Research Article

Analysis of the Visual Design and Expression Effect of Virtual Reality and Three-Dimensional Space Technology in Art Space

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Received 8 June 2022; Revised 27 July 2022; Accepted 12 August 2022; Published 29 September 2022

The application of information technology has realized the transformation of people’s production and lifestyle and also promoted the improvement of people’s aesthetic level. Currently, the application of information technology in the art industry is getting stronger and stronger, and using its advanced methods and technologies of information display, this study aims to realize the exploration of art space under virtual reality technology to promote the study of the expression effect of visual design. This study proposes the use of virtual reality technology to guide the study of the effect of visual design expression in art spaces, which helps to analyze and solve a series of problems that objectively exist today in terms of single visual design and people's aesthetic fatigue, and draws on the principles and algorithms of virtual reality technology to conduct research on the effect of visual design and expression in art spaces. In the experiment for the algorithm of the three-dimensional model, it can be seen from table that the score of one-dimensional space is around 4, the score of two-dimensional space is around 5.6, while the average score of three-dimensional space use is around 8.2; the score is very high, thus we get the following conclusion: three-dimensional space, no matter once or now, in the visual art of art space, as well as the expression effect is a great role, so the study of virtual reality. It is therefore of great vitality and social significance to study how virtual reality can be used to maximum effect in the visual arts and expressions of all art spaces.

1. Introduction

With the rapid development of the social economy, the application and popularization of information technology have prompted human society to enter the information age, with the emergence of new media and the diversification of imaging methods such as digital media, video media, and integrated photoelectric media. The emergence of media in the design of art spaces has greatly enriched the technical means of display, thus improving the artistry of display and achieving the harmonious unity of technology and art. With the great development and prosperity of national culture, the current emphasis on culture is also driving the flourishing development of the art field. And art museums, as an important part of the great cultural development and prosperity, have also begun to reflect on their own position in society. It has the rhythm to adjust the spirit and emotions, can enrich the learning content, make people pleasing to the eyes, feel refreshed, and evolve life.

With today's social and economic transformation, virtual environment modeling in virtual reality systems is becoming more and more important. Modeling technology is one of the most important technical fields and key technologies in virtual reality technology. In human interaction, the mastery of art visual space design principles has opened a new window for the future development of visual communication design and has even become the mainstream of design development in the information age. The information design and development of the art visual space will usher in a new design era. It can integrate multiple experiences and feelings and has irreplaceable research value and aesthetic significance. The visual space art language can
use the corresponding artistic images to form the beauty of the cultural image of the visual space, form the visual pattern through the decorative combination of the building, or form a new spatial vision by the morphological design of the interior decoration.

The realistic role of virtual reality is mainly reflected in the application of virtual reality technology products in manufacturing, education, culture, health, commerce, and other industries. In recent years, virtual reality has become one of the hot topics in social circles. Murata S discovered the field of Oriental art history and visual design and discussed the cognitive effects of white space. But the visual process behind perception has not yet been fully elucidated. This study uses a psychological experiment to test the spatial characteristics of the region. In this experiment, participants reported that they thought the patterns of regions and arrangement of disks in Japanese art paintings were very special. In order to explain the spatial characteristics of these areas, based on the field of view theory, they constructed a simple calculation model. Their model assumes that the region can be specified based on the threshold of the two-dimensional Gaussian filtered image of the stimulus. This model can explain the areas within the disc pattern very well, but it is not so good for those areas in artistic paintings. This difference may be attributed to the spatial background depicted in art painting [1]. The purpose of Chang’s research is to analyze the internal architectural elements of the space with circulation routes. In order to analyze the experiment, first, he organized the frame with elements of circulation and interior architecture through a literature review; second, based on the frame, he analyzed the destination. Third, he determined the current situation of the architectural elements of the interior space planning of the museum. In the research results, there are specific experience elements and interior architectural elements planning in the museum. A variety of materials have been used to provide the maximum visual perception experience in the space that has been reached. In addition, the vertical expansion provides an impression of the spatial experience. The created space may be completely or partially enclosed to obtain the area and experience the depth of the space [2]. Perchard used an imaginary transnational living room as a background to examine the status of jazz in the modern middle-class family in the West after the war. And he explored the audience’s domestic use of recorded music. In clearly diverse magazines such as Ideal House in the United Kingdom and Playboy in the United States, some kind of art space helped new middle-level connoisseurs in the 1950s and 1960s. However, this work does not simply locate this style in the sociology of historical taste but attempts to describe the role of jazz in the emerging middle-class senses. The sound characteristics of music are often used to complement the new fashionable visual and tactile experiences of furniture, fabrics, plastics, light, and space in modern home buildings. Then, it defines the ideal bourgeois family. Jazz album cover art reflects the international modern visual aesthetics [3]. Wu et al. found that the unprecedented availability of social media data provides data owners, system operators, solution providers, and end users with numerous opportunities to explore and understand social dynamics. However, the amount, speed, and variability of social media data are increasing exponentially, which prevents people from taking full advantage of this data [4]. Bastug et al. discovered the concept of wireless augmented reality and virtual reality (AR/VR). It has swept the entire 5G ecosystem and inspired unprecedented interest in academia, industry, and others. However, the success of immersive VR experiences depends on solving a large number of major challenges that span multiple disciplines [5]. Elbamby et al. believed that virtual reality (VR) is expected to become one of the killer applications in 5G networks. However, many technical bottlenecks and challenges need to be overcome to promote its widespread adoption. In particular, VR’s requirements for high throughput, low latency, and reliable communication require innovative solutions and basic research across multiple disciplines. In view of this, this article discusses the challenges and drivers of achieving ultra-reliable low-latency VR. Furthermore, an interactive VR arcade case study shows that intelligent network design using mmWave communications, edge computing, and active caching can wirelessly realize the future vision of VR [6]. Ronchi et al. conducted a virtual reality (VR) experiment with 96 participants and provided advice on emergency exit flashers designed for emergency evacuation of highway tunnels. The experiment was carried out in the cave automated virtual environment laboratory. In the experiments, we examined a set of variables, such as flashlight color, flicker rate, light source type, number of door lights, and layout. Participants were asked to immerse themselves in an emergency evacuation scenario of a VR highway tunnel and rank different portal designs using a usability theory-based questionnaire. The results show that green or white light is better than blue light. Flicker frequencies of 1 and 4 Hz perform better than flicker rates of 0.25 Hz. The performance of an LED light source is better than that of single strobe light and double strobe light. The three layouts of lamps considered work in the same way [7]. Ozusaglam et al. analyzed whether the performance advantages of environmental management systems (EMS) and environmental technologies (ET) can be enhanced by their complementarity. Their subsidiary assumption is theoretically based on a resource-based view of the firm’s strategic suitability and asset complementarity approach. They specialize in two different types of aliens. Externality Reduction Technology (ERT) focuses on reducing emissions and pollution, while Efficiency Technology (EIT) focuses on reducing material and energy consumption. The results of a sample of 36,645 companies in 8 countries show that there is complementarity among the three companies. In short, companies using EMS and both ETs achieved higher sales growth than companies using EMS, ERT, or EIT alone [8]. Through the experimental analysis of scholars, we can see that virtual reality and 3D space form construction technology can play a great role in the visual design and expression effect of art space. But how to make it work is still a big problem.

The innovations of this article are: (1) taking into account the virtual reality and the form construction technology in the three-dimensional space, it can play a good role in the
visual design of the art space and have a good expression effect. (2) This article uses the 3D model reconstruction algorithm and reconstruction process to compare the advantages and disadvantages of one-dimensional space, two-dimensional space, and three-dimensional space. Thus, it is concluded that the three-dimensional space is more widely used in the visual art of fine art space.

2. 3D Model Reconstruction Algorithm and Reconstruction Process

3D reconstruction refers to a technology that obtains the 3D appearance of real objects and builds a reusable model. It is a research hotspot in current computer vision. The continuous improvement of 3D reconstruction algorithms promotes the continuous development of 3D modeling technology. Only more advanced three-dimensional reconstruction algorithms can calculate more high-precision calculation results and provide a strong guarantee for the reconstruction of the three-dimensional model [9]. There are already many simulation systems using virtual reality-oriented modeling technology. The following study several commonly used virtual reality modeling key technology algorithms [10]. Dynamic environment modeling technology is the core content of the VR system, the purpose of which is to obtain the three-dimensional data of the actual environment and establish the corresponding virtual environment model according to the needs of the application.

As shown in Figure 1, when the three-dimensional complex model has multiple geometric shapes, the same but different positions of objects, the instantiation technology is used. Instantiation is a reference to an existing model in the database, and its appearance is the same as copying. But the instance is not the real geometry in the database, it is just a pointer to the object [11]. A dynamic link library file is a nonexecutable binary program file that allows programs to share code and other resources necessary to perform special tasks.

In the 3D model reconstruction system, the reconstruction process involves various data files, especially the data in these files need to be converted. The file format content and conversion process of these files, especially the intermediate data files in various XML formats and the model files in VRML format, have been introduced above [12]. The XML file format is a plain text format, and XML elements can be tagged as price, order number, or name. A markup is a description of the document storage format and logical structure. Next, the generation process of the intermediate data file in XML format and the model file in VRML format will be described in detail, as shown in Figure 2.

As shown in Figure 2, during the overall development of the virtual roaming system, the following aspects are mainly considered: first, importing the modeled scene into the roaming system; then determining the roaming method. That is, whether the scene is automatically browsed or manually browsed, or a combination of the two is set and developed [13]. The continuous progress of science and technology should have huge development space for the development of future guide design. Therefore, the research ideas in this area can be broadened. It should be considered in the space to receive information through nonphysical expression methods, such as smell, color, light, or music. In this way, we can change the way people receive information normally, and use the whole body organs to experience space, which is no longer limited to vision.

2.1. Projection Reconstruction Algorithm. To explain the process of three-dimensional imaging, it needs to be explained through the Euclidean theory of motion, that is, the theory of rigid body motion. Applying this theory can clearly explain the geometric relationship between two-dimensional images and three-dimensional images captured by the same camera [14]. The Cartesian coordinate system is the collective name for the Cartesian coordinate system and the oblique coordinate system. The two axes intersecting at the origin constitute a plane affine coordinate system. The theory of Euclidean motion theory is based on the three-dimensional Euclidean space theory. Expressed by $E_3$, in this way, the three-dimensional Euclidean space can be converted to a Cartesian coordinate space. Then, all points $\rho \in E_3$ in the space can be represented by a certain three-dimensional coordinate point as in formula (1):

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix} \in \mathbb{R}^3.$$

For two points $p$ and $q$ in space, their coordinates are $A$ and $B$ respectively, then the inner product of the vector $v = B - A \in \mathbb{R}^3$ formed by $p$ and $q$, and the two vectors $V$ in space, $\rho \in E_3$ is expressed as formula (2):

$$\langle u, v \rangle = u^T v = u_1 v_1 + u_2 v_2 + u_3 v_3.$$

The vector product generally refers to the vector product. Vector product, also known as outer product and cross
product in mathematics. And their vector product is expressed as formula (3):

\[
\mathbf{u} \times \mathbf{v} = \begin{bmatrix} u_2v_3 - u_3v_2 \\ u_3v_1 - u_1v_3 \\ u_1v_2 - u_2v_1 \end{bmatrix} \in \mathbb{R}^3. 
\] (3)

In addition, they define such a matrix as (4):

\[
\mathbf{u} = \begin{bmatrix} 0, -u_3, u_2 \\ u_3, 0, -u_1 \\ -u_2, u_1, 0 \end{bmatrix} \in \mathbb{R}^{3\times3}. 
\] (4)

Since the actual rotation of the rigid body is continuous, it must also be a continuous function. At the initial moment, the origin of the rigid body local reference system can be selected to coincide with the origin of the global reference system. Then, the vector product can be directly expressed as \( \mathbf{u} \times \mathbf{u} = \mathbf{uv} \). In addition, the rigid body motion theory needs to be introduced as shown in Figure 3:

As shown in Figure 3, the rigid body motion theory illustrates the rigid body transformation process of an object from the world coordinate system \( \mathcal{W} \) to its own coordinate system \( \mathcal{C} \) [15]. Moving all points on the graph by the same distance along a certain straight line on the same plane is translation, and this graph motion is called graph translation motion. Its conversion process includes both rotation and translation, which can be expressed as formula (5):

\[
\mathbf{A}_W = \mathbf{R}_{WC}\mathbf{A}_C + \mathbf{T}_{WC}. 
\] (5)

Among them, \( \mathbf{A}_W \) represents the vector from the origin \( \mathbf{o} \) of the world coordinate system to any point on the rigid body, and \( \mathbf{A}_C \) represents the vector from the origin \( \mathbf{o} \) of the rigid body’s own coordinate system to the same point [16]. The rotation matrix and translation vector from the own coordinate system to the world coordinate system are denoted by \( \mathbf{R}_{WC} \) and \( \mathbf{T}_{WC} \) respectively. On the basis of the theory introduced above, the introduction of projection reconstruction theory is shown in Figure 4:

As shown in Figure 4, Pinhole camera, that is, an ultraminiature camera. Its shooting aperture is indeed only the size of a pinhole, while the size of the camera is about the size of a dollar coin. It can be seen that this is a relatively simple schematic diagram of pinhole camera imaging. The optical center of the camera in the figure is the origin \( \mathbf{O} \) of the coordinate system. At the same time, the \( \mathbf{B} \) axis is perpendicular to the horizontal plane, and the \( \mathbf{Z} \) axis points to the subject in the positive direction. At this time, a camera...
imaging plane is formed at the distance \( f \) in the negative direction of the \( Z \) axis. Therefore, \( f \) is equal to the focal length of the camera, and the image point formed by any point \( P \) on the object on the imaging plane through the optical center is \( P \) [17]. In the modeling process, the problem of over-emphasizing details often occurs. All structures and surface features are implemented with polygons, ignoring the optimal design of the overall structure of the scene database. The traditional 3D scene construction process is mainly to optimize the model. Although good application effects have been achieved, there are still many problems.

At this time, assuming that the coordinate of point \( P \) in the camera coordinate system is \( A = \begin{bmatrix} A \\ B \\ Z \end{bmatrix} \in \mathbb{R}^3 \), then the coordinate of the point on the imaging plane on the \( Z \) axis is \( F \). Therefore, the two-dimensional coordinates of \( P \) on the imaging plane can be expressed as formula (6):

\[
A = \begin{bmatrix} A \\ B \\ z \\ f \end{bmatrix} = \begin{bmatrix} f \\ \frac{z}{f} \end{bmatrix}.
\] (6)

The purpose of introducing homogeneous coordinates is mainly to combine multiplication and addition in matrix operations. It can be written in homogeneous coordinate form as (7):

\[
\lambda_\alpha = K_\Pi \alpha.
\] (7)

With the above foundation, the next thing that needs to be verified is how to correspond to the two-dimensional coordinate points on the imaging plane and the coordinate points on the pixel plane. Flat mirror imaging is a physical phenomenon. It means that the light of the sun or lamp shines on the human body, is reflected on the mirror surface, and then reflects the light into the human eye. The
conversion relationship between the imaging plane and the pixel plane is shown in Figure 5.

As shown in Figure 5, through this conversion, the coordinate values are converted into pixel coordinate values, and the scaling ratios of the horizontal and vertical coordinates of $S_a$ and $S_b$, respectively. $S_a$ corresponds to the pixel value of the length of the pixel plane, and $S_b$ corresponds to the pixel value of the width of the pixel plane. In this way, the translation vector of the coordinate origin of the imaging plane relative to the origin of the pixel coordinate system is the vector $(O_a, O_b)$. Therefore, the coordinate relationship between a certain point $a$ on the imaging plane and its corresponding point $a'$ on the pixel plane is (8):

$$a' = \begin{bmatrix} a' \\ b' \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} S_a & 0 & O_a \\ 0 & S_b & O_b \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ 1 \end{bmatrix}$$

The final process is to divide the object plane by $Z$ into a normalized plane, multiply by $f$ to become an imaging plane, zoom and translate into a pixel plane, or multiply the internal parameter from a normalized plane to a pixel plane. Similarly, in the case that the pixel plane is not a rectangle, the above formula is transformed into a more general form, expressed as formula (9):

$$a' = \begin{bmatrix} a' \\ b' \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} S_a & S_b & O_a \\ 0 & S_b & O_b \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ 1 \end{bmatrix}$$

Among them, $S_b$ is called the distortion constant, which is in constant proportion to $\cot(\theta)$. $\theta$ is the vertical angle between the two coordinate axes of the pixel plane. Therefore, the value of $S_b$ is usually equal to 0. The final form of projection reconstruction can be obtained as (10):

$$K = K_aK_f,$$

$$\Pi = [k, 0] \in R^3.$$

It is a ray to convert a two-dimensional coordinate point to a three-dimensional space, but when the value of a certain latitude in the three-dimensional space is known, it can be reversed. Finally, according to formula (10), there is a correspondence between the three-dimensional pixel coordinates in the camera coordinate system and the two-dimensional pixel coordinates as formula (11):

$$\lambda_a = K\Pi_2A = \Pi_2.$$

Of course, in addition to the corresponding relationship, other reconstruction algorithms are also needed to calculate some of the parameters. Only in this way can the values of the three-dimensional coordinates be truly calculated. This will be introduced below [18].

2.2. Affine Reconstruction Technique. The target recognition method based on affine transformation reconstruction can correctly identify the target without the influence of affine transformation, and can effectively overcome the influence of noise and target shape distortion. The theoretical basis of the affine reconstruction technique is the pole constraint. The so-called pole constraint refers to the camera shooting the same object from two different perspectives. There is a constraint relationship between the point coordinates of the image formed by it [19]. The following will briefly explain the evolution of this constraint, as shown in Figure 6:

According to the relationship shown in Figure 6, this system selects the virtual reality modeling language VRML as the final generated model file format. Because the model code file written in VRML language adopts the plain text format file, it is helpful to write the template code when the model file is generated. Therefore, with the development of virtual reality space display design, it will present a more fascinating state than before. In general, people’s understanding of virtual reality display design will be more profound [20]. A display mode that integrates rational thinking and perceptual thinking will shine in the future. Virtual reality modeling language is a scene modeling language used to build real-world scene models or people’s fictional three-dimensional worlds, and it is also platform-independent.

The point coordinates of any point $P$ on the object respectively formed on their imaging plane are expressed as a sum. After matrix conversion, the coordinate relationship between them can be obtained as formula (12):

$$\lambda_1a_2 = \lambda_2a_1 + T.$$  \hspace{1cm} (12)

In order to eliminate $\lambda_1$ and $\lambda_2$, multiply both the left and right sides of formula (12) by the $T$ matrix. Because of $T = (0, 0, 0)^T$, it is as in formula (13):

$$\lambda_1^TTRA_1 = 0.$$  \hspace{1cm} (13)

2.3. Instancing Technology Algorithm. Instanciation means that in object-oriented programming, the process of creating an object with a class is called instantiation. It is the process of converting an abstract conceptual class into the physical object of this class. Instancing techniques can be used when a 3D complex model has multiple objects with the same geometry but different locations. Instancing is an algorithm used in graphs to save computer running costs [21]. However, using instancing techniques can increase the number of similar objects without increasing the polygon count. Using instancing can greatly reduce the number of polygons in the scene, saving a lot of memory. Using this technique in a distributed simulation will greatly reduce the amount of data transfer [22]. The instanciation algorithm has attracted much attention in current research and is famous for its various advantages. It uses matrix transformation and sacrifices time in exchange for memory space [21, 22].

6 Mathematical Problems in Engineering
Translation, rotation, and scaling can be expressed in the form of unified matrix multiplication as in formula (14):

\[
T_{3D} = \begin{bmatrix}
    b_1 & b_2 & b_3 & b_4 \\
    b_4 & b_5 & b_6 & b_7 \\
    b_2 & b_3 & b_4 & b_5 \\
    b_3 & b_4 & b_5 & b_6 \\
\end{bmatrix}, \quad (14)
\]

If the object position is \( p(a, b, z) \) and the target translates to position \( T_a \) in the three axis directions, the translation transformation matrix is formula (15):

\[
[a, b, z, 1] = a + T_a + b + 1. \quad (15)
\]

Hierarchical bounding volume technology is a common algorithm in collision detection algorithms. Collision detection algorithms are generally divided into two categories:

![Conversion diagram between imaging plane and pixel plane.](image5)

Figure 5: Conversion diagram between imaging plane and pixel plane.

![Model file format conversion diagram.](image6)

Figure 6: Model file format conversion diagram.
spatial decomposition method and hierarchical bounding box method. The algorithm cost of collision detection with the hierarchical bounding volume algorithm can be expressed by (16):

\[ T = N_x \times C_x + N_y \times C_y + N_z \times C_z. \]  
(16)

There are also disadvantages to using external references. Because some externally referenced models are read-only and cannot be edited directly. It can only change the position, direction, and size ratio. If a modified file wants to be got, the model file must be opened. After the modification, the calling model needs to be refreshed [23].

In the right-hand coordinate system, the transformation formula for rotating the angle \( \theta \) relative to the origin of the coordinate system around the coordinate axis is around the \( X \) axis, and the rotation is formula (17):

\[ [a', b', z', 1] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \theta & \sin \theta \\ 0 & -\sin \theta & \cos \theta \end{bmatrix}. \]  
(17)

Rotating around the \( A \) axis is (18):

\[ [a', b', z', 1] = \begin{bmatrix} \cos \theta & 0 & -\sin \theta \\ 0 & 1 & 0 \\ \sin \theta & 0 & \cos \theta \end{bmatrix}. \]  
(18)

Rotate around the \( Z \) axis as (19):

\[ [a', b', z', 1] = \begin{bmatrix} \cos \theta & \sin \theta & 1 \\ -\sin \theta & \cos \theta & 0 \\ \sin \theta & 0 & 0 \end{bmatrix}. \]  
(19)

The main goal of the instantiation technique is to save memory. In this sense, the memory occupies less and the display speed will be faster. But at the same time, the geometric position of the object must be obtained through geometric transformation. So when the number of instance objects increases, the amount of calculations of the system will increase significantly. Excessive calculations will cause the system to slow down and affect the real-time performance of the system [24]. Therefore, when using the instantiation technology, the number of instance objects and the number of geometric transformations should be considered comprehensively, so as not to affect the real-time performance of the system.

3. Experiment and Analysis

3.1. Experiment and Analysis of 3D Model Algorithm. This article studies the artistic techniques of virtual reality technology in modern space display design. This article discusses the modeling elements and design principles of modern space display design, summarizes its unique artistic charm, and analyzes and discusses the current problems and development directions of virtual reality technology in display design from an aesthetic point of view. The space display design in this article refers to the display design applied to the indoor and outdoor space environment of the building. It is different from other product display designs. The most obvious feature lies in the fusion of its physical and virtual spaces. Based on this aspect, its technical and artistic research can fill the theoretical vacancy of the art design major [25].

A complete virtual reality system must use some labels to give instructions. Moreover, the pros and cons of label design will directly affect the beauty of the entire virtual scene. Therefore, the labels must be analyzed and classified first and then designed according to specific needs. This article takes \( N \) values of different three-dimensional space positioning points. The statistics of the \( Z \)-direction offset and the objective function value \( \text{Min} \) of the nine key points after the optimization calculation are shown in Table 1:

<table>
<thead>
<tr>
<th>Reference point number</th>
<th>( N=2 )</th>
<th>( N=3 )</th>
<th>( N=4 )</th>
<th>( N=5 )</th>
<th>( N=6 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.5432</td>
<td>0.5643</td>
<td>0.6435</td>
<td>0.7578</td>
<td>0.4245</td>
</tr>
<tr>
<td>2</td>
<td>2.4321</td>
<td>0.9746</td>
<td>0.6532</td>
<td>0.4234</td>
<td>0.5356</td>
</tr>
<tr>
<td>3</td>
<td>2.5643</td>
<td>0.4267</td>
<td>0.4673</td>
<td>0.1234</td>
<td>0.3567</td>
</tr>
<tr>
<td>4</td>
<td>3.5322</td>
<td>0.4216</td>
<td>0.6436</td>
<td>0.1353</td>
<td>1.8646</td>
</tr>
<tr>
<td>5</td>
<td>0.6533</td>
<td>0.2467</td>
<td>0.8536</td>
<td>0.4244</td>
<td>0.4356</td>
</tr>
<tr>
<td>6</td>
<td>0.6753</td>
<td>0.2457</td>
<td>0.4687</td>
<td>0.6457</td>
<td>0.6784</td>
</tr>
<tr>
<td>7</td>
<td>1.5678</td>
<td>0.3578</td>
<td>0.5736</td>
<td>0.3567</td>
<td>0.6744</td>
</tr>
<tr>
<td>8</td>
<td>1.6853</td>
<td>0.6429</td>
<td>0.1632</td>
<td>0.5683</td>
<td>0.3673</td>
</tr>
<tr>
<td>9</td>
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<td>0.6578</td>
<td>0.1535</td>
<td>0.1345</td>
<td>0.5465</td>
</tr>
<tr>
<td>( \text{Min} )</td>
<td>15.6536</td>
<td>2.6533</td>
<td>1.5324</td>
<td>2.7535</td>
<td>3.6367</td>
</tr>
</tbody>
</table>

Table 1: Deformation absolute value and objective function value of each reference point at different three-dimensional space points (mm).

It can be seen from Table 1 that the above research content shows that analyzing the age, gender, occupation, and preferences of online users’ behavior, mining users’ personalized needs, and analyzing the formation of individual user data structures are data-driven precision marketing. The expected value is at the right time, with the right marketing channels and the right virtual form, which breaks through the limitations of traditional two-dimensional impressions.

When virtual reality technology is applied to art space design, the most important thing is the rationality of the space arrangement and the correct understanding of the relationship between space and display design. This is the basis of modern display space design.

Through the application of one-dimensional space, two-dimensional space, and three-dimensional space in the visual space of art space, this study investigates the growth rate from January 2020 to June 2020, as shown in Figure 7:

As shown in Figure 7, the growth rate of the three-dimensional space increased from 5.6% in January 2019 to 6.2% in January 2020. It can be seen that the application of three-dimensional space in the visual space of art space has been developed. From the current display design of some representative developed countries, more display behavior is a combination of innovative consciousness and scientific and technological means, which express the content of the theme with strong visual tension.
When $N = 5$, the objective function value is $\text{Min} = 2.342$ mm. When $N = 5$, there is an optimal support point coordinate. The $Z$-direction deformation equivalent value of the part is shown in Table 2.

According to Table 2, when $N = 5$, the objective function value in the optimization calculation drops significantly. But there are still three key points where the $Z$-direction deformation exceeds the allowable value of workpiece deformation, so this state cannot meet the processing requirements of the workpiece.

When $N = 6$, the objective function value is $\text{Min} = 2.342$ mm. When $N = 6$, there is an optimal support point coordinate, and the equivalent value of $Z$-direction deformation of the part is shown in Table 3.

According to Table 3, when $N = 6$, the objective function value in the optimization calculation is further reduced. And the $Z$-direction deformation of the nine key points is all within the allowable value (0.5 mm) of the workpiece deformation, so this state can meet the processing requirements of the workpiece. It can fully limit the $Z$-direction deformation of the workpiece.

When $N = 7$, the objective function value is $\text{Min} = 1.234$ mm. When $N = 7$, there is an optimal support

<table>
<thead>
<tr>
<th>Support point number</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>253.5</td>
<td>65.65</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>654.3</td>
<td>245.62</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>30.56</td>
<td>13.54</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>54.64</td>
<td>78.64</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>15.67</td>
<td>347.81</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Deformation absolute value and objective function value table of each reference point when $N = 5$ (mm).

<table>
<thead>
<tr>
<th>Support point number</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>153.52</td>
<td>56.73</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>345.32</td>
<td>356.32</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>39.87</td>
<td>26.432</td>
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<tr>
<td>4</td>
<td>23.25</td>
<td>56.89</td>
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</tr>
<tr>
<td>5</td>
<td>18.67</td>
<td>263.64</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>13.23</td>
<td>453.76</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3: Deformation absolute value and objective function value table of each reference point when $N = 6$ (mm).

<table>
<thead>
<tr>
<th>Support point number</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>187.63</td>
<td>65.72</td>
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<td>4</td>
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<td>36.78</td>
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<td>5</td>
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<td>455.55</td>
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<tr>
<td>6</td>
<td>12.86</td>
<td>254.76</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>17.32</td>
<td>453.73</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4: Deformation absolute value and objective function value table of each reference point when $N = 7$ (mm).

**Figure 7**: Bar graph of the growth rate of 3D space applications from 2019 to the first half of 2020.
point coordinate, and the equivalent value of $Z$-direction deformation of the part is shown in Table 4:

According to Table 4, the $Z$-direction deformation of the key points is also within the allowable value of workpiece deformation (0.5 mm). However, the objective function value in the optimization calculation has increased compared with $N = 6$.

Through a questionnaire survey of 11 art space visual art designers, this article investigates their use of three-dimensional space in art space in 2019 and 2020 respectively, as shown in Figure 8:

As shown in Figure 8: in 2019, 11 designers used about 15% of the three-dimensional space. In 2020, the percentage of the use of three-dimensional space by 11 designers is about 18%, an increase of about 3%. Before digitization entered human life, whether it was a totem of primitive society or a product of relatively advanced industrialization, it appeared in front of the world in two states: patterns on a two-dimensional plane and entities in a three-dimensional space. Therefore, the use of three-dimensional space should be widely recognized.

3.2. Questionnaire Survey. The art space is for people to use. People’s activities in space give meaning to space, so people are the protagonists of space. In the design of the museum’s compound space, people’s behavioral activities and psychological needs also need to be considered. In design, designers are required to use skills proficiently. The basic principles and application of visual space are also one of the basic skills that designers need to master. A better understanding of the development of visual space design in visual communication design is a new starting point for the development of visual communication design. This article starts with the specific elements of visual communication design, analyzes the visual space performance techniques and presentation effects through specific examples, summarizes, and refines the different visual space performance techniques. It carries the effect and importance of information transmission in the design. This study investigates the several-dimensional space technology and effects used in 6 art spaces, as shown in Table 5.

According to Table 5, the score of one-dimensional space is about 4, the score of two-dimensional space is about 5.6, and the average score of three-dimensional space usage is about 8.2, which is very high. The following conclusions can be drawn. With the upsurge of building their own digital art museums by large physical art museums, we should see that digital art museums based on the purely virtual sense of three-dimensional space are the most dynamic and socially meaningful. This topic will be beneficial to the establishment of new ideas and theoretical foundations for virtual digital art museums in the future.

This article then conducted a survey of 12 art space designers. They scored one-dimensional space, two-dimensional space, and three-dimensional space respectively, as shown in Figure 9.

As shown in Figure 9, the average score of the twelve raters on the one-dimensional space in the art space is about 3.5, while the average score of the one-dimensional space in the art space is about 8.3. Through a series of comparisons, we can know that everyone is more in favor of the application of visual art in the art space under the three-dimensional space.

Figure 8: Bar chart of the use of three-dimensional space in art space in 2019 and 2020.
In this study, the two-dimensional space and three-dimensional space are studied separately through 61 sets of survey samples, as shown in Figure 10:

As shown in Figure 10, the trend of the use of two-dimensional space in daily life fluctuates greatly, and the utilization rate is about 55%. The trend of three-dimensional space in daily life is relatively stable, and the utilization rate is about 70%. In visual communication design, graphic language is the most important visual design language. Graphic language can transmit information more accurately, quickly, and vividly than color and text language. In the visual recognition of visual communication design, the design application of appropriate graphic language will attract the viewer’s instant visual attention.

4. Discussion

By analyzing the research progress of visual art in three-dimensional space and fine art space, this article expounds the related concepts of virtual reality and three-dimensional space. Based on the related theories of the art space visual art of the three-dimensional space of virtual reality, this article explores the design method of art space visual art and expression effects. Through the actual investigation method, this article discusses the importance of the virtual reality three-dimensional space to the visual art of the art space. Finally, it discusses the connection between virtual reality and three-dimensional space in the visual art design of art space.

In this study, a 3D model reconstruction algorithm is reasonably used to perform the reconstruction process. With the increasing scope and importance of 3D model reconstruction algorithms, many scholars have begun to compare some specific theories with real-world application scenarios to propose feasible algorithms. There are basically two types depending on the intended use of the 3D model reconstruction. The first category is to ensure the certainty of the collected data and remove uncertain parameters. According to algorithms, virtual reality and 3D space are indispensable elements of visual arts in art spaces.

Combining the general situation and development direction of virtual reality and 3D reconstruction, this article
Figure 10: Two-dimensional and three-dimensional comparison chart. (a) Bar graph of 61 survey samples in two-dimensional space and (b) 61-group survey sample bar graph in three-dimensional space.
makes a new attempt to digitally simulate the visual art of art space. And this article combined with the corresponding questionnaire to make certain research and exploration, and also laid a certain foundation for the development of art space in the future.

5. Conclusion

Starting from virtual reality and three-dimensional space, this article mainly discusses the relationship between the two and how to apply virtual reality and three-dimensional space to the visual art of art space. Based on the three-dimensional model reconstruction algorithm, it can be known that only when the unique virtual reality and three-dimensional space are applied, the visual art of the art space can give the most basic contemporary characteristics. Virtual reality and three-dimensional space are indispensable for the visual art and expression effects of fine art space. Unbounded imitation and copying will result in similarities and repetitions in art space design. This article needs to fully understand the importance of virtual reality and three-dimensional space. Because the research on virtual reality and three-dimensional space application involves a wide range of related scientific fields, the author is not talented, knows little about the world, and has weak academic theories and business capabilities. It is inevitable that there will be fallacies, and there are still certain problems in the design work. At the same time, this study is constantly discovering and solving problems, and trying to do better.

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 no conflicts of interest.

References


