Construction of Robotic Virtual Laboratory System Based on Unity3D

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Abstract. Paper introduces the virtual reality laboratory system based on virtual reality technology. Using the Unity3D engine, the robotic arm is used as the research object to develop the virtual simulation teaching system. The system is released on the PC side and applied to the teaching and training of the mechanical arm structure. Establish a virtual laboratory to realize the first person perspective roaming, on-the-spot observation robot arm structure, assembly virtual interaction simulation, intelligent automatic assembly simulation, solve complex mechanical structure cognitive teaching and assembly planning problems. The application of powerful virtual reality technology to engineering technology teaching has improved the teaching effect and teaching efficiency of mechanical structure cognition, structural assembly training, curriculum design and other teaching links.

1. Introduction

Virtual assembly simulation teaching has always been a research hotspot in the teaching of virtual manufacturing technology at home and abroad.

The teaching method comprehensively utilizes computer-aided design, virtual reality technology, modeling and simulation technology, and information physics system for students, from the perspective of product assembly, carrying out exploratory experiments, cooperative learning and innovative practices has established an immersive virtual environment, adding ideas to the laboratory construction [1]. Because robotic arms have a large market share and broad application prospects, universities and educational institutions attach great importance to the teaching and application of robotic arms, and take it as one of the important research objects of mechanical students in teaching and practice.

The traditional college teaching has the following disadvantages: ① With the rapid development of science and technology, new concepts and methods continue to appear in the field of mechanical engineering, and educational institutions need to be constantly updated and improved to meet new educational needs, which is difficult to achieve for any educational institution. ② Traditional experiments require sufficient mechanical hardware equipment, experimental space, and experimental support personnel. These are often difficult to meet the students' experimental learning needs during the mechanical arm experiment. ③ The safety of real robotic arm experimental platform is also questioned. These problems have greatly restricted the development of robotics and the improvement of the quality of robotics talents.
As the construction of virtual laboratory education in China enters the stage of large-scale, systematization, standardization, and sustainable development, by integrating 3D modeling technology and virtual reality technology, the entire robotic arm virtual laboratory is interactive and immersive. Applying this system to the teaching of related courses in colleges and universities can enable students to repeatedly observe the mechanical arm structure with this system, better understand the teacher's theoretical explanations, and avoid the hidden safety hazards that occur in real mechanical practice, and improve the teaching quality.

2. Basic Structure and Structural Analysis of a Robotic Arm

Robots are one of the greatest inventions of mankind in the twentieth century. Research on robotics has a long history.

Since the last century, with the rapid development of computer control and artificial intelligence, robot technology has also achieved rapid development and has become a high-tech combination of multiple disciplines.

Manipulators are the main form of industrial robots, with 3 to 6 degrees of freedom of movement. As shown in Figure 1, the mechanical system of the robotic arm is composed of six main components, namely the base, the large boom 1, the large boom 2, the small boom 1, the small boom 2, the wrist and the end effector.

![Figure 1. Typical industrial robotic arm](image1)

As shown in Figure 2, the entire mechanical arm is a tandem mechanism, and the joints are driven by a motor. The moving joint provides a corresponding degree of freedom for the mechanical arm.

![Figure 2. Six degree of freedom robotic arm](image2)
3. Laboratory system construction

3.1. System construction scheme

The process of developing a virtual laboratory based on the Unity3D engine is essentially the process of developing virtual reality content.

First use 3D modeling software to build a simulation model of the robot arm and laboratory environment, and then import the 3D model in FBX format into the Unity3D engine. Through program scripts, add interactive functions, such as scene roaming, collision detection, system interface, etc. So that students can observe the robotic arm from the first person perspective in the virtual laboratory, realize immersive interaction, increase students' awareness of the robotic arm, and achieve the expected practical teaching effect. The system frame structure is shown in Figure 3.

![System frame structure](image)

3.2. 3D Modeling of Robotic Arm and Related Specifications

In the process of creating a 3D model of the robotic arm (as shown in Figure 4), the information contained in the model (name, size, unit, coordinate, axis, material, etc.) must conform to the production specifications, which helps model programming and software between import and export. The development process of the virtual laboratory system is shown in Figure 4.

![System development process](image)

Some points to note during the modeling process:

1. Unit. The default unit of the Unity3D engine is meters. In the Unity3D engine, the system's default scale is 1:1, so no matter what the system unit of the 3D modeling software model is, as long
as the model shows the unit scale is 1 meter, the default after importing the Unity3D engine. The displayed effect is still 1 meter. Therefore, during development, the units are set to meters.

(2) Name. Note the name of the model. It cannot have duplicate names. The model name is best to be named in English and numbers. The Chinese name has some delay when instantiating the Unity3D model.

(3) Coordinates. Set the initial coordinates of all models to the origin and the axes in the model to the center of the object.

You can use mechanical modeling software or animation modeling software to create a robotic arm model. During the modeling process, pay attention to avoid that the Unity3D engine cannot read the model due to incompatible data formats or lack of required information. Creo mechanical modeling software is selected to build a 3D model of the robotic arm. After modeling the robotic arm, the 3D model in Creo will have some redundant faces during the creation process. The model needs to be checked and removed by 3ds Max combine isolated vertices, and process the model to reduce unnecessary faces, thereby improving the display efficiency of the system. At the same time, the 3ds Max software rendering module adds materials and textures to the model to increase the realism of the model. Finally, the robotic arm model must be exported to the official FBX data format recommended by the Unity3D engine through 3ds Max software, and finally imported into the virtual scene of the Unity3D engine. In order to maintain the size of the model when displaying it, you need to zoom in after importing the model.

3.3. Construction of Virtual Lab

After modeling the robotic arm, you need to assign the texture map to the corresponding model, and finally package the robotic arm model and export it in FBX format. It should be noted that during the export of the model, the Y-axis of the model should be set upward so as to be consistent with the coordinate system in the Unity3D engine. At the same time, the "embedded media" option should be selected, so that the texture file on the model is imported. The Unity3D engine will only be saved in a separate folder to avoid loss of textures. Create a new project using the Unity3D engine and import the model exported from 3ds Max into the project. At the same time, a lab environment was built using similar modeling techniques and resource packs (such as the Skybox included with the Unity3D engine), as shown in Figure 5.

![Figure 5. Laboratory environment](image)

3.4. Lab system function implementation

The function analysis and structure identification of the robotic arm are the main teaching content in the teaching process. Therefore, the main functions of the developed laboratory system are: virtual laboratory roaming, dynamic display of the robotic arm, virtual assembly and human-computer interaction.

(1) Virtual laboratory roaming. Lab roaming is to observe the structure of the robot arm and its dynamic functions from a first-person perspective. The control method is mouse and keyboard. When implementing first-person perspective roaming in the Unity3D engine, use software standard resources (if the software is not installed during the installation, you need to download and import the standard resources to the Unity3D engine) the preset body under the first-person controller "First person
controller", place this preset in the scene, and adjust the position about 1.6m from the ground to simulate the height of the human eye. At the same time, add a capsule detection collider to make it meet other in the laboratory scene Objects can achieve physical collisions.

(2) Robot arm function display and virtual assembly. The Unity3D engine includes the NVIDIA PhysX physics engine. Unlike the VRML environment, which relies on pure code to achieve virtual motion effects, the Unity3D engine enables designers to achieve the required motion simulation with very little code. Dynamic simulation "joint" connections are provided in the Unity3D engine. During the working process, the robot arm needs to achieve relative rotation between parts, so the design "joint" is mainly a hinge, and the parts fixed on the base are connected by fixed joints.

In order to achieve the physical effects of the mechanical arm dynamics in the virtual laboratory system, the Unity3D engine provides a variety of collider components. These collider components can simulate the collision and friction of cube, sphere, and capsule during the movement. More complex mesh colliders can simulate the complex collision and friction effects during the movement based on the 3D model mesh shape. In the model display part of the robotic arm virtual experiment system, the script driven method GameObject.transform.Translate () is used to achieve motion drive to achieve the dynamic display of parts and virtual assemblies [2].

The virtual assembly must conform to the actual robotic arm assembly process route. Therefore, the interactive assembly program needs to add a logical judgment function, so that the entire assembly process is a logical and interactive dynamic control. The process of interactive virtual assembly is shown in Figure 6.

![Interactive virtual assembly process](image)

**Figure 6. Interactive virtual assembly process**

(3) User interface (UI). The UI interaction between the main interface of the system and the roaming scene is generated using the UI system that comes with the Unity3D engine, including the main interface, assembly explosion function buttons, automatic assembly function buttons, and automatic display function buttons. The main interface is shown in Figure 7.
3.5. Teaching effect

The robotic arm virtual laboratory system in this article can be released to the PC by the Unity3D engine to form an executable file and installed on the computer in the computer room. Each student can use the monitor, mouse and keyboard in a first-person perspective in the virtual laboratory. Roaming, the robotic arm in the virtual laboratory works automatically in a virtual scene and is displayed in a loop. Students can observe the structure of the robotic arm and its working process during the roaming process.

This system greatly improves the effect of practical teaching: (1) The system has low hardware requirements and is installed in a computer room with low cost, which is conducive to popularization and application. (2) Improved students' learning interest and enthusiasm. Learning is no longer just about acquiring knowledge, but emphasizing the application of knowledge, which lays the foundation for subsequent professional course learning, curriculum design, graduation design, and other practical links.

With the development of virtual reality technology hardware, HTC Vive, oculusrift, CAVA and other virtual peripherals that have a good experience, students can get a better immersive experience in the teaching process, by integrating virtual reality software with hardware,

4. Conclusion

The robotic arm virtual laboratory system based on the Unity3D engine uses a certain type of robotic arm as a simulation prototype, analyzes the actual structure of the mechanical arm, creates a 3D virtual model, and implements the connection of part models and work assembly through script-driven operations And finally realized the construction of a robotic arm virtual laboratory system. The virtual laboratory has good interaction, and students can operate the robotic arm in real time.

With the continuous development of 3D modeling technology and virtual reality technology, the development of virtual reality content has become more and more simple. Compared with the existing solution, the robot arm virtual laboratory system construction method has different degrees of improvement and improvement in terms of convenience and interactivity. It can be applied to courses related to mechanical specialty. Students can pass the virtual laboratory. Better understand the theoretical explanations of teachers.

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