Research on Interactive Design of Virtual Museum Based on VR Technology

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Abstract. In this paper, through VR technology and human-computer interaction technology, using JavaScript and C# language, etc. We study the implementation of a virtual museum and improve the interaction design in the virtual museum to explore a novel and public-compatible virtual museum, so that users can achieve the effect of multiform interaction experience. The virtual museum in this study can break some of the limitations of traditional physical museums and realize the preservation of cultural relics on the basis of cultural dissemination, while meeting the needs of the public in all aspects. It also shows that interaction design is inevitably an integral part of virtual museums and plays an important role in their promotion in order to be the main direction of development.

Keywords: Virtual reality technology, Virtual museum, Interaction design, User experience

1 Introduction

With the continuous improvement of people's living standards and the continuous development of social science and technology innovation, virtual reality technology has become more and more common in various industries, VR technology is also very widely used, thus reflecting people's pursuit of spiritual culture more and more intense. Through some international virtual museums, it is easy to see that the traditional museum display mode and concept can no longer meet the needs of the public. Today's users are good at using the Internet to obtain relevant information, which is naturally a key point that cannot be ignored. The virtual museum is based on VR technology, based on the user experience perspective, to achieve human-computer interaction, so that the exhibition hall effective information quickly and three-dimensional presentation to the user. It allows users to experience the charm of the museum through cell phones alone. Interaction design as a technology application, not only allows people to be in the virtual space environment, all-round visit to the museum, but also to enhance the user experience, to achieve multi-sensory information, multi-level communication. This approach not only saves some of the resources of

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offline physical exhibition halls, but also allows users to realize the freedom of visiting without space constraints [1].

2 Related theories and technologies

2.1 Meaning and characteristics of VR technology

VR is the full name of Virtual Reality, and VR is the use of computer and Internet technology to create a virtual environment through simulation systems that simulate sensing devices and sensory perceptions to bring users an immersive experience and provide a new interactive experience [2]. The current virtual reality technology has been successfully applied to several scenarios, such as "virtual classroom", "virtual house viewing" and "virtual tourism". These virtual businesses are very popular, but research shows that most programs and platforms take traditional resources, such as pictures and videos, which are relatively single-mode and not really designed for interaction based on VR technology, resulting in no good experience for users.

VR technology has the characteristics of multi-perceptiveness, immersion, interactivity, conceptiveness and autonomy. The current multi-perceptual features of VR technology include basic perceptions such as sight, sound, and touch. This multisensory feature allows users to feel immersion and the "real world" brought by VR technology in the virtual environment. The interactivity refers to the user in the use of the process of human-computer interaction with objects and the environment in the virtual scene, so that the touch in the virtual scene becomes more real, and "remote control" of objects. The autonomy of VR technology is also a key feature, as objects in virtual scenes can objects in the virtual scene can follow the objective laws of movement. For example, objects thrown from high places will naturally fall to the ground, and this simulation of reality will enhance the user's sense of immersion and experience.

2.2 Principle of Human-Computer Interaction Technology

Human-computer interaction technology is widely used, especially in the field of virtual reality, which can bring different experiences to users. Human-computer interaction technology refers to the exchange of information between human and computer. It incorporates multiple technologies, as shown in Figure 1.

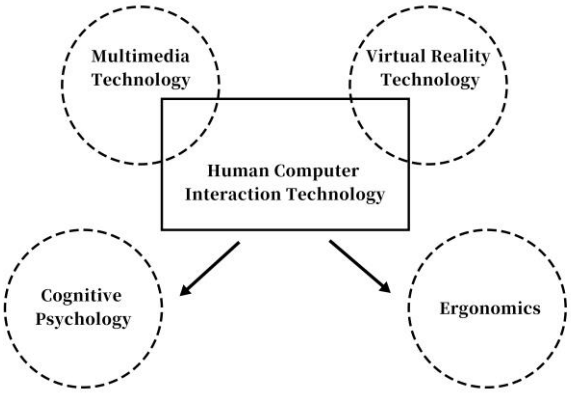

Fig. 1. Diagram of the relationship between HCI and other related disciplines.

In fact, the interactive interface is the most essential presentation of human-computer interaction. The process of human-computer interface interaction is that the user inputs information into the computer, and then outputs it to the user after information processing, as shown in Figure 2 below.

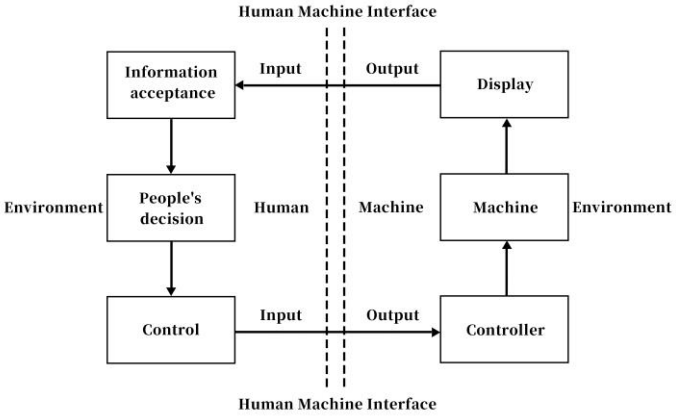

Fig. 2. Human-machine interaction interface diagram.

2.3 LOD Technology

LOD technology is called Level of detail, which means multi-level detail. It is a 3D object optimization technique, which can choose the level of the museum according to its location and model characteristics, LOD technology can realize different 3D models with different parameters, and improve the efficiency of the operation by reducing the level of unimportant models. LOD technology is a popular technology and has been used in many software system models to optimize the LODs, which require an artist to handle the LODs and create a customized Pipeline [3].

2.4 System Language

The main languages used in the development of the system are JavaScript and C#. JavaScript is known as a scripting language for developing Web pages. It is an object-oriented language that provides a fully runtime object system, and JavaScript can be used in a clever way to achieve asynchronous processing with a single thread. It has a good security mechanism and can provide a perfect exception handling mechanism, which makes the program more powerful [4].

2.5 Collision detection algorithm

When entering the virtual museum, users will inevitably collide with objects in the experience, so in order to better improve the virtual scene, collision detection algorithms are needed for collision detection. Collision detection can improve the restoration of the virtual museum, enhance its immersion and interactivity. The OBB detection algorithm is the directional bracketing box detection algorithm, which is considered the standard algorithm for collision detection because it is the fastest detection algorithm when it was first proposed [5]. The principle of the OBB collision detection algorithm is to first cut all polygons with three extra edges into triangular slices, and let the vertices of the i triangular slice be p^i, q^i, and r^i, respectively, then we have.

$$\mu = \frac{1}{3n}\sum_{i=0}^{n}\left(p^i + q^i + r^i\right) \tag{1}$$

$$C_{jk} = \frac{1}{3n}\sum_{i=0}^{n}\left(\overline{p}_j^i \overline{p}_k^i + \overline{q}_j^i \overline{q}_k^i + \overline{r}_j^i \overline{r}_k^i\right), 1 \le j,k \le 3 \tag{2}$$

The flow of collision detection is shown in Figure 3.

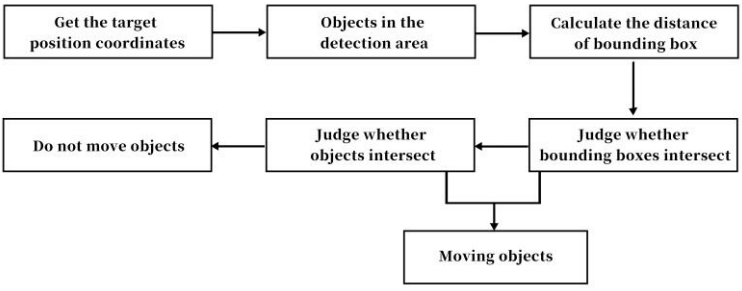

Fig. 3. The process of collision detection.

3 Virtual Museum Requirements Analysis and Design Summary

3.1 Demand Analysis

When users use the virtual museum system, they can tour the pavilion and experience the culture simply through the computer and the Internet. The comparison between the physical museum and the virtual museum is shown specifically in Table 1.

Table 1. Comparison table between physical and virtual exhibition halls.

Contrasting features	Physical Pavilion	Virtual Pavilion
Carrier	Placement of exhibits in physical pavilions by matching	Through the form of sound effects, video and interactive games
Mode	Single display form, fixed tour route	Combined with VR technology to enhance the visual effect and interactivity of the exhibition hall
Information Resources Utilization	Limited information resources	Huge information resources
Theme Selection	Older themes	Variety of themes
Processing speed	Slower	Very fast

The analysis of the table shows that the virtual museum not only has advanced science and technology, but also can store a large amount of information resources, good tour effect and diversified themes can enhance the user experience, human-computer interaction can also let the user and the exhibits interact and resonate with each other.

3.2 Design Outline

For the design of the virtual museum, the user's cognition and operation of the system should be fully considered, with a perfect functional system to bring the user a practical experience. As far as possible to restore the physical museum function is the basis of the system, the design on this basis also consider the following points. The first is to classify and manage the information, store it as a background resource, and complete a good data organization. Secondly to establish the specific application of VR technology in the scene, such as exhibit information introduction, physical display and human-computer interaction activities and other operations. Finally, the simulation of visiting perspectives and routes is carried out to add multi-view and multi-route modes without changing the structure of the physical museum as a way to meet part of the user's needs.

4 Detailed design of the virtual museum

4.1 Construction of the system model

The virtual scene can be constructed by CAD to obtain the relevant data, after which the model is constructed. This includes the spatial layout and exhibits on display. Firstly, the space and exhibits can be built by 3DMax software, and after that, Unity3D can be used and the parameters can be set to build the environment. In the model construction, attention should be paid to the optimization of polygon model.

4.2 Optimization of collision detection algorithm

According to the analysis of collision detection algorithm mentioned before in the paper, it can be seen that OBB algorithm has good tightness and high detection efficiency. The tightness is related to the simplicity of the enclosing box, the simpler the enclosing box, the worse the tightness, which leads to a low accuracy rate in collision detection for simple models [6]. Therefore, this paper proposes an optimized OBB collision detection algorithm to meet the requirements of collision detection in virtual environments. Since the center of the OBB is a vertex formed by the stitching of the triangles, if the size of these triangles is different, the calculated enclosing box will definitely be different, which will also have an impact on the collision detection results. The solution is to weight each triangle by giving the area of the triangle as the weight[3]. Let the area of the i triangle be denoted by A^i and the vertices of the i triangular piece be p^i, q^i and r^i, then.

$$A^i = \frac{\left|\left(q^i - p^i\right)\right| \times \left(r^i - p^i\right)}{2} \tag{3}$$

The surface area of the wrapped object is denoted by A, then.

$$A = \sum_i A^i \tag{4}$$

The center of the i triangle is denoted by m^i, then.

$$m^i = \frac{p^i + q^i + r^i}{3} \tag{5}$$

The center of the enclosed triangle with power is denoted by m, then.

$$m = \sum_i A^i m^i \tag{6}$$

Elements of the covariance matrix C.

$$C_{ij} = \int_H f_{ij} d\sigma = \sum_{k=1}^{n} \left[\frac{A^k}{12} \left(9 m_i^k m_j^k + p_i^k p_j^k + q_i^k q_j^k + r_i^k r_j^k \right) - m_i m_j A \right] \tag{7}$$

4.3 System Interface

When the user enters the interface, the first thing shown is the introduction of the virtual museum, so that the user has a preliminary understanding of its exhibits and environment. After that, users can enter each theme exhibition hall through the interface menu, or enter the exhibition hall through map roaming. For the convenience of users, a learning manual is also included in the interface design to facilitate users' quick integration into the virtual museum. By clicking on the ground, you can move forward, and by rotating the exhibition hall, you can control the multi-viewing angle.

4.4 Interaction design concept

In the virtual museum, interactive functions can be realized through video, allowing users to have an in-depth understanding of the information related to the exhibits. Scene interaction can also be added, so that users can interact with the environment in the scene, and truly experience the story of the era in which the exhibits are located. The use of VR technology and collision detection algorithms allows users to experience the charm of the virtual museum in an immersive way. In the scene, users can pick up the exhibits for multi-directional viewing, and even use virtual simulation technology to disassemble and combine the exhibits to give users an in-depth understanding of their internal structure [7]. In addition to visual interaction, there will also be auditory interaction. 3D narration allows users to immerse themselves in the virtual scenes, and voice recognition technology allows users to ask and answer questions in real time with virtual docents. Users who are online at the same time can also communicate with each other, adding to the interactivity of the system. At the same time in the virtual environment, will also be integrated into some games, for example, through the selection of materials to create the corresponding exhibits, so that users can understand the exhibits, but also to increase the interactivity of the fun. Or the interactive game of heritage quiz, where users can click on the answer button to earn points, which can be exchanged for corresponding cultural and creative products.

5 Conclusion

This paper presents an in-depth study on the design of the virtual museum system based on VR technology and collision detection algorithms, using human-computer interaction techniques. The implementation of the system. The system contains the database and relevant information materials of the museum and optimizes the collision detection algorithm used in the system. The UI design direction is specified, and the system interaction effect is made more realistic by combining it with VR technology. The traditional display form is expanded from single-dimensional to multi-

dimensional, static to dynamic, and spaced screen viewing to being in it. Using rich interaction design to attract users' curiosity and design a more experiential and high level virtual museum.

References

1. Zhao Qinping. Overview of virtual reality [J]. China Science (F: Information Science), 2-46 (2009).
2. Chen Haolei, Zou Xiangjun,Chen Yan, Liu Tianhu. The latest development and prospect of virtual reality technology [J]. China Science and Technology Paper in Line, 1-19 (2011).
3. Bian Huan. Research and implementation of online virtual museum based on VR [D]. Xi'an University of Petroleum, 8-27 (2020).
4. Zhao Wei. Research on virtual reality software [J]. Computer Technology and Development, 12-14 (2016).
5. Zheng Hua, Liu Jia. Web-oriented building model analysis and collision detection [J]. Journal of Shijiazhuang Railway Vocational Technology College, 89-94 (2016).
6. Cui Hanguo, Chen Jun, Wang Dayu. Research on optimized OBB collision detection algorithm in virtual environment [J]. Hubei Naval University of Engineering, 54-56 (2007).
7. Lv Ping, Yang Pengfei, Li Xu. Interactive Design of Virtual Museum Based on VR Technology [J]. Packaging Engineering, 138-140 (2017).