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Design and Development of Ship Virtual Roaming Design and Assembly System based on VR

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Abstract

The artistic design of cruise ship interiors is getting more and more attention because of the gradual popularity of cruise travel. This article is different from the traditional interior design method. It uses virtual reality technology, takes the cabin of a domestic medium-sized cruise ship and a certain section of the engine room as the research object, and combines the Unity3D engine to develop a ship virtual roaming design and assembly system. In this way, it will explore the new model of "VR + ship interior + assembly". The system design serves conceptual design users and engineering construction users through virtual space display and interaction, with different functions. The system can not only enhance the design expression information of conceptual design users and improve the assembly design efficiency of engineering design users, but also multi-scene design with strong scalability and can be applied in multiple fields.

Keywords

Virtual Reality; Cruise Ship; Interior Decoration; Assembly; System Design.

1. Introduction

In today's era, China's national economy is developing rapidly and people's living standards are constantly improving. Cruise tourism has gradually become the country's best choice for high-end leisure entertainment and healthy life. The livability of its interior has been paid more and more attention to the overall performance of cruise ships[1]. Comfortable interior layout, convenient and reasonable interior engineering design can greatly improve the comfort experience of passengers.

Traditional cruise interior design can be divided into two types: drawing design and physical model design. The expression of the form of drawings requires mastering of drawing technology, and the cost of learning is relatively high. Moreover, 2D drawings lack more information than 3D solid models, which makes it difficult for users to understand and apply. Although the expression of the physical model will give the design user a real feeling and understanding, it consumes huge manpower and material resources and covers a large area, which is not suitable for designing large-scale projects.

Compared with traditional cruise ship interior design, Wang Zhen[2] team has already explored the new model of "VR + ship interior" in China, which can roam in the virtual space and experience the various design styles of ship interior. This design method focuses on the sensory experience of the design and is suitable for conceptual design users, but lacks the assembly process and details of the ship's interior, and does not consider the experience of engineering design users.

This article is based on VR technology to develop a ship virtual roaming design and assembly system. It increases the internal assembly process and detailed information, which can not only display the information of the cruise ship interior design in a completely virtual space, and let the designer intuitively feel the different design styles, but also design the internal assembly details and program components . The system explores a new model of "VR + ship interior +

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assembly", mainly serving users of ship internal conceptual design and engineering construction users, and can improve their design efficiency.

2. System application and logic

2.1. The application of the system in cruise ship interior design and piping system assembly

The theme design of a cruise ship refers to a specific concept as the starting point, the interior and exterior design of the cruise ship is designed to show the cultural concept and artistic style of the concept[3], and only show the unique personality of the theme from the perspective of the cruise space atmosphere and appearance style. Let visitors experience the unique charm of the theme. The interior theme design elements of the cruise ship include color matching, lighting, furniture, wall design, space layout, etc., which are all used as the operating objects of the virtual space cruise interior design.

The application of the model in virtual assembly requires that the model assembly process be realistically simulated according to the model's shape characteristics, accuracy characteristics and model constraint relations [4], and it also allows users to control the virtual assembly process of the model through interactive means to verify the model's assembleability ability. There are various piping accessories for piping assembly, which serve ship cabins and purposes. The piping can be divided into multiple systems and types. Therefore, there are many assembly parts and the assembly is complicated. This is in the virtual environment without the actual assembly conditions. The assembly of components is particularly important.

2.2. System product logic

The system is currently in the conceptual design stage, using Unity3D development, combined with SteamVR SDK to develop a virtual roaming system. It has functions such as scene layout interaction, scene roaming, and model assembly operations. It mainly serves conceptual design users and engineering design users, and provides virtual design space. The system allows users to assist users in designing cruise ship interiors and assembly details in a virtual space with a design approach that is close to reality and convenient, which helps improve design efficiency.

Wearing the HTC VIVE suit, the user can roam in the virtual space generated by the system, observe the layout of the cruise cabin, and interact with the scene elements. When designing the interior, the user can define the assembly process, analyze the interference of the assembly path, and analyze the model components. Cooperating situation and time consumed.

3. System development

3.1. System environment and development process

The ship virtual roaming design and assembly system based on VR technology has certain requirements for software and hardware. The specific development environment is shown in Table 1 below.

Table 1. Development environment configuration

System environment	Hardware equipment	Software	Other
Windows 10 Pro	HTC VIVE Cosmos Elite set	Visual Studio 2019	Plug-in:Steam VR Plugin 1.2.3
Microsoft.NET 4.7 or higher framework	DELL computer	Unity3D 2019.4.23f	Development language:C#
--	--	Substance Designer 2.17.1.2	Database:SQL Server 2012
--	--	Autodesk 3ds Max 2016	Plug-in:Steam VR Plugin 1.2.3

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This system mainly uses Unity3D engine for development, and the platform undertakes most of the development work. The general process of the system design is shown in Figure 1:

(1) Establish scene model and built-in part model through 3D modeling software (3D Max, SolidWorks).

(2) Make a material file with modifiable parameters through the material mapping software (Substance Designer).

(3) Configure and write HTC VIVE VR device interactive interface.

(4) 3D model and material file import, data interface configuration.

(5) Model and scene layout, lighting, material, and interactive rule design; model and scene resource display optimization, reducing the computer's CPU and memory consumption.

(6) The collision detection strategy design and optimization of the model reduce the computer CPU and memory consumption.

(7) The camera operating angle of view simulates human eye roaming.

(8) Interactive design of part model assembly, construction of assembly tree, and optimization of assembly information.

(9) The data interaction between the database and the system mainly stores assembly tree information and model and scene parameter information.

(10) Configure and compile the output interface, and the system finished product is packaged and released.

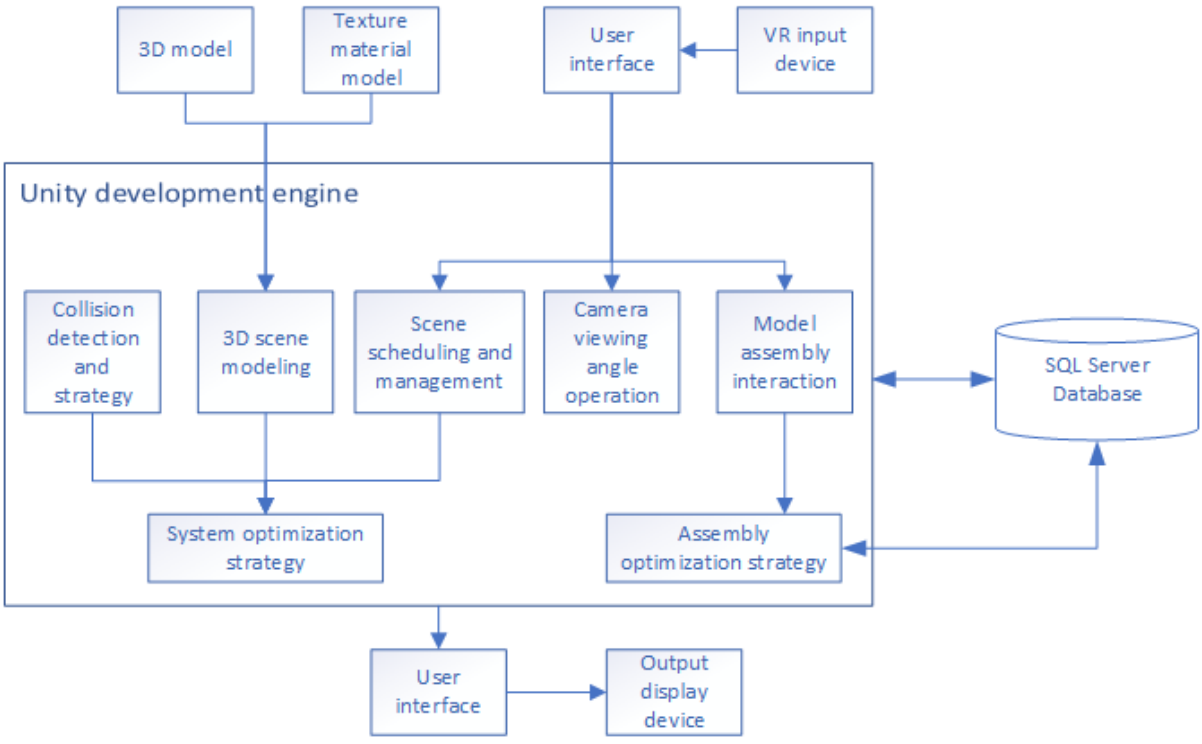

Figure 1. Design process of virtual roaming system

3.2. System design architecture

The architecture of the system is shown in Figure 2. The system serves conceptual design users and engineering design users, and different users have different emphasis on operations in the virtual space. Conceptual design users focus on the overall layout and look and feel of the interior, and the interaction focuses on theme selection, light source layout, component placement and component material look and feel design; Engineering design users focus on the

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specific details of component assembly and space utilization design, and the interaction focuses on component assembly sequence, component selection and component material adjustment.

The interaction of the scene is close to reality, and collision detection runs through the interaction operation. Concept design user's collision detection focuses on the detection of character models and scene parts, which is in line with the concept of serving the perception experience; The collision detection of engineering design users not only pays attention to the detection of the character model in the scene parts, but also the detection between the scene parts, and the collision detection accuracy is higher.

As the support of interactive data, the database also runs through the interactive operation. Data information that is highly relevant to conceptual design users includes lighting parameters, component location parameters, component material parameters, theme and component type parameters; Data information that is highly relevant to engineering design users includes component material parameters, component type parameters, data on the fit between components, assembly tree data, assembly man-hour information, etc. The above information is stored in the database in a data type that can be recognized by the SQL Server database and serves the virtual roaming system.

In addition, the system supports data export operations. Conceptual design users can set the camera angle of view and export the scene interior display diagram; engineering design users can export component assembly tree files and information files for auxiliary analysis.

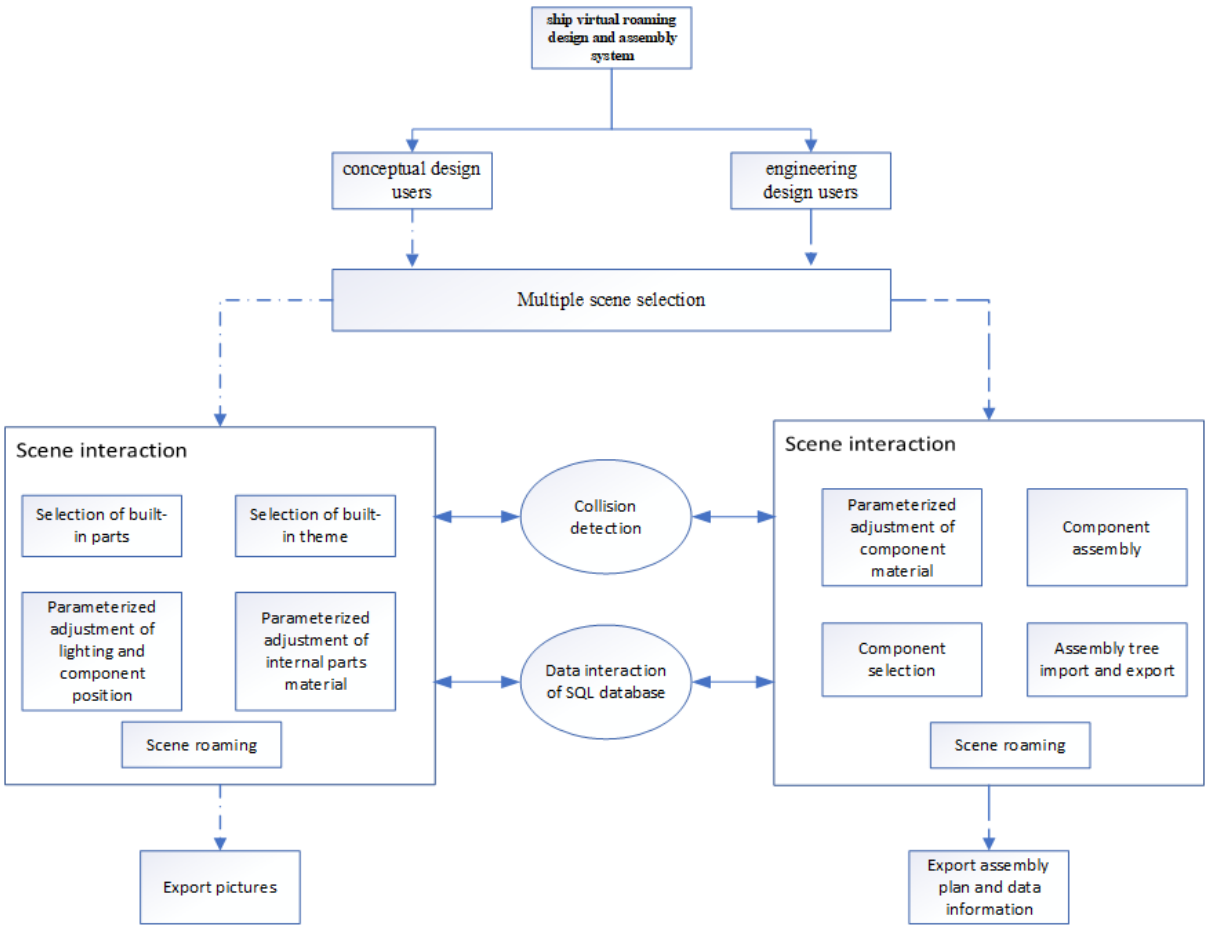

Figure 2. System architecture

This system currently only designs two virtual scenes, namely the cruise ship living cabin and a certain section of the engine room. The living cabin focuses on interior design, suitable for conceptual design users, focusing on roaming in the virtual cabin, and interactive layout of

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interior styles; The segmented engine room piping system is dense, focusing on the piping model assembly design, suitable for engineering design users, focusing on component coordination, interference detection, and design assembly process.

3.3. The key technology of system development and application

3.3.1. 3D modeling technology

The three-dimensional model in the virtual space is composed of points, lines, and surfaces. The "polygon modeling" technology is commonly used in 3DMAX software. After the model is converted into an editable polygon, the shape of the model can be modified and subdivided. Polygon tessellation technology can give the model a smooth surface. The degree of smoothness depends on the number of model edges and the number of iterations. The higher the number of model edges and the higher the number of iterations, the smoother the model surface.

Models based on 3DMAX only have shape and material information, but no assembly information. Solidwork software is used for modeling. The model file is used as a separate part and has part assembly information.

3.3.2. Database interaction technology

The operation of the system will continue to use or generate data, and there must be a database for data support. For data communication between the system and the database, the system reads the system initialization parameters from the database, reads equipment parameters, lighting parameters, etc., and also writes equipment and lighting parameters, assembly information, analysis results, etc., to the database.

Data interaction is mainly through configuring and calling Unity's class library System.Data.dll to operate SQL Server database for operations such as adding, deleting, checking, and modifying. The operating language is Structured Query Language (SQL).

3.3.3. Layered accurate collision detection technology

In the virtual space, a three-dimensional 3D model is described by nodes. If a node of the model falls in the body of another model, it will inevitably cause the phenomenon of "penetration" between the two models, which cannot happen in reality. In order to simulate reality, it is necessary to provide model collision detection technology. Collision detection algorithms can be divided into three categories[5]: bounding box hierarchy method, distance tracking method, and space subdivision method, among which bounding box hierarchy method is the most widely used. In order to meet the requirements of high-precision virtual assembly, the system adopts the layered accurate collision detection technology proposed by Liu Jianhua[6], including the layered collision detection algorithm of the containment box layer, the middle layer, the surface layer and the precision layer. Achieve precise component assembly.

3.3.4. Intelligent algorithm of assembly path

In the research on path planning of piping system virtual assembly [7], Tian Xiufeng [7] proposed a path planning algorithm based on the matching relationship that follows the principle of "detachable and assembled". This system is developed based on this algorithm, and an algorithm suitable for this system is proposed according to the actual use. Assembly planning includes assembly path planning and sequence planning. Based on assembly process rules and reasoning algorithms, an assembly sequence that conforms to the actual situation is obtained. The assembly sequence is determined by the constraint relationship between components and is an important factor in assembly.

3.4. Optimizeable space

On the basis of basic functions, this system should also consider the performance of the system, improve the user experience, and reduce system stalls, slow operation, weak compatibility and other issues. The angles considered are as follows:

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(1) When the system interacts with the database, if the amount of data is large, poor query code will seriously slow down the query speed. The principle of database optimization query is to eliminate full scan query and use index query.

(2) The full-space application of high-precision 3D models is a huge waste of resources, but the details are rich. To this end, each model is prepared for two types: low-mode and high-mode. The high-mode baking renders the texture to give the low-mode, which consumes less resources and has rich model details.

(3) In order to focus on the use of "occlusion culling technology", within the camera's perspective in Unity, the part of the model that is occluded by the object is not rendered, only the visible part is rendered. This can greatly reduce the consumption of computer resources.

(4) In the camera's perspective, the model can be seen near and far, then use the "multi-level of detail LOD technology" to use high-precision models near and low-precision models in the distance, which can reduce the consumption of computer resources while reasonably meeting the needs of use.

4. Conclusion

The design and development of this system serves users, providing users with a virtual space interaction platform, which visualizes the design information and assembly information of the built-in scenes in the virtual space. The new model of "VR + ship interior + virtual assembly" allows design users to carry out design work from a new perspective, with richer design display details than graphic design, and a design method that is more convenient than actual sample design and has a higher fault tolerance rate, which improves design user productivity. Moreover, the multi-scenario design of the platform is highly scalable and can be applied in multiple involved fields.

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