in exhibition space and installation art.

2. Modern Theater Space and Installation Art

2.1. VR and Theater Space and Installation Art. Now, digital things such as VR have already been shown in theater space and installation art. As shown on the left, the three-dimensional effect made by the stage play with the lighting curtain makes the audience's senses stronger. As shown in Figure 1, with the help of VR, the materials and emotions of art installations have got different feelings [10].

The application of VR in installation art is mainly reflected in the change of materials. Installation art is a completely different form of artistic expression from traditional paper paintings. Artists will design and create according to the existing exhibition place or exhibition hall structure, forming an artistic whole that is "adapted to local conditions." It requires a relatively independent space, which is generally only for short-term exhibitions. This feature makes every installation art work nonreplicable, so that a certain installation art work can be permanently preserved in a specific spatial layout, as shown in Figure 2.

The application of VR in theater space is biased towards the integration of multimedia and theater space. VR interaction, integration, and symbiosis are the performance themes of multimedia theater space in the post-theater era. Multimedia intervention expands the limited physical area infinitely, making it impossible to distinguish the true from the false, thus enhancing the expression of assumptions. Under the influence of postdrama thoughts and creative ideas, a multimedia vision has become a "performer" on the stage. It depicts the changes of real and virtual bodies, the interaction between abstract symbols and body language, and the audience's participation in the virtual world. Participatory activities eliminate the insurmountable gap between the audience, performers, and the stage and infinitely expand the virtual space Earth [11, 12]. In actual production, we should give up single, rigid and closed forms of expression and adopt immersive, interactive, and diversified forms of expression. It extends the architectural form of the stage through abstraction, deformation, reconstruction, and other methods, using visual metaphor and symbolism, and the interaction and change between music and painting. It connects the audience's senses and pays attention to the audience's live interactive experience and synesthesia, as shown in Figure 3.

2.2. Multisensor Data Fusion Algorithm for Improving VR Transmission Efficiency. Virtual reality technology is a communication technology based on the Internet of Things and wireless communication network. When viewing theater space and appreciating installation art through VR equipment, a bad network will cause the effects of jamming and picture distortion, which will lead to the decline of viewing experience and fail to reach the expected experience of VR in viewing [13, 14]. In this paper, the multisensor data fusion algorithm to improve the efficiency of VR transmission is improved based on network delay and data transmission, which makes the interaction between VR equipment and exhibition hall zero delay and zero stagnation. The best viewing effect is achieved.

In order to improve the reliability of the data fusion process and the accuracy of the fusion results, it will first cluster all the nodes in the sensor network and select the cluster head node. At the same time, each node will be set with an initial weight. Cluster head nodes will distinguish between trusted nodes and abnormal nodes according to the weight and pull the detected abnormal nodes into the blacklist. At the same time, the grey prediction algorithm is used to predict the data loss caused by abnormal nodes. This can ensure that the data fused by cluster head nodes are reliable. Finally, the cluster head node calculates the fusion

Figure 1: Application of VR.

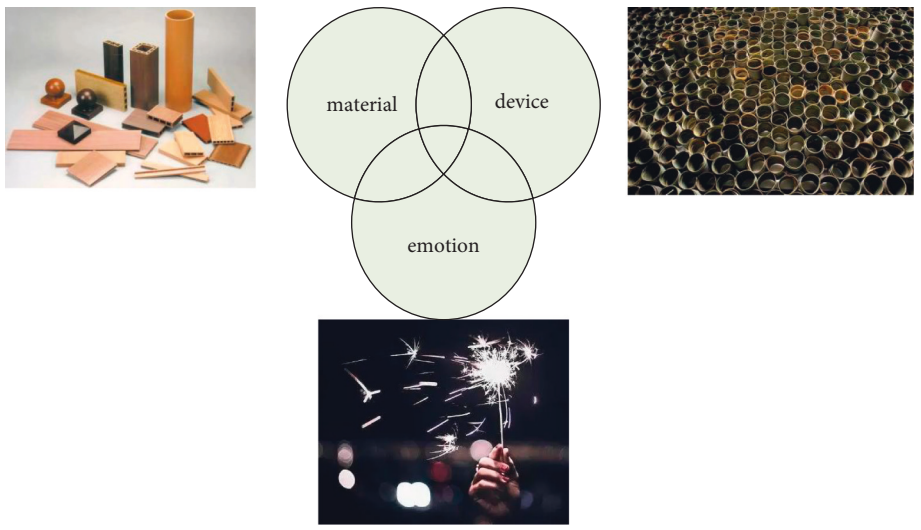

Figure 2: Three components of installation art.

result, broadcasts the fusion result in the cluster, and forwards it to the top base station layer by layer. Ordinary member nodes will compare the fusion results with the historical data collected by themselves, and then update and modify their own weights according to the comparison results. It makes the next prediction result closer to the real situation. The upper base station will synthesize the uploaded fusion results and make corresponding decisions or judgments.

The main energy consumption in WSNs is the operation of sending and receiving data. Kaizeman energy model is adopted in the TGDA fusion algorithm [15]. In this model, firstly, a threshold parameter needs to be set d_0, and d_0 are constants, which depend on the current communication environment and are mainly used to compare with the actual situation. The energy consumption formulas of sender node a is as follows:

$$\begin{aligned} E_s(k,d) &= kE_e + k\mu_{fs}d^2, \quad d < d_0, \\ E_s(k,d) &= kE_e + k\mu_{amp}d^4, \quad d < d_0. \end{aligned} \tag{1}$$

Since the newly deployed nodes will not be attacked or damaged in a short time, all nodes will work t round normally first. Suppose a node is detected as an abnormal node after sending t-round data, then GM (1, 1) grey model will be called to predict the data value at $t+1$ time. Taking the numerical value in a short time as the research object, the accuracy of prediction based on this will be relatively high. Therefore, the $T-N+1 \sim t$ round data of abnormal nodes, that is, the recent n round data, are used to form the original time series. The energy consumption formula of receiver node B is as follows:

$$E_r(k) = kE_e. \tag{2}$$

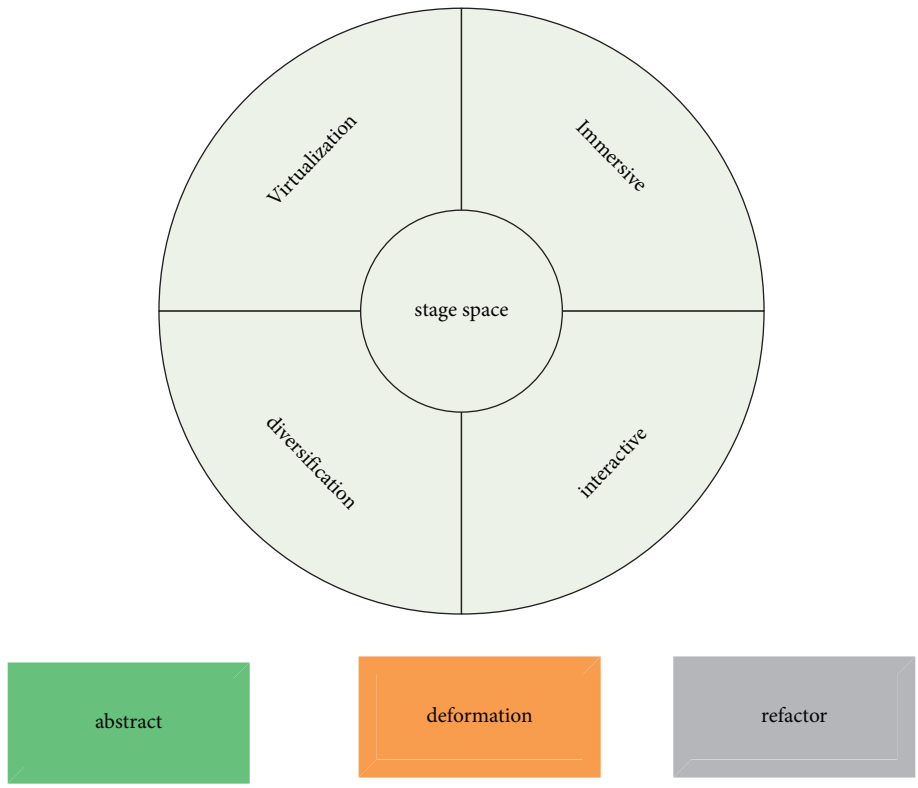

Figure 3: Characteristics of theater space.

Table 1: Psychological effects of hue.

1	Tone	Visual psychological effect
2	Pale tones	Bright, clear, soft, mature, transparent, romantic, cheerful
3	Light tones	Sunny, cheerful, simple, mature, charming, delicate, dreamy
4	Bright tones	Youthful, bright, radiant, gorgeous, cheerful, fit, bright, clear, sweet, fresh, feminine
5	Fresh tones	Brilliant, gorgeous, vivid, active, outgoing, developing, excited, moonlit, stimulating, free, passionate
6	Dark tones	Calm, vivid, noble, capable, profound, antique, traditional
7	Black tones	Steady, resolute, capable, simple, strong, composed, substantial
8	Light grey	Gentle, light, weak, passive, mature
9	Cloudy tones	Hazy, quiet, composed, simple, stable, weak
10	Grey tones	Simple, weak, introverted, passive, mature, plain, reserved

The cluster head node not only detects abnormal nodes but also selects credible data and uses the data predicted by GM (1, 1) grey model to replace the data detected by abnormal nodes. Compared with the lack of data caused by other methods, the data fusion method based on the grey model makes the final data to be analyzed and fused are trusted and safe data, and the results will be closer to the real value. After the data fusion operation is initiated by the cluster head node, the cluster head calculates a fusion result and broadcasts it in the cluster. Common nodes within a cluster comparing the results of the feedback with historical data they collect, and then updating their weights based on the results of the comparison. At the same time, the cluster head will forward the result layer to the top base station, which will judge or analyze the uploaded results. Through the feedback and upload process above, the results of the next fusion can be more accurate [16, 17]. Optimize the communication transmission effect of the final VR.

Table 2: Reference to decorative properties of traditional and digital materials.

Serial	Traditional material	Digital material
1	Color	Diffuse reflection, specular reflection
2	Luster	Specular map
3	Transparency	Transparency parameter
4	Texture	Texture map
5	Refractive index	Fresnel parameter
6	Shape, size	Model

2.3. Application Analysis of VR Theater Space and Installation Art. Application of VR in Theater Space: VR theater space can provide an exhibition experience that is not available in traditional theaters. The transformation from offline physical art galleries to online virtual digital art galleries has brought users not only a convenient location, space, and

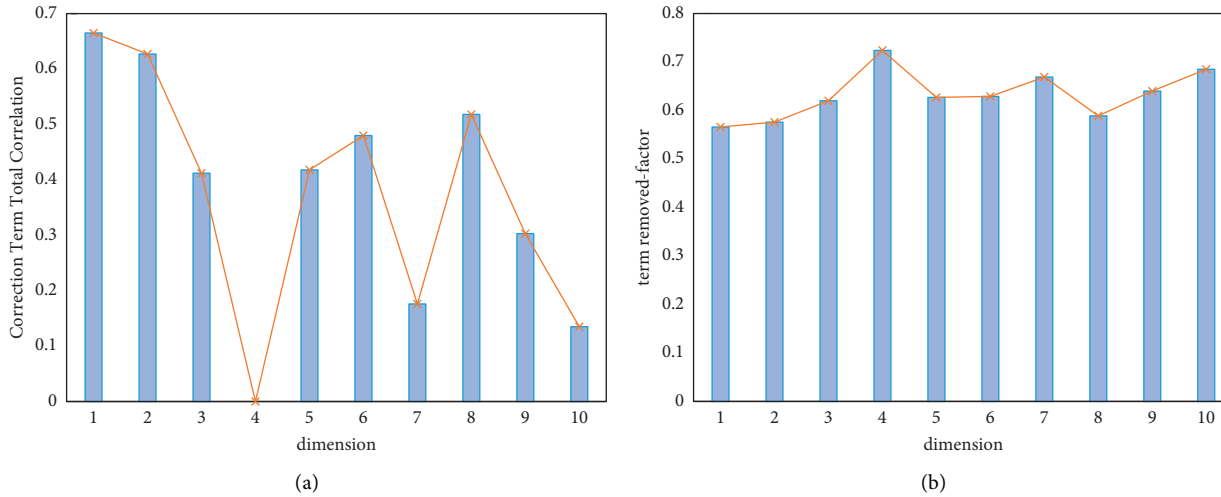

Figure 4: Cronbach reliability analysis. (a) Total correlation of correction items. (b) Alpha coefficient of deleted item.

time, but also convenient ways to visit. In the exhibition of works, users prefer to restore the visual experience effect of offline physical art galleries. In order to meet this visual requirement, this paper studies how to build a three-dimensional multi-view digital art gallery in combination with artistic characteristics, hoping that users can walk freely in the virtual reality environment and watch all corners of the art gallery in 720° [18].

Adopt a variety of routes to view the exhibition: "Dot Art" Digital Art Museum does not realize the preset roaming route in the exhibition form but determines the order and direction of the exhibition by the user's own choice and selects the traveling route by controlling the visual angle with the mouse and the direction with the keyboard so that the user can choose the visiting route more independently [19].

Man-machine interaction in the exhibition hall: as far as possible, the interactive design should be consistent with the original intention of the artist's design works, and on this basis, the interest should be appropriately increased. Some exhibition halls will restore the interactive methods between artists and audiences during the physical exhibition. This not only allows users to have a zero distance from the works but also enables users to understand the works themselves and the ideas and emotions that artists want to convey when designing works. To some extent, the exhibition is more interesting and exploratory, which can arouse users' desire to participate in the exhibition [20].

Application of VR in installation art: the most important feature of VR installation art is digitalization. For the materials of installation art, VR can be virtualized through computers and systems, producing more and richer colors, producing more and more special materials, even materials that do not exist in reality.

Enrich the decorative nature of installation art. In installation art, the decorative properties of materials refer to the color, luster, transparency, texture, shape and size, texture, and so on. VR equipment is made of computer-generated materials, and the color, luster, and transparency of the materials can be adjusted according to the needs. Even variable materials can be generated based on the user's emotions. The decoration of materials also affects the humanistic characteristics of materials. For example, the huge statue of the Church will give people a solemn feeling, not only because of its material but also because of its huge size, which makes people feel different psychologically. As shown in Table 1, VR can produce different colors. Different hues can even affect people's physiology and psychology. People with different religious beliefs, different regions, and different cultures have different feelings about the same color. Therefore, VR-based installation art can achieve different artistic display effects by changing the decoration of materials.

Enrich the sensory experience of installation art. In the installation art, the biggest impact is the visual feeling. Although in the traditional installation art, there may be tactile and olfactory feelings, but these are few. VR-based installation art can maximize the visual impact, and the immersive viewing experience will not be disturbed by other viewers. From the foregoing description, we can know that digital materials will use diffuse reflection or specular reflection, refraction, texture, and other parameters to simulate the color, luster, transparency, and texture of real materials. A model is a simulation of shape and size. From these correspondences, the decorative properties of digital materials should come from traditional materials, as shown in Table 2.

VR-based installation art can take online exhibition or online and offline exhibition, which is different from the traditional exhibition. Online exhibitions have more choices, for example, you can stay for your favorite installation art and watch it in many directions, so you do not need to take into account the feelings of other tourists like the traditional way of viewing exhibitions. Moreover, the viewing of online VR device art does not need to consider the limitation of the venue, and the audience can choose a variety of perspectives such as looking down and looking up. There is a strong openness.

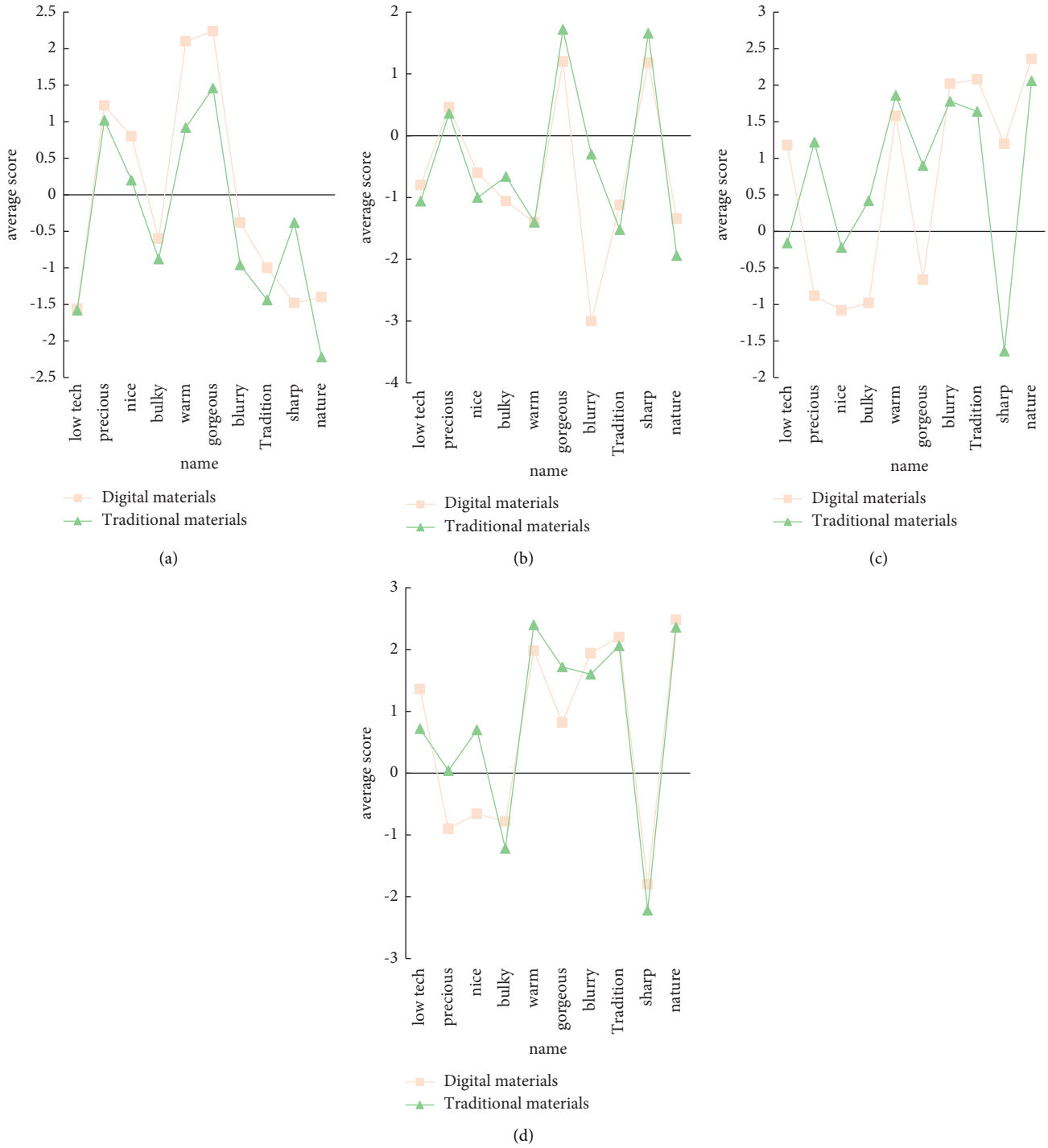

Figure 5: Comparison of SD scale scores between traditional and digital materials. (a) Stone. (b) Wood. (c) Glass. (d) Metal.

3. Simulation Experiment

Research on VR-based Exhibition Experience Survey: according to the VR exhibition experience, this paper selects the exhibition visitors with different identities as the survey objects, including young students, elderly groups, exhibition enthusiasts, and VR enthusiasts. Using the SD scale to design questionnaires, 209 valid questionnaires were received.

The survey population is mainly concentrated in the same region and the same cultural background, which can effectively control the important factors such as culture and region that affect the humanistic characteristics of materials. Through the reliability analysis of the questionnaire, it can be seen from Figure 4 that the value of the reliability coefficient is 0.660, which is greater than 0.6, thus indicating that the reliability quality of the research data is acceptable.

Table 3: VR's exhibition experience in theater space.

	Fluency	Viewing angle	Interactivity
A	10	6	5
B	9	9	9
C	8	7	8
D	8	8	8

As can be seen from Figure 4, the coefficients of all dimensions and indicators are above 0.5, which indicates that the questionnaire designed in this paper has high reliability and can be used as the basis for investigation and analysis.

Viewing the exhibition experience in VR installation art: in the questionnaire, the exhibition experience of VR in installation art mainly focuses on the change of materials. As VR changes the decoration of installation art, which is the most direct feeling of the audience and can be quantified well, in the questionnaire, materials are divided into digital materials and traditional materials, and they are divided into four types: stone, wood, glass, and metal. The survey results are shown in Figure 5:

This paper analyzes the cognition of traditional materials and digital materials by using the 10-dimension average score of the SD scale. The average score calculation can effectively remove the interference of personal subjectivity and draw a line chart for comparative study. It is found that the cognition of digital materials and traditional materials tends to be the same in 209 samples, and the precious and low-tech errors in Figure 5(c). After analysis, although the influence of nonmaterial factors will be deliberately excluded when selecting material pictures, it is inevitable that there will be some influences. This problem is the cognition caused by the rendering of the environmental atmosphere of a given picture.

3.1. Viewing the Exhibition Experience in VR Theater Space. In the questionnaire, the audience who used VR technology to participate in the theater space were investigated. The experiment adopted the experimental control method, and the experimental subjects were divided into four groups. Group A watched the whole process with naked eyes. Group *b* uses VR equipment to watch the whole process; Group C is to watch with naked eyes first and then with VR; Group *d* is to watch with VR first and then with naked eyes. After watching the theater, the viewing experience is described by the scoring system, in which the viewing experience is divided into viewing fluency; viewing angle and interaction in the viewing process. The results are shown in Table 3:

As shown in Table 3, viewing the theater space with VR equipment can effectively improve the viewing angle. In the traditional exhibition space under the line, the seat position is different, and the position directly determines the viewing experience. While using VR for the online exhibition, users can choose their appropriate position and have a better viewing experience. Moreover, the use of VR for the exhibition of theater space can effectively enhance the interactivity. Because VR device technology can be connected to the computer through the Internet, you can choose some interfaces independently and interact with the exhibition space.

4. Conclusion

VR technology has brought a lot of colors to life. From the application of movies and games to the realization of online clothes selection and other functions in life, VR technology has been widely used in life. However, the application of VR technology in theater space and installation art is just beginning. Firstly, this paper improves the problems of slow data transmission and high communication delay of VR technology through a multisensor data fusion algorithm. The improved algorithm can optimize the algorithm of VR communication so that users can have a better experience when using VR for exhibition. After that, based on VR technology, this paper investigates the influence of users on theater space and installation art and investigates theater space and installation art respectively. Finally, the influence of VR technology on theater space and installation art is summarized. Although VR technology can bring different feelings to the audience, it is difficult to realize a complete, interactive, and experienced virtual reality exhibition hall because VR technology is not mature enough, and it does not reach natural and real immersion compared with the realization.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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