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Digital Virtual Exhibition Paths for Art Museums Based on Internet and Virtual Technology

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ABSTRACT

There are many precious cultural relics collected in the art museum. If it is not properly managed, it will have a great impact on the economy and culture of the country. The construction of a digital art museum that represents the history and culture of the country is very important for the protection, research and dissemination of history and culture. Legacy plays a very important role. Therefore, the current art museum is no longer just a simple display, but more for people to appreciate and understand cultural knowledge, technology and feelings. Under the background and environment of informatization, the main forms of contemporary digital art museums are virtual exhibitions and virtual experiences. From the perspective of art museums, the authenticity of virtual reality is more significant, which can improve the audience's viewing and experience of various exhibitions. Therefore, under the support of digital technology, the museum combines various exhibits and technologies to present a brand-new "virtual" experience. Based on virtual reality technology, this paper combined digital technology and intelligent technology to establish a virtual display platform for digital art museums with rich content and open sharing. The optimization of the loading mechanism of the scene model can effectively shorten the loading time. When the distance between the viewpoint and the exhibits is within 2m, the optimized shortening time is 509ms. The system can display the virtual art gallery very well. Users can browse the cultural relics exhibits from different perspectives in the scene, so as to realize the real-time roaming of the virtual art gallery scene.

Keywords: Virtual Exhibitions, Art Galleries, Virtual Reality Technology, Internet Age

1. Introduction

As one of the carriers of art dissemination, art museums are entrusted with the important mission of developing and popularizing knowledge of art and culture. In order to promote the comprehensive dissemination of art and culture, applying virtual reality technology to it is a key decision towards the future, so that more good works can be popularized and a large number of art works can be

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shared with the world. Through the dissemination of the Internet, to attract a large number of art enthusiasts into the Museum of Fine Arts, in the development of the direction, clear positioning, so that visiting the Museum of Fine Arts into a universal social behavior, only then the Museum of Fine Arts will develop more and more better, the development of the national cultural enterprise can be everlasting [1-4]. Nowadays, with the development of the times, network information technology, the application of digital technology is becoming more and more common, especially the digital technology used to display exhibitions has received good results.

The digital virtual exhibition hall has unlimited expandability and innovativeness regardless of the work data or exhibition space, all of which can make the works better serve the society [5-7]. The application of digital technology in the display of exhibits in art museums can greatly promote the development of change in the industry, which is conducive to the exhibition halls to show visitors more exquisite and detailed art, humanities and science [8-12]. The digital virtual exhibition path, which provides a platform for art museums to interact, display and disseminate online, spreads around the world through VR and AR virtual viewing, greatly enhancing the popularity and dissemination of art museums at home and abroad [13-17]. In particular, the rapid development of AR technology in cultural tourism space, art museums display exhibition and other more application scenarios of the actual landing, to create a series of pioneering, groundbreaking large space AR cases, for the global art museums to provide a new curatorial ideas and exhibition experience [18-21]. Through the organic combination of technology and cultural tourism, it promotes the development and extension of the digital cultural tourism business in the new era, and also contributes to the close integration of technology and art on a global scale [22-24].

When constructing the virtual scene model, in order to test the load balancing mechanism proposed in the system, the static load balancing algorithm and the dynamic balancing algorithm are compared, and the running frame number of the dynamic balancing algorithm is stable between 55-64. The QEM simplification algorithm improves the simplification time by 145ms when the number of simplified triangles is from 100 to 200, which can better maintain the detailed characteristics of the model. When using the QEM algorithm to simplify the 60% effect operation, the simplification time increases as the number of triangle faces increases. When the number of triangular faces is 3091, the simplification time is 734.1ms. When the number of triangular faces is 4201, the simplification time is 1820.2ms. In order to test the user's browsing effect on the browser, the experiment found that the optimization of the loading mechanism of the scene model can effectively shorten the loading time. When the distance between the viewpoint and the exhibits is within 2m, the optimized shortening time is 509ms.

2. Method of Digital Virtual Exhibition Path of Art Museum Based on Internet and Virtual Technology

Digital technology refers to the use of technologies such as computers to convert substances or concepts into digital signals in digital form, and then the computer converts them into human senses (vision, hearing, touch, etc.). Many exhibits in art museums cannot be fully displayed due to various reasons, and even if there are, they can only be seen at a glance, and the use of digital technology for exhibitions has greatly alleviated these problems. With the rapid development of computer technology and network technology, and the widespread use of computer control, digital media, virtual reality and other technologies, the digital technology of the exhibition has undergone tremendous changes.

Virtual exhibition is a form of exhibition, and its ultimate purpose is to maximize information, rather than simply "graphics + multimedia". Instead, it adopts the form of rich media, such as "text + language + 2D cultural relic graphics + 3D cultural relic model + video + hotspot + interaction". It is spread through different terminal devices such as PC and mobile phone. A virtual exhibition is a system for disseminating information, and it is also composed of communicators, communicators and recipients. Combining the above-mentioned changes in objects, information, and people, a new display and communication method has been established. It is shown in Figure 1.

Art galleries communicate information to the public in the form of virtual exhibitions. Among them, the virtual display media includes digital information, technology and network. After the audience receives the information, the individual audience is not completely independent, because the socialization of the network audience mentioned above, the interaction between the individual and the individual also affects each other. Audiences go through three stages of cognition, emotion, and behavior, and combine them with their own prior experience. Under the selective attention (cognition), the audience has a strong interest in a certain exhibit or main exhibit, or even a deeper research. They will acquire more information through interaction, discussion, etc., and turn it into action, so as to have a new understanding of the virtual exhibition, thereby promoting their field trips to physical and physical galleries. The influence of noise on the communication system, such as network signal, viewer viewing and browsing environment, is unavoidable.

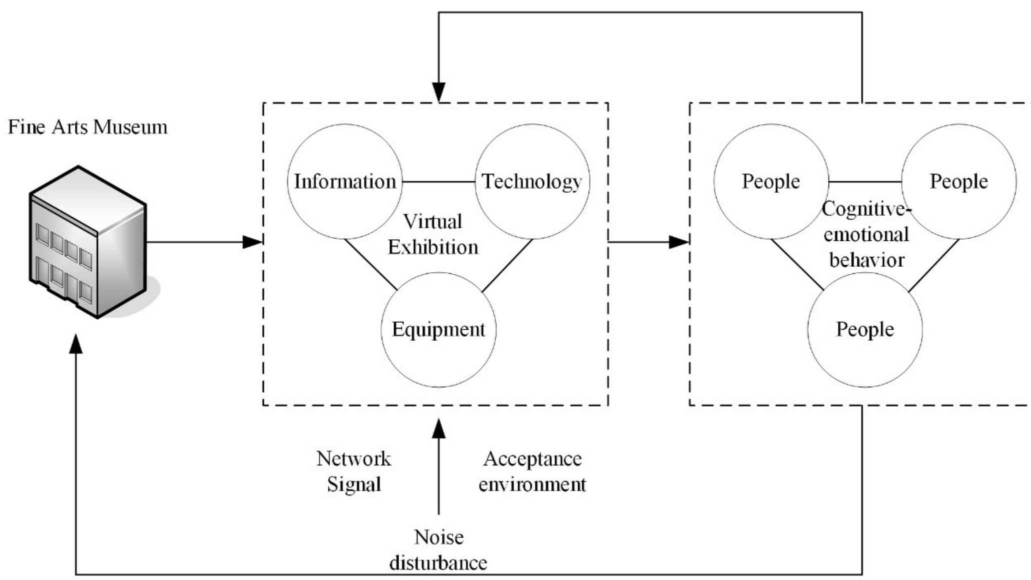


Fig. 1. Diagram of the dissemination mode of virtual exhibitions in art museums

The virtual exhibition system architecture of the art museum is divided into three layers: data storage layer, core business layer, and presentation layer (Figure 2).

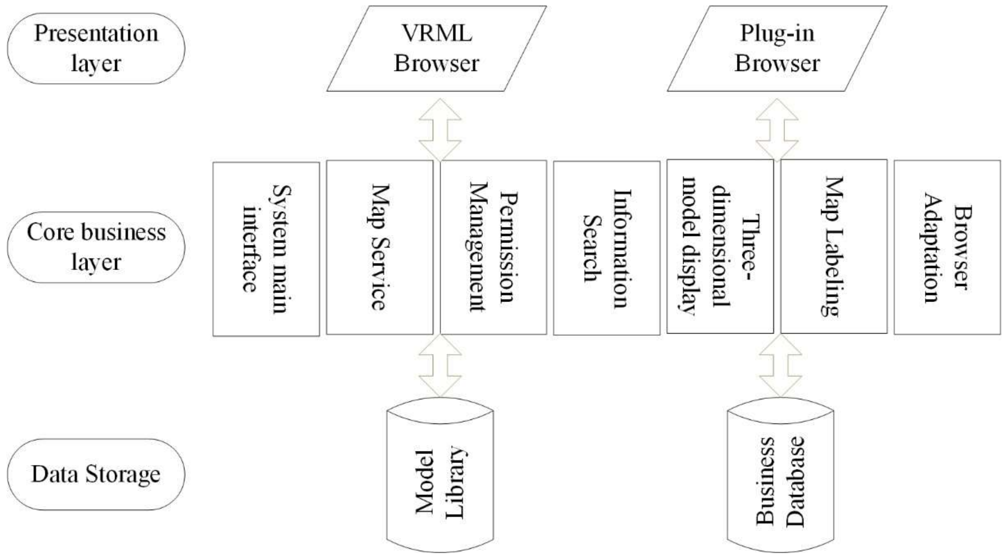


Fig. 2. Frame diagram of the virtual exhibition system of the art museum

Immersion, interactivity and creativity are basic and important attributes of virtual reality. Virtual reality is a computer-generated and digitally created panoramic virtual simulated environment based on visual and auditory representations. It shows a mirror image of the real world or any other completely artificially created fantastical environment. The experiencer is completely immersed in it and can interact with the virtual environment or objects existing in the space through some technical means. Immersive interactive virtual reality, including VR/AR, covers the visual field, is immersive, can move in space, and can interact physically. And based on the virtual reality engine, the spatial information is rendered in real time.

In the "Internet +" era, the basic resources for processing information data mainly exist in the server, and the dynamic configuration of the server must not only meet the needs of users, but also meet the response speed and convenience of use. With the integration of server resources with cloud computing, big data and other technologies, virtualized server configuration combined with virtualization software can easily achieve unified deployment and management of the experimental environment. The architecture of desktop virtualization is shown in Figure 3.

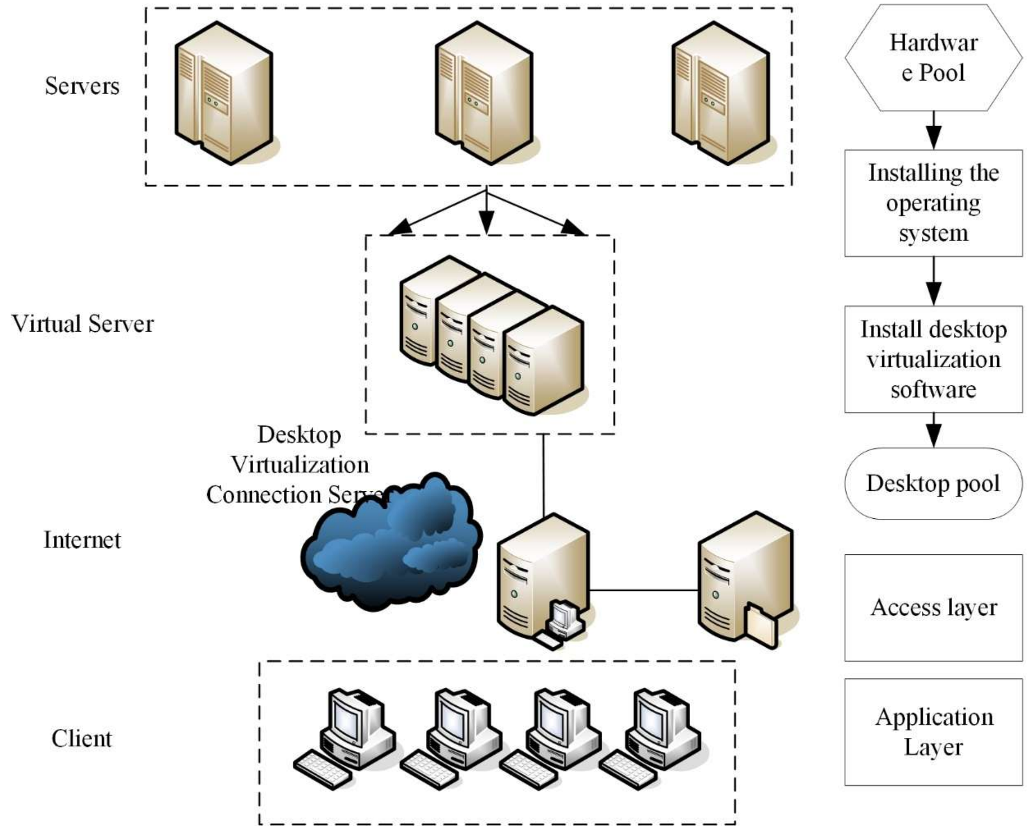


Fig. 3. "Internet +" desktop virtualization architecture

Load balancing, also known as load sharing, refers to real-time adjustment and processing according to changes in the load situation in the system, so that the load of each node is consistent. According to the time of tasks bound to processor nodes, load balancing strategies are mainly divided into static load balancing and dynamic load balancing. Static load balancing assigns task processes to processors during program compilation, which cannot meet the needs of dynamic and unpredictable parallel programs. The dynamic load balancing strategy maintains the balance of the system load by monitoring the load of each node during the running process, scheduling and relocating the running tasks. In a distributed virtual reality system, the load of nodes changes dynamically over time. In the initial operation stage, the mapping between tasks and nodes may become bad, so dynamic load balancing is used in the system to restore the balance of the system, so that the system always maintains efficient operation.

The dynamic load balancing algorithm mainly includes three stages: (1) node load information collection (2) decision processing based on load information (3) task migration. The load balancing problem is an NP-complete problem, therefore, it is impossible to achieve three-step simultaneous optimization, and can only try to achieve sub-optimization based on three-step compromise. In order to evaluate the performance of each node server more comprehensively, this paper selected multiple indicators to evaluate the load. The specific indicators are described as follows:

1) CPU utilization: CPU is the most important indicator to measure server performance, reflecting the CPU resources occupied by running programs. When the CPU utilization is too high, it means that the system is in an overloaded state, the number of task units is too large or the unit execution time is too long.

2) Memory utilization: The memory utilization indicates the memory spent by the process. If the hardware performance of the node server is quite different, the absolute memory (that is, the available memory) is often used to indicate its load. In a distributed virtual reality system, the

performance of each node server is not very different, and the memory utilization is used to measure the available capacity of the node server.
3) Disk I/O utilization rate: The disk I/O utilization rate mainly reflects the utilization rate of data access. The higher the utilization rate, the more frequent the data access is.
4) Bandwidth utilization rate: This parameter reflects the performance of server communication, and the system uses traffic within a fixed time interval to represent the server load.
5) Operational information of task units: The number and execution time of task units in the node server will directly affect the operation status of the node server. The use of task unit operation information can measure the system load more intuitively.

It is necessary to select a reasonable evaluation function to quantitatively calculate the load of the node server. The evaluation function is usually calculated by setting different weight values for the indicators and using appropriate mathematical expressions for combined calculation. The commonly used expressions are:
1) The indicators are added. This form is suitable for the value changes of the evaluation indicators that are independent of each other. It only affects the total evaluation value from the degree, but there is no qualitative distinction. Therefore, they can be linearly compensated for each other. Assuming that there is an evaluation index M_j composed of sub-evaluation indexes $M_{j1}, M_{j2}, \cdots, M_{jn}$, the composition of the evaluation function is as follows:

$$H(M_j) = \sum e_{ji} M_{ji} \tag{1}$$

2) Multiply the indicators. The form of multiplication of indicators is also suitable for the situation where the indicators are opposed to each other and has an impact on the total evaluation value. Compared with the form of addition of indicators, this form is more suitable for the situation where the compensation relationship between the indicators is weaker. The form is as follows:

$$H(M_j) = \prod_{i=1}^{n} \left(M_{ji}\right)^{e_{ji}} \tag{2}$$

3) Index substitution. This form is suitable for situations where each indicator can compensate each other, and its form is:

$$H(M_j) = 1 - \prod_{i=1}^{n} \left(1 - M_{ji}\right)^{e_{ji}} \tag{3}$$

The linear weighting method is based on the different proportions of each evaluation index in the total evaluation index. Weight parameters with different degrees of importance are set, and the weighted multiplied index values are added, and finally the value of the total evaluation index is obtained. The obtained total evaluation index value can truly reflect the real situation. According to the principle of linear weighting method, the capacity of the node server is evaluated, and the dynamic load value L of the design node is:

$$\begin{aligned} L = {} & L(\text{CPU}) * e_1 + L(\text{Task}) * e_2 + L(\text{Memory}) * e_3 \\ & + L(\text{IO}) * e_4 + L(\text{BandWith}) * e_5 \end{aligned} \tag{4}$$

Among them, e_i is the weight coefficient of each influencing factor, and $L(\mathrm{x})$ represents the measurement value of each resource capability. $L(\text{CPU})$ is the CPU load capacity. $L(\text{Task})$ is the load capacity of the task unit. $L(\text{Memory})$ is the memory load capacity. $L(\text{IO})$ is the disk IO load capacity. $L(\text{BandWith})$ is the negative load capacity of the network bandwidth. $L(\text{Task})$ is determined by the number of tasks in the node server and the task execution time, and the set of task units in the node server is defined as

$$T = (T_1, T_2, \cdots, T_n) \tag{5}$$

The execution time of each task unit is

$$t = (t_1, t_2, \cdots, t_n) \tag{6}$$

t_{avg} represents the execution time of each task unit node server when it is working normally, and the load capacity of the task unit is defined as:

$$L(\text{Task}) = a_1 \frac{t_{avg1}}{t_1} + a_2 \frac{t_{avg2}}{t_2} + a_3 \frac{t_{avg3}}{t_3} + \cdots + a_n \frac{t_{avgn}}{t_n} (0 < a_1 \frac{t_{avgn}}{t_n} \leq 1) \tag{7}$$

Among them, a_n is determined by the priority of the task unit and the size of the task unit. To prevent t_n from being too large, set the maximum value of $\frac{t_{avgn}}{t_n}$ to 1.

The flow chart of the design and implementation of the digital exhibition hall is shown in Figure 4. In the 3D scene of the virtual art museum, there are many exhibits of cultural relics, and the exhibits are the main objects for browsing and interaction. Therefore, the cultural relic exhibits must be modeled in detail, which will easily cause the vertices, edges and edges of the 3D mesh model in the scene. The number of polygons increases sharply, which increases the workload of the scene rendering model and causes the scene rendering speed to be too slow. In order to achieve smooth and realistic 3D visual effects, mesh simplification of the 3D model in the scene is usually required. For the special requirements of virtual art museums, the visual realistic effect is the main factor to be considered, so this paper simplified the model based on the visual effect.

Quadric Error Metric (QEM) uses the sum of squared distances from vertices to their associated planes as an error metric, and calculates the edge shrinkage cost according to the error metric. Compared with other algorithms, this algorithm has the following advantages: it is relatively simple, runs fast, consumes less memory, and the simplified mesh obtained can maintain a high overall model similarity. Multi-resolution LOD models can be generated for real-time display of the LOD models by reducing the simplified models of different hierarchies resulting from the reduction process.

The coordinates of vertex o in the 3D mesh are set to $\left(o_x, o_y, o_z\right)^T$, and the plane P is

$$ax + by + cz + d = 0 \tag{8}$$

$$a^2 + b^2 + c^2 = 1 \tag{9}$$

$$P = (a, b, c, d)^T \tag{10}$$

The square of the distance from vertex v to plane P is:

$$d^2(o) = (P^T o)^2 = o^T (PP^T) o = o^T K_P o \tag{11}$$

In the formula:

$$K_p = PP^T = \begin{bmatrix} a^2 & ab & ac & ad \\ ab & b^2 & bc & bd \\ ac & bc & c^2 & cd \\ ad & bd & cd & d^2 \end{bmatrix} \tag{12}$$

Assuming a vertex o in the mesh, the set of triangular meshes associated with vertex o is:

$$s(o) = (s_1, s_2, \cdots, s_N) \tag{13}$$

Then, the sum of the squares of the distances from any point in the mesh to the triangular faces in the triangular mesh set, that is, the quadratic error measure of the vertex, can be rewritten as the following formula:

$$\Delta(o) = \sum_{s\in s(o)} d^2{}_p(o) = \sum_{s\in s(o)} o^T (K_p) o = o^T (\sum_{s\in s(o)} K_p) o \tag{14}$$

$$W = \sum_{s\in s(o)} K_p \tag{15}$$

is the quadratic error measure matrix of vertex o, edge contraction operation

$$o_1, o_2 \to \tilde{o} \tag{16}$$

The quadratic error measure is the sum of the quadratic error matrices of vertices o_1 and o_2, namely:

$$\Delta'(\tilde{o}) = (\tilde{o})^T (W_1' + W_2')\tilde{o} \tag{17}$$

$W_1' + W_2'$ is the quadratic error measure matrix of the new vertex. It can also be written as:

$$\text{Error}(\tilde{o}) = (\tilde{o})^T (\sum K_P')\tilde{o} = \tilde{o}^T W' \tilde{o} \tag{18}$$

In the formula, K_P' refers to the sum of the quadratic error matrices of the two vertices in the shrinking operation.

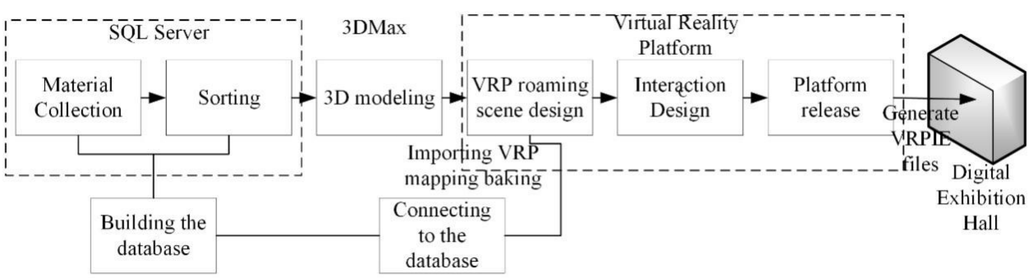


Fig. 4. Flow chart of design and implementation of digital exhibition hall

The 3D modeling implementation process is shown in Figure 5. The gallery is displayed brightly in the simulation of the 3D scene and is an important part of the virtual art gallery associated with the virtual gallery. In this configuration, the development of the scene of the virtual image is divided into two stages. In the first step of the art gallery, each grounded object is modeled, the second level has been integrated in a virtual environment, well modeled for all the simulated buildings.

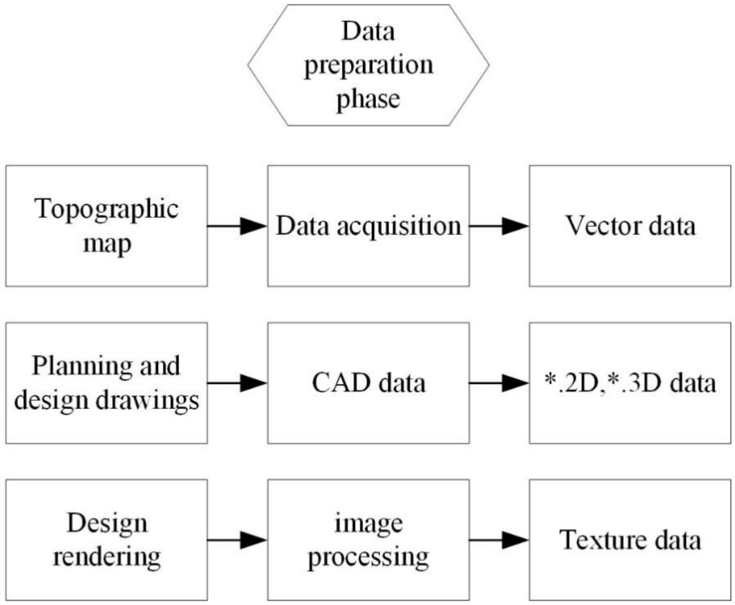


Fig. 5. 3D modeling implementation process

In computer graphics, polygon meshes are generally used to represent objects in the scene, and LOD models of different levels are provided for objects to achieve the purpose of controlling complexity and speeding up rendering. LOD models are usually generated by gridding. Mesh simplification refers to reducing the number of vertices as much as possible on the premise of retaining the shape characteristics of the original mesh, and using an approximate model to express the initial model. The usual approach is to remove some primitives (vertices, edges, or triangles) from the polygon mesh that have little effect on the appearance of the model or are considered "less important" to achieve its simplicity.

3. Experiment of Digital Virtual Exhibition in Art Museum

This paper summarized the development environment and operating hardware requirements of the immersive virtual reality interactive system, as is shown in Table 1. Five high-performance computers are selected in the system, one of which is used as a central server, and the remaining four are used as node servers. A small local area network is built with these five machines, and the interconnection between servers is realized through switches. The platform selected 0culus Rift CVl as the display device (resolution: 960x1080, screen: 5.7-inch OLE), data gloves and capture device as Noitom neuron, and the test was performed in a local area network with a bandwidth of 1Gbps. The hardware configuration of each server is shown in Table 2.

Table 1. System development environment

System Components	Development Environment	System Components	Development Environment
Development Platform	Windows 7	Development Tools	Visual Studio 2012,Unity3D 5.3.4,3ds Max 2016
Development Language	C#,C++	Software Platform	Unity 5.2
Operating Environment	CPU: 6.00GHz, GPU: 1GB video memory 810MHz core frequency	-	-

Table 2. Server configuration

Machine Category	Central Server	Node Server1	Node Server2	Node Server3	Node Server4
CPU	E3—1220V5 3GHZ	E3—1220V5 3GHZ	E3—1220V5 3GHZ	E3—1220V5 3GHZ	E3—1220V5 3GHZ
Memory	16G	8GB	8GB	8GB	8GB
Hard Disk	500GB	500GB	500GB	500GB	500GB
Operating System	16.04LTS 64bit	16.04LTS 64bit	16.04LTS 64bit	16.04LTS 64bit	16.04LTS 64bit

In order to test the load balancing mechanism proposed in the system, a local area network composed of five servers is built in the system. The central server is responsible for the collection and processing of load information and load scheduling. The node server implements load migration through task migration. The data of running performance is mainly obtained through the analyzer window in the Unity software. The specific mechanism is shown in Figure 6.

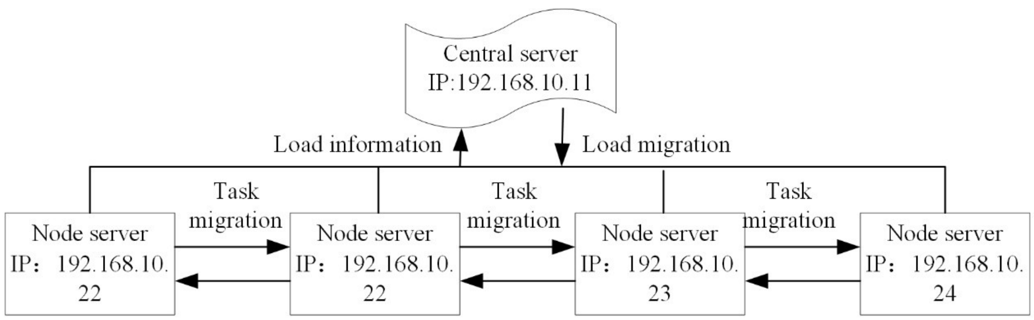
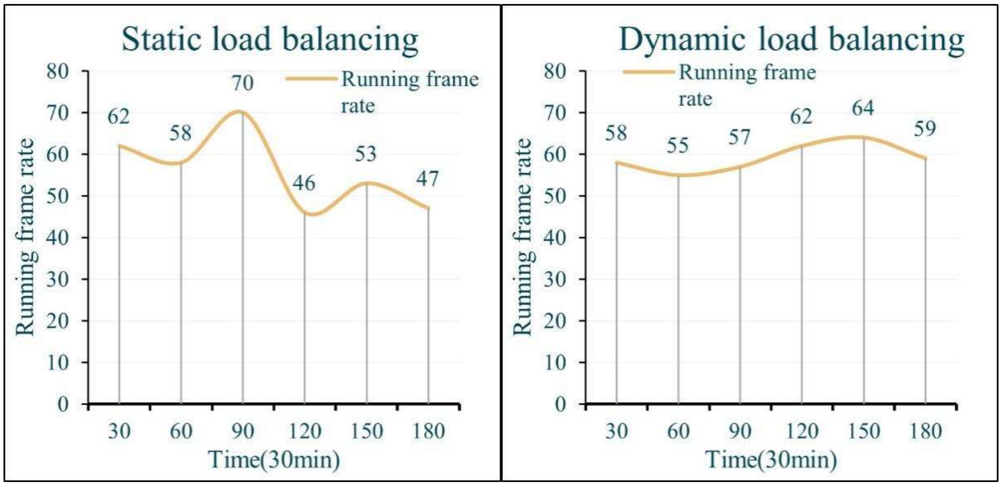


Fig. 6. LAN mechanism

4. Data of Digital Virtual Exhibitions in Art Museums

This article will compare the static load balancing algorithm and the dynamic balancing algorithm. The static load balancing algorithm divides task units according to the performance of each node server before the system runs. Migration of task units is not involved in the running process. Dynamic load balancing performs scheduling and migration of task units according to the load balancing of the system during operation. During the operation of the system, the performance monitoring of the node server is performed every 30 minutes. It is shown in Figure 7.



(a) (b)

Fig. 7. The number of frames running the two algorithms

It can be seen from Figure 7 that with the increase of running time, the number of running frames of the load balancing algorithm in this paper is compared with that of the static load balancing algorithm. The running frame rate remains relatively stable, between 55-64. In the initial stage, the dynamic load balancing mechanism runs at a lower number of frames than the static load balancing mechanism. Because in the initial stage of system operation, the system is in a state of equilibrium. A system using a dynamic load balancing mechanism needs to periodically collect and analyze the load information of each node. It is bound to increase the burden on the network and nodes and affect the overall performance. Therefore, the number of running frames will decrease when the system is in a balanced state. With the increase of time, the running state of the task unit changes, and there is an unbalanced state between nodes. The load balancing algorithm will be activated to migrate between high and low loads, which can effectively achieve load balancing of each node server.

Figure 8 shows the relationship between the QEM algorithm's simplification time and the number of simplified triangles.

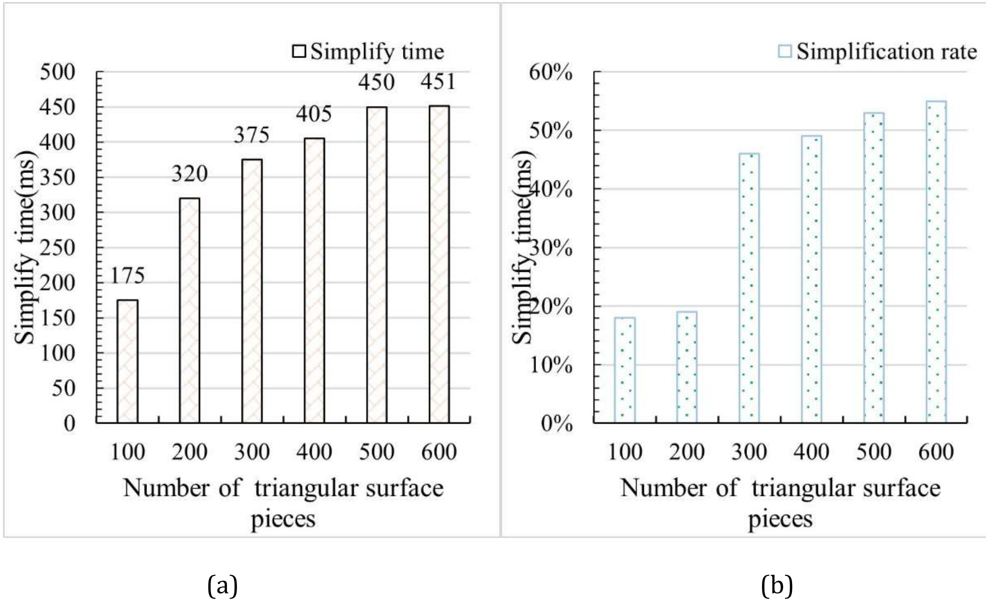


Fig. 8. QEM simplification time

It can be seen from Figure 8 that the QEM simplification algorithm has a faster simplification speed at the beginning of the simplification process. When the number of simplified triangles is increased from 100 to 200, the simplification time is increased by 145ms, which can better maintain the detailed characteristics of the model. This paper will use the QEM algorithm to simplify the effect operation by 60% on the five cultural relic models. The experimental results are shown in Figure 9.

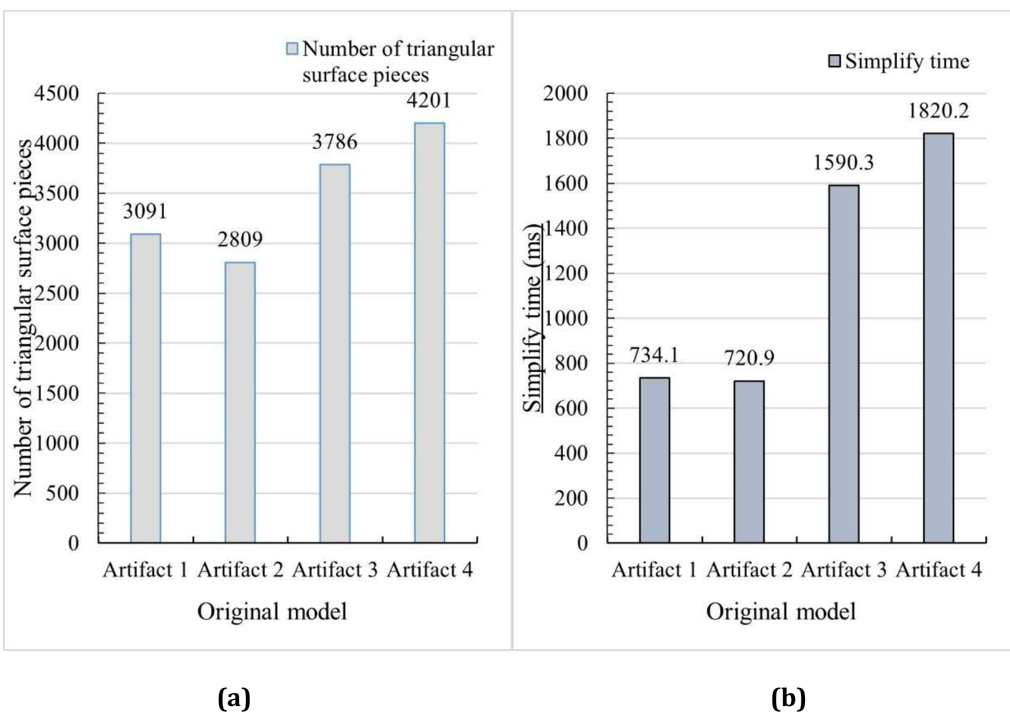


Fig. 9. Relic model QEM algorithm simplified time

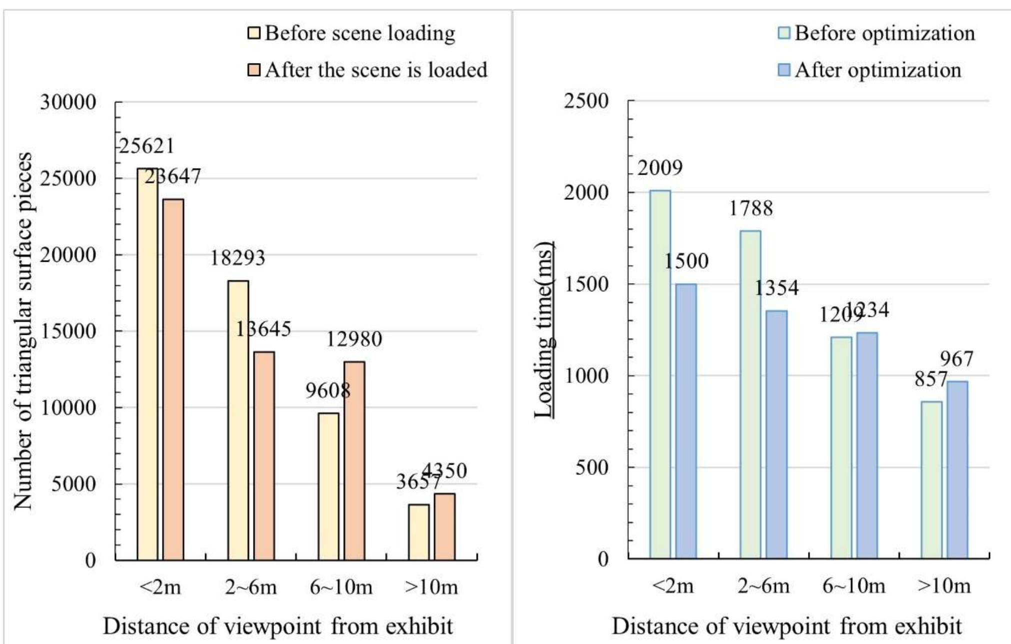
It can be seen that the algorithm has an advantage in maintaining the detailed characteristics of the model, and the simplification time increases with the increase of the number of triangle faces. When the number of triangular faces is 3091, the simplification time is 734.1ms. When the number of triangular faces is 4201, the simplification time is 1820.2ms.

A set of continuous or discrete simplified models is obtained by expressing LOD level of detail techniques with different levels of detail for model objects. The system mainly builds a multi-resolution LOD model for the cultural relic model in the scene, so the reasonable level of detail content to be displayed in the scene can be determined by means of the grid simplification algorithm. When switching between different resolution models, it must ensure that the difference is not large. It cannot produce abrupt phenomena, but the QEM algorithm based on vertex discrete curvature and local area area. The half-edge folding method used does not generate new vertices and is a subset of the original mesh model. Therefore, it is faster and more accurate to restore LOD models of different levels of detail.

Determination of a reasonable level of detail is the primary task of building an LOD model. Too many or too few layers are created to have an impact on the system. Therefore, based on the actual situation of the art museum scene, this paper divided the art museum scene model into four levels, and the scope of action of each level of detail is shown in Table 3. The virtual art gallery scene is displayed through a browser that supports HTML5, and the main test content is the user's browsing effect on the browser. Figure 10 shows the parameters before and after scene loading.

Table 3. Selection of LOD models

Level of detail	LOD1	LOD3
Range of action (m)	<2	6~10
Level of detail	LOD2	LOD4
Range of action (m)	2~6	>10



(a) (b)

Fig. 10. Scene loading data

It can be seen from Figure 10 that the loading time of the scene model can be effectively shortened by optimizing the loading mechanism. Especially when the viewpoint is closer to the cultural relic exhibits, the more obvious the optimization time is. When the distance between the viewpoint and the exhibits is within 2m, the optimized shortening time is 509ms. Because the model to be loaded at this time is relatively fine and the amount of data is large, it often exceeds the limited drawing time, so as to achieve the optimal picture quality and display time. The loading mechanism adopted in this paper can ensure the best loading LOD level of the current frame, and appropriately reduce the LOD level of some unimportant models, reduce the complexity of the scene, and improve the real-time performance of the system. When using a low-level LOD model, it can effectively increase the simplification quality of the model and ensure the best picture effect under the premise of not exceeding the limited time. The test results have shown that the system can display the virtual art gallery very well, and users can browse the cultural relic exhibits from different perspectives in the scene, so as to realize the real-time roaming of the virtual art gallery scene.

5. Conclusion

This article has introduced the basic concepts of virtual exhibition halls, the required software and its functions, and the various steps to build a virtual exhibition hall. 3DMAX software is used for model making, texture mapping, and realistic visual effects. Modeling of the 3D scene and work was done. At the same time, it paid attention to aesthetics and improves the artistry of visual effects. Under the traditional exhibition mode, art museums were usually limited to presenting certain physical art museum collections to the audience. Both virtual exhibitions and digital exhibitions constituted the key technologies for creating digital art museums. The art museum itself carries the responsibility of inheriting a long-standing civilization. Therefore, it is urgent to introduce information technology to serve the local people. Based on this, a new digital art museum exhibition form has been created. Therefore, in future practice, as art museums and their relevant departments, they still need to be committed to facing the overall information technology environment at this stage, and ensure that the means and methods of virtual exhibitions are used to optimize the digital art museum exhibition experience. The technical level of virtual exhibitions in art museums has been comprehensively improved.

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