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Distributed Collaborative Virtual Assembly Technology

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Abstract

Collaborative design is an inevitable trend of complex product design nowadays, because product design involves the participation of many designers, product assembly phase will inevitably be biased. Therefore, assembly verification before production is very important. Based on single user system, distributed collaborative virtual assembly technology enables collaborative designers to design collaborative virtual assembly in a unified virtual environment through network between different places, in order to ensure the success rate of product design. This paper analyzes the research status of distributed collaborative virtual assembly technology at home and abroad, expounds the theory of virtual assembly technology and collaborative simulation theory, and introduces the related technology of distributed collaborative virtual assembly.

Keywords

Distributed system; Collaborative mechanism; Virtual assembly.

1. INTRODUCTION

The development of science and technology and the acceleration of economic globalization have given birth to a series of inter-industry, inter-regional and inter-national virtual enterprises and changes in the enterprise environment, the design and manufacture of many complex products is no longer satisfied with a single enterprise, distributed collaborative virtual assembly technology emerged.

Distributed collaborative virtual assembly technology is based on single-user system, which supports multi-user working together in different places, it provides a condition for real-time assembly test in the same virtual scene by multiple users distributed in different geographical locations, it plays an important role in improving design quality, shortening assembly test cycle and guiding assembly in different places. With the development of Internet communication technology and the increase of the demand for collaborative work in different places, distributed collaborative virtual assembly technology has become an important research topic.

2. PREVIOUS RESEARCH

The good application prospects of distributed collaborative virtual assembly technology have made the research of its related technologies highly concerned at home and abroad. The Dutch Delft University [1] studied the framework of a distributed collaborative system based on the network, and implemented a network-based collaborative system architecture that supports developers from different regions to collaborate on the network and supports single or multiple component hierarchical structure product simulation can also distribute assembly design tasks

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to achieve distributed collaborative work. Tsinghua University [2] adopted the standard web system three-layer model, developed a collaborative assembly system, and proposed the coding concept of assembly tasks, as well as assembly evaluation, collaboration mechanisms and protocols and other technical research. Shanghai Jiaotong University [3] studied the collaborative virtual assembly technology on the network, and proposed a distributed collaborative method based on the high-level system framework (HLA), which solved the user management and collaborative assembly operations in the distributed system. In order to solve the problem, the remote assembly simulation and evaluation of complex product design are realized. On this basis, a distributed and parallel collaborative virtual assembly system is realized, which can complete the real-time collaborative assembly simulation.

3. RELATED THEORY

3.1. Overview of Virtual Assembly Technology

The development of virtual assembly technology[4] is a key part of virtual manufacturing technology, which is the comprehensive application of many advanced technologies such as virtual reality technology and computer simulation technology in the field of manufacturing assembly, compared with general assembly simulation and assembly simulation based on virtual reality technology, it has greater intelligence and superiority, and can complete or support assembly process visualization or assembly process planning, greatly improve the efficiency of mechanical design and manufacturing. From the perspective of model repositioning and analysis, virtual assembly technology is a process of repositioning part models according to constraints, and is an effective means to analyze the rationality of product design, it is based on the shape characteristics and precision characteristics of product design to simulate the Product 3D assembly process, and allows users to control the product 3D real simulation assembly process in an interactive way to test the product assemblability.

3.2. The Combination of Distributed System and Virtual Assembly Technology

The original intention of constructing the distributed system is to achieve the goal of sharing resources. The main characteristics of the distributed system are as follows: The client can freely access the data resources stored by the server through the networked computer. Users of different geographical space can interact with each other by computer, conveniently realize task assignment and distributed simulation computation, have good space-time synchronization performance, and the system scale has good expansibility.

The combination of distributed system and virtual assembly technology can realize distributed virtual assembly, which can realize networked collaborative assembly of product design in different regions, verify the assembly performance of products, modify the design through network and verify it again, realization of collaborative assembly simulation verification after cross-region product design.

3.3. Collaborative Simulation Technology

Co-simulation technology is based on distributed system, multi-user operate in different regions and in a real-time, interactive and co-operative environment, using their own professional knowledge and tools conveniently and friendly, simulation of the subsystem, or participate in the overall simulation of the whole system, make full use of the technical advantages of designers in different fields, collaborative and efficient technical methods to complete complex simulation analysis. Co-simulation consists of a single point in time simulation over the entire life span of a product, as well as simulations performed at different times, by different operators and methods, or at the same point in time, co-simulation analysis with different operators and methods.

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Distributed system, collaborative simulation combined with virtual assembly technology, supported by computer and network communication technology, based on multiple PCs and high-speed local or wide area network to build a distributed collaborative virtual assembly system, to achieve complex products off-site collaborative assembly simulation verification analysis, achieve the purpose of developing high quality, short cycle and low cost is to improve competitiveness.

4. KEY TECHNOLOGIES OF COLLABORATIVE VIRTUAL ASSEMBLY

4.1. Requirements Analysis

In a distributed collaborative virtual assembly environment, the system should be able to simulate the multi-user collaborative assembly process in the virtual environment. It should be able to establish and maintain a unified virtual assembly scene, handle various assembly constraints, and detect the inter-model during the movement Interference and collision situations [5], it is the real-time simulation of the assembly process with the help of computer hardware and software equipment. The purpose of virtual assembly is to obtain one or several feasible assembly sequences through pre-assembly. Therefore, the collaborative virtual assembly system must have the functions of real-time rendering, real-time collision detection, constraint recognition, constraint-based motion navigation, and component-level virtual assembly.

4.2. Product Data Management in Collaborative Virtual Environment

In the virtual environment, the solid model needs to meet the real-time requirements of rendering and collision detection, and it also needs to describe the assembly constraint connection relationship between the entities [6]. The virtual environment system itself does not have modeling capabilities, so the models in the collaborative virtual environment need to be obtained from external modeling tools. Collaborative assembly design is composed of more than two design subjects, through certain data sharing and information exchange, to complete different design tasks to achieve a certain design goal, therefore, the security protection of sensitive data information is an important issue. According to the security level required for the model, the designer can use the system data interface to convert the feature model established in the CAD system into a display model with different accuracy.

At the same time, collaborative assembly requires that the server and user nodes in different places use unified model data, and design users upload their respective models to be tested to the collaborative assembly server through the File Transfer Protocol (FTP) tool, and the main control server will process good models are placed in the FTP folder of each designated user. When users log in to the collaborative assembly server, they first check whether each user node has a corresponding data model and whether it is consistent with the latest version of the server. If it exists and the version is the same, log in and load directly. otherwise, download the required model information and load it. Before starting the simulation program, make sure that the model data of all user nodes is completely consistent with the server. The user's update during the simulation process must be approved by the assembly server.

4.3. Multi-user Collaborative Assembly Operation Management

The collaborative assembly operation involves the participation of multiple subjects with different roles. Different roles have different permissions. The permissions are the user's permission to operate objects in the virtual environment.

The collaborative assembly operations include processes such as object grabbing, moving, constraint confirmation, and release. When a user issues an instruction to grab an object, an ownership request is sent to the server in an interactive manner. The server determines

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whether the ownership of the object should be given to the user based on the role and authority of the applying user. The second crawl failed. If it is, the user crawled successfully, you can move and other operations. After the user captures successfully, bind the posture of the object to the posture of the virtual hand, the object will move with the change of the posture of the virtual hand, and at the same time update the real-time attribute information such as the posture of the object to the main control server and other user nodes. When the object is moved near the position to be assembled, a prompt for the precise assembly position appears, and a constraint confirmation signal is sent to perform precise position assembly. The constraint completion flag indicates the assembly state of the object during the assembly process, which is expressed by the object class of the runtime frame. When a user completes an assembly constraint of an object, its completion flag changes from 0 to 1, and it is updated to other master servers and other user nodes through the runtime frame. After the user releases, the ownership of the operation object is released to the runtime frame, and the server reclaims the ownership managed by the runtime frame at the specified time interval.

4.4. Collaborative Assembly Process Management

The records of the object movement process in the collaborative assembly process are divided into: distributed, centralized and distributed centralized. Centralized recording means that there is a member in the system to record the properties of all the simulation objects, which is more convenient for data organization and analysis after the simulation is completed, but for a large system, all data are collected on a node, which will form a bottleneck; distributed recording means that each member of the system records some data related to their own operations, which will not affect the network transmission and will not increase the load of the runtime frame, but after the simulation, the data of all nodes needs to be merging, and there is also a synchronization problem; distributed centralized is that each node records the interaction data between multiple system members. In this way, the network transmission bottleneck caused by the centralized and unique data recording node is solved, and the interactive data between related nodes is also organized together to facilitate data analysis and reduce the complexity caused by data consolidation. Through the playback of the recording process and the generation of trajectories and sweeping bodies, you can see whether the object has interference in the assembly space, which can better guide the assembly.

In order to facilitate the viewing of the entire assembly process, the assembly hierarchy tree display box of the product is established. The assembly hierarchy tree represents the assembly hierarchy relationship of the product. When an object is assembled, the assembly completion status of the object can be updated and displayed in the assembly hierarchy tree in real time.

5. CONCLUSION

Distributed collaborative virtual assembly technology is an effective way for complex product collaboration technology, and it plays a very important role in improving design quality, shortening assembly test cycle and off-site assembly guidance. With the development of Internet communication technology and the increasing demand for collaborative work in different places, future research should be based on collaborative virtual assembly technology in different distributed simulation environments.

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