Research on Virtual Assembly Simulation System for Aircraft Flight Control System Based on Unity3D

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Abstract. Based on Unity3d's digital assembly simulation technology, this paper designs a virtual assembly simulation system for the flight control system of a certain aircraft nose. Firstly, the structure tree division of the flight control system assembly model based on modular decomposition is studied. Secondly, a virtual assembly simulation system for the assembly operation of the flight control system is designed and implemented by Unity3D. Finally, the system verified the virtual assembly operation of the flight control system of the aircraft nose through the laboratory platform. The assembly guidance and interaction functions of the flight control system are initially realized by this simulation system.

1. Introduction
In order to improve the efficiency and quality of assembly engineers, technical methods such as virtual assembly simulation technology, 3D assembly instructions, and electronical work instructions are gradually applied to the assembly site to provide engineers with a visual and interactive display of the operation process. However, for the assembly process of certain types of aircraft flight control systems, the complicate assembly process brings a series of problems to the actual operation for the engineers. Standard & cumbersome assembly drawings and procedures cannot effectively provide convenient operation guides, and also cannot provide appropriate assembly training and demonstration functions. At the same time, with increase in product development frequency and assembly quality requirements, the contradictions between assembly efficiency, assembly quality and manual assembly operations have become increasingly prominent. Traditional instruction visualization technology has been unable to meet the current urgent requirements[1-2].

Therefore, during the assembly operation phase of the aircraft flight control system, a virtual assembly simulation system capable of visualization and interaction is urgently needed to enable assembly engineers to interact with the assembly guidance system, thereby improving workers' assembly proficiency and quality. With the rapid development of virtual simulation assembly technology, its visualization, interaction and other characteristics have shown great application potential in aircraft assembly research.
2. Research Status of Virtual Assembly Simulation Technology

All of the aircraft manufacturers generally adopt the model of “main manufacturer + suppliers”. The suppliers are responsible for manufacturing parts and assembly of the airframe structure (excluding the system part), and the main manufacturer is responsible for the entire aircraft butt and system parts manufacturing, installation and commissioning. Because the system parts are installed on the body structure, there are many coordination relationships between them. Therefore, the main manufacturer and suppliers often delay the production progress due to the organization and system coordination problems.

Virtual assembly refers to the use of virtual reality technology, computer tools, artificial intelligence technology and simulation technology to construct a virtual environment, through analysis and prediction of product models, interactive analysis of product data and simulation of the product assembly process and assembly results. Virtual assembly technology enables aircraft assemblers to influence product design, thereby reducing manufacturing costs and avoiding aircraft assembly cycles and costs due to design issues. Simulation technology can find potential problems in the early stages of design maturity and eliminate potential assembly defects. The aircraft assembly process can use virtual simulation technology to simulate the assembly process, thereby evaluating and optimizing the design and process of the aircraft, which can improve production efficiency and reduce product assembly cycle, reducing costs, thus greatly improving the professional level of aircraft assembly [2].

3. Construction of Modular Assembly Process for Flight Control System

The flight control system modular assembly is an assembly technology based on the modular design of components to carry out modular assembly, testing, and delivery. The following analysis will be made from three aspects of modular feature analysis, traditional assembly processes, and modular assembly processes.

3.1. Modular feature analysis

The flight control system consists of a rudder, an elevator, an aileron, and a central console. The aileron performs roll control of the aircraft, the rudder controls yaw control of the aircraft, the elevator controls pitch of the aircraft, and the central console serves as the control centre, integrating multiple control devices. The rudder, elevator, and ailerons are separated by a central wing. The central control system is located in the middle of the nose compartment. In fact, each module forms a unit structure, which has the basic modular features of the overall assembly. On the rudder, elevator, and aileron, there is an interrelated relationship. Therefore, its modular characteristics include two major characteristics, namely structure and system function.

3.2. Analysis of traditional assembly processes

From the perspective of the manufacturing process of a certain aircraft nose structure, in the traditional assembly method, the components of the aircraft control system need to be completed during the component assembly stage, such as the docking assembly, the installation of parts and standard parts and the flight assembly control The testing of the moving state and sensor state of system components and related moving parts is the main task. The flow analysis is performed according to aircraft motion control and structural principles. All control of flight activities is directly through the central wing to the cockpit central console. All operation and control signal data collection and processing are performed in the central console[3]. Flight control of the nose of a certain aircraft The overall process of system traditional assembly is shown in Figure 1.
3.3. Analysis of modular assembly processes

According to the traditional assembly process and characteristic analysis of the flight control of a certain type of aircraft, its structural assembly has been separated from the final assembly. The assembly process is mainly to place the central controller, rudder, and elevator in the local assembly, and the aileron docking and control system inspection to the final assembly phase, the most influential factor for the traditional modular assembly of flight control is the final assembly test. To achieve the traditional modular assembly of flight control, the traditional assembly process of flight control needs to be changed firstly. For assembly integration, docking digitalization, and flexible assembly, the system modification of test unitization and other aspects. The modular assembly process of the aircraft flight control system is shown in Figure 2.

4. Design of Virtual Assembly Simulation System for Flight Control System

The process of developing a flight control system virtual simulation system based on Unity3D software includes three main steps. The first step is to package all models according to the divided modules. The second step is to export the .fbx file and import it into the established Unity3D software project. The final step is to add the according components, such as cameras, collision detection, and systems interface, etc. The interface and other components are implemented through C# programming to complete the design of the flight control virtual assembly simulation system, to observe the
components, the assembly sequence, and the completion situation, etc., to increase the user's awareness of the flight control system assembly, and to achieve the expected teaching guidance effect[4]. Its system structure diagram is shown in Fig. 3.

Figure 3. System structure diagram

4.1. Models imported into Unity3D
According to the Catia 3D model provided by an aircraft manufacturer, it is divided based on the modular structure tree; then the CGR format file is exported to 3d Max software, and then the FBX format file is exported, where the model's Y axis is set in the export dialog box, So that it is consistent with the coordinate system in Unity3D software, and then create a new project, import the FBX model exported from 3DMax into the new project[5-7]

4.2. Interface design
To create a new scene, one main camera by default, and two game objects with directional light. The main camera is equivalent to the "eye" that observes the scene. What the eye sees will be displayed in the game view. The directional light is equivalent to the "sun" in the scene, thereby enhancing the brightness of the entire scene. In order to meet the assembly perspective of the front view, left view and side view functions, please add two cameras in the function box and assign IDs. In addition, to add components, such as function buttons, text boxes, and combo boxes, assign IDs accordingly and create script files. The complete interface structure is shown in Figure 4.
4.3. Functional design
According to the corresponding function button definition of the interface, to create the corresponding script file, and write the corresponding function code using C# language. The main function scripts include initialization scripts for binding model components, scripts for view display and camera perspective conversion; automatic assembly scripts for automatic display of assembly sequence; manual assembly scripts for manual assembly by users.

To initialize the scripts, bind the model components and interface ID, for subsequent function implementation; camera script, bind three cameras to achieve custom view, left view and side view functions; automatic assembly script to achieve assembly with start-up, The order of the pause and progress display functions is automatically displayed; manual assembly of the script enables the user to manually assemble the next, previous and progress display functions. Finally, you can bind the script to the component and verify the function implementation.

5. Application examples of virtual Assembly simulation systems

5.1. Functions of Flight Control System Virtual Assembly Simulation System
In the actual assembly process of the worker, the layout of the flight control system and the cognition of the assembly process are very important. Therefore, the following system functions have been developed for the flight control system of the nose of a certain aircraft: the switching of the assembly perspective and the animation of the assembly process interface for display, virtual manual assembly, and human-computer interaction[8].

(1) Perspective conversion. The perspective view of the virtual assembly system is divided into custom views, front view, left view and side view. These four views are switched by the interface perspective function buttons.

(2) Animation demonstration of the assembly process. Uses C# script to control component coordinates so that the model can be animated for assembly in a specific order.

(3) Virtual manual assembly function. Uses C# script to control component coordinates to realize manual assembly by the user, with next, previous and progress display functions

(4) User interface. The initial interface of the system and the UI interaction of the information display box are made using the GUI components that come with Unity3D.

5.2. Use case of flight control system virtual assembly simulation system
The virtual assembly simulation system of the flight control system in this paper is exported as a Windows 7/8/10 system executable program file through Unity 3D. The user uses the monitor and mouse control to assemble the scene on the virtual machine head from the first angle of view. The user can observe the assembly process during use, and the corresponding information display box can make the user quickly familiar with the assembly process and details. The simulation system is shown in Figure 5. The assembly progress is shown at the bottom left.

![Figure 5(a). Initial interface diagram (front view)](image)

![Figure 5(b). Top view](image)
6. Conclusion
This article builds a virtual assembly simulation system for an aircraft flight control system based on Unity3D, which has been verified by laboratory environment simulation. The simulation system can guide and train workers to assemble a flight control system in actual aircraft assembly production process. The results show that the system is in use. It can effectively guide assembly and interactive operations. With the development of digital technology and virtual reality technology, the traditional assembly guidance and training methods in the manufacturing industry will be gradually replaced, and the development of virtual reality will also be increasingly perfected to achieve the requirements of improving better production efficiency and quality.

Acknowledgments
This work is supported by Sichuan Science & Technology Program under Grant 2018GZDZX0019 & 2019YFG0383 & 2019YFG0052.

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