# Research on Collaborative Virtual Assembly Technology Based on Web Haijun Wang

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**Abstract.** Product design is very important in the process of product development. The traditional process is to carry out experiments and evaluation by the physical prototype, and the development cycle is longer. Virtual reality equipment can avoid these processes, and then simulate the process of product design on the computing device. Web based collaborative virtual assembly system will be integrated in all aspects, through voice, text, pictures and other forms of mutual exchange, to complete the design and installation of the product, can shorten the development cycle, reduce product costs. Collaborative virtual assembly technology is the key to support system, the assembly sequence generation of semi manual interaction, based on the Web technology, multi channel interactive technology are essential.

#### 1. Introduction

Product design is a key part in the process of product development. Product in the design stage of success or not determines how the product is processed and assembled. Although design cost accounts for 5% of the total cost of the product development, it determines 70% ~ 80% of the total cost of the product, and the cost of the upstream design's defect is to be enlarged continuously to the downstream. According to statistics, the proportion of the amplification is even up to  $1:10^{[1]}$ . Therefore, the design should be considered in the comprehensive, try to avoid adverse effects due to unreasonable design and to follow-up related activities such as processing, assembly, testing, etc.. The assembly process accounts for 20% ~ 70% of the total workload, and it is the main factor restricting the production automation. So in the product design, we must take into account the assembly process and its related factors, to avoid large rework.

With the rapid development of China's manufacturing industry, the market competition is more intense, and the user needs of the individual and diversified, and the constraints of many kinds of standards and norms, etc., put forward higher requirements for the development and production of modern engineering products. All kinds of manufacturing enterprises must be faced with the T (Listing Time), Q (Quality), C (Cost), S (Service) and E (Environment) problems which have to be confronted with the new products, and have a place in the market. In the process of the traditional products to the market, to go through the process of product design, physical prototype testing, industrial testing, and then design and modify the cycle of testing<sup>[2]</sup>, the long development cycle, high cost, high risk, which weakened the competitiveness of enterprises.

With the development of the network and the progress of technology, the virtual assembly based on Web becomes possible. The collaborative virtual assembly system is supported by virtual assembly technology. In virtual reality environment, the 3D visual simulation of digital model is generated by computer instead of physical product. Through visual, auditory, tactile and visual perception of the real-time dynamic induction of collaborative, the user simulates the product assembly or disassembly of the objects in the virtual environment. Virtual assembly technology involves CAD technology, intelligent technology, network, virtual reality and other technology to achieve. In the virtual environment<sup>[3]</sup>, the research and development personnel, experts can understand the impact of design decisions on a single operation, comprehensive grasp the design, production and assembly process in the virtual manufacturing. It is very important to the product quality and reliability, and to improve product development success rate. And based on Web, the system can eliminate the restriction of space and region, save the time cost, and can push the product to the market as soon as possible.



## 2. Collaborative virtual assembly system based on Web

Fig.1. Support collaborative virtual assembly system flow chart

The implementation of the system is based on the following process. First, the product designers introduce the product digital model which is produced in the CAD system into the assembly system by certain human computer interaction. The assembly sequence is automatically generated with the expert database and in the process of manual intervention, which is the assembly sequence of tips during the assembly process. Designers at different regions can use stereo glasses, data glove, tracker, voice and other means of interactive 3D objects according to the sequence of tips and in the virtual environment, test product assembly, disassembly, to find out the problem of the assembly

interference between components and the size etc.. In order to prevent the operation conflict in collaborative assembly, the assembly constraints and priority functions are set up. Taking into account the high cost of hardware, in order to meet the requirements of different size of the company, to achieve the hardware down compatible, the above work can also be completed with only ordinary PC and mouse, but the sense of immersion is poor. The total work flow of the system is shown in Figure 1.

At present, the company of Chinese has a special research on virtual reality technology, but the realization of virtual assembly system is very little, and it is less to support collaborative non-specific domain products. Therefore, in this system, many technologies are useful to try and innovate as following.

- (1) The method of combining the hierarchical analysis and expert knowledge is used in the automatic generation of a assembly sequences, which can accelerate the speed and improve the accuracy of the results.
- (2) Support for Web based collaborative work mode, the use of C/P (command / parameter) mechanism to improve the transmission speed, for different regions of the workers to provide a good communication platform.
- (3) Virtual reality has a good sense of immersion and interaction means, support stereo display, can use data gloves, position tracking, voice, etc..
- (4) Supporting hardware down compatibility, only using common PC and the mouse can also complete the virtual assembly task.
- (5) Has the detailed path record, and can edit the reverse play, be advantageous to the design modification and the training.

System can meet the needs of different people. Product designers can have an intuitive understanding of the products through the system, and verify the assembly. If the designers encounter problems, they can discuss with other designers personnel through the network. The assembly workers can be repeatedly watching the assembly sequence and master the assembly sequence. The customers and management can observe the assembly process in time and see the appearance of the product in advance during the process of establishing the design plan.

## 3. Key technology

Support for collaborative virtual assembly system is the test platform which is built on the basis of the Hoops 3D of Tech soft company and is constructed by virtual product disassembly in a virtual environment. Hoops 3D provides the basis operation of the selection of the mouse keyboard, translation, collision detection, rotation angle of view, and has a good support of the file generated by the CAD Auto and Edge Solid, and has a good support of the synergy, three-dimensional display, which is conducive to the expansion of the system. Segment tree structure provided by Hoops 3D provides a convenient to our virtual platform for the user to interact with the task.

## (1) Assembly sequence generation technique for semi manual interaction

On the basis of "detachable can be installed" principle, the system use the semi-automatic hierarchical sequence generation method. The so-called hierarchy is the use of engineering design drawings. First, products are carried on the whole assembly, and then assemble the specific parts of the products. The specific approach is to write the name of the assembly to the file at the different levels of demand, and then to import this file. This will not only meet the needs of different levels of detail, but also conducive to reducing the number of parts, improve efficiency. The so-called semi-automatic generation sequence is defined by the interaction between human and machine. On the one hand, it is difficult to distinguish between the constrained information of the parts. On the other hand, many of the constraints in the CAD software are lost when they are imported into 3D software. In addition, there are many industry knowledge constraints in the process of assembly and expert knowledge is difficult to form. So by experts to specify the main constraints is conducive to the integration of expert knowledge, and is the key to improve the processing speed and the reliability of the results. The computer automatically establishes the constraint directed graph according to the specified constraints, and generates a sequence of nodes with topological sort.

The concrete methods are as follows: firstly, the assembly task is decomposed, and then the corresponding assembly sequence is generated. An assembly is decomposed into several parts, each part is then subdivided, and the assembly sequence is generated by using the cut set method on a suitable scale. For complex assembly tasks, especially the number of sub assembly parts, through the definition of key parts and decomposition rules, using incidence matrix and off set method to deal with, and then the cut set method to get to and / or graph representation of assembly sequences and according to the workload of assembled with the task.

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## (2) Network based collaborative technology and hardware compatibility

This system is extended on the basis of the network which is provided by the original Hoops 3D system and according to the actual situation of the expansion. With server / client mode shown in Figure.2, the user can cooperate with the assembly and disassembly. At the same time, considering the larger CAD model, the transmission speed is slow, so the transmission technology of C/P (command / parameter) is adopted, which is to transmit the commands and parameters to the CAD model instead of itself, so that the command is executed by the local computer, and the network transmission is reduced. The client is divided into two categories according to the authority of the system: one is to have control, the other is without control. The client with control right has the right to read and write data.



Fig.2. Cooperative frame diagram

Multi-client provide the conditions for the realization of the backward compatible. The program can be run on a common PC client and run the sending command, receive messages, while a stereoscopic display function of the client can receive messages from other clients to achieve compatibility with different hardware.

#### (3) Virtual reality technology of multi channel interaction

The system uses multi-channel interaction such as voice, tracker bird, data glove, three-dimensional glasses and other new interactive means. The user has the immersive feeling through visual, auditory, tactile and dynamic real-time perception. The users use more natural

removal means to complete the demolition task, so that the virtual environment in the demolition activities is more close to the reality. In the process of the virtual environment, the use of speech is faster and more efficient than the keyboard input. The tracker bird provides a very good three-dimensional space positioning method, tracking the movement of the data glove and defining a series of gestures to complete the interaction task.

The system takes into account the physiological and psychological characteristics of human being, and the effective resources are allocated and used reasonably in the completion of the task of virtual product removal. Data glove, tracker bird and voice cooperation to complete the task, complex tasks are decomposed into a simple task can be completed by the data glove, bird and voice parts, reducing the complexity of the task of relying solely on a device to complete it. At the same time, each channel can be independent of the completion of the demolition task, to the user a variety of options, to avoid the lack of a certain type of equipment or equipment failure can not complete the task of disassembly.

In addition to the above technologies, the system also has a collision detection, viewpoint automatic switching, path records and other technologies.

#### Conclusion

Virtual assembly system has the following advantages:

- (1) Can shorten the development cycle, reduce the cost of design;
- (2) Can "test" more design in the same time, which is better than the physical prototype:
- (3) Can reduce the design changes in the late period of product development, and then make the whole product development cycle minimization;
- (4) Compared with the conventional simulation, it involves a wide range of design, considering the more comprehensive, and thus can improve the quality of the product;
- (5) As a result of supporting collaborative operations, communication between the design team becomes more convenient.

Virtual assembly technology is a new research and development model, which will have a profound impact on the enterprise's product design pattern. However, the virtual assembly technology is not yet mature in many technologies and equipments, and it can not completely replace the physical model, the main problems are as follows:

- (1) Correctly generating assembly sequence. Since the exchange of data between different applications can cause data loss, how to save the complete data and how to extract the effective data and improve the efficiency is the first problem to be solved. Secondly, the assembly sequence is also influenced by the factors such as the assembly process and the assembly resources, so how to consider the influence of these factors is an urgent problem.
- (2) How to optimize product design. The optimization of product design requires that all aspects of the product can be accurately quantified. In addition, the optimization of product design involves many different subjects. How to obtain the optimal value of multiple objectives is an important research topic.
- (3) Error of virtual assembly and actual process. Because of the uncertainty of the model and the quantization of various constraints, it is bound to cause the error of the virtual assembly process, how to carry on the quantitative analysis to these errors, making it possible to simulate the physical process is also an important research direction.

But it can be predicted that in twenty-first Century the virtual assembly technology will become the mainstream of product research and development in the field of engineering design. Accelerate the application of it, so that the enterprise products in the quality, the price of more market competitiveness, to meet the challenges of global economic integration.

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