Rapid Assembly Modeling in Computer Aided Design System

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Abstract. Rapid assembly modeling system is a tool that needs to be used in the design process. Because the three-dimensional modeling is intuitive, powerful and can be used in actual engineering, it is more and more used in manufacturing production. In the rapid development of computer-aided design technology, CAD/CAM software is the most commonly used and most widely used modeling tool. Therefore, the purpose of this article to study the rapid assembly modeling in the computer-aided design system is to improve the performance and accuracy of the assembly system and promote the high-quality production of products. This article mainly uses experimental method and case analysis method to test the assembly system designed in this article. The experimental results show that, under low temperature conditions, the relative error and absolute error of the assembly size are in a small space, which meets the actual requirements. Therefore, the system designed in this paper can be used in practice.

Key words: Computer Aided, Design System, Rapid Assembly, Modeling Research

1. Introduction
As a new design method and process, rapid assembly has many advantages such as higher efficiency and saving more resources. It is an indispensable part of the future product development process. At the same time, its high-efficiency, fast, easy-to-realize automatic control and other characteristics are widely used in mechanical equipment and automotive industries.

There are many researches on rapid assembly modeling in computer-aided design systems. For example, Xu Zhijia said that product modeling is one of the key factors affecting the competitiveness of manufacturing enterprises [1]. Ji Xiaopai believes that assembly is the last link in the manufacturing process, and assembly modeling is the basis of assembly design [2]. Wang Yonghui said that based on the analysis of product structure complexity and hierarchical relationship, a modeling method for assembly design has been formed [3]. Therefore, this article intends to study the rapid assembly modeling method in the computer-aided design system to improve the efficiency of product development.
This article first studies the related theories of computer-aided design and its system composition and technology. Then the assembly features and ideas are described. Then design the rapid assembly system. Finally, the size of the assembly system is tested and tested, and the data results are obtained.

2. Rapid Assembly Modeling in Computer-Aided Design System

2.1. Computer Aided Design
CAD is a technology. In this technology, humans and computers unite into a group, work closely to leverage each other's strengths, and provide the possibility of using a multidisciplinary approach to collaborate. In addition to common general CAD systems, there are also specialized CAD systems. CAD technology has the characteristics of wide range, complexity, rapid technological development, fierce competition, high investment, high risk, and high return [4-5].

In the research process of the computer-aided design system, the first thing we have to do is to determine the content of the rapid assembly modeling system. As an indispensable part of software product production and development, rapid assembly is an important part of it.

In our daily production and life, designing products requires a large amount of data to help complete, and assembly is such a process. So the computer-aided manufacturing system can also be called CAD. It mainly has the following points: It can use three-dimensional drawing software to establish part models and two-dimensional graphics. Before assembling, model the entities such as draft bills and blanks to be made and generate draft bills (OP) and other components (SMF), and then manually splice these components into a complete product.

Engineering workstations generally refer to interactive computer systems with ultra-micro computing capabilities. It has powerful computing power, uses standard graphics software, and has a high-resolution display terminal. In addition to computer-specific software such as operating systems and compilers [6-7].

2.2. Assembly Features and Feature Assembly Ideas
The feature is an important area on the surface of the part. It is part of the design object. The application of feature technology enables designers to abstractly describe the geometric shapes and technical semantics of products.

(1) From the concept of features, we can see that features have two main attributes. First, features are geometric objects that can be expressed and objects that can be used in engineering applications. At the same time, features also express the relationship between semantics and general form elements. The assembly feature is a collection of component information related to the assembly, including the assembly attributes of the component itself and the assembly information between the components. The first includes information such as shape, roughness, geometric tolerance, nominal size, nominal dimensional accuracy, and component mounting surface material. The second one includes the positioning constraint relationship between components, positioning sequence, positioning movement mode and its constraints and other information [8-9].

For assembly features, a parametric part library of assembly features needs to be created in advance, and the designer selects the model to be assembled from the model library. The feature assembly system must configure assembly feature maintenance modules for users to facilitate maintenance of model assembly features, including creating, modifying and deleting assembly features. Assembly features are a more advanced and intuitive way of expressing information than geometric features. Therefore, feature-based assembly improves the level of assembly operations and can avoid the restoration of geometric voxels from the assembly model. The user only needs to move around the component [10-11].

(2) Feature-based assembly modeling technology
Three-dimensional design is an inevitable trend in the development of CAD technology. The method
of creating a 3D model in a CAD system can be divided into three levels, namely line modeling, surface modeling and volume modeling. Surface modeling is still one of the most active and critical branches in CAD systems and computer graphics, and is a powerful tool for expressing complex objects [12].

Feature modeling is a new step in CAD modeling method. Its purpose is to use a computer to process a unified product model instead of traditional product design and engineering drawings, so that design and production preparations can be paralleled. Feature modeling is no longer the designer's active subject to the original line, but the functional element of the product. It directly reflects the design intent, and the design model is easier to modify. Product assembly models play a central role in the development of mechanical products. Assembly modeling is an extension of geometric feature modeling, but it cannot achieve satisfactory results in the description of product process information, especially in supporting feature-oriented product design and assembly. Since assembly modeling is a modeling technology based on the expression of product functional requirements, it can be used for feature-driven modeling of product assemblies and achieve good results.

2.3. Design of Rapid Assembly Design System

(1) Functional requirements
Product bill of materials (BOM): The bill of materials required to design the assembly process of this system is the finished product configuration engineering bill of materials provided by the product data management (PDM) system, called EBOM. Or read the product information data from the CAD system through the interface, and generate the product EBOM according to the relational database data structure in order to organize and store the product information. Therefore, it is necessary to develop a system interface to read product information data into the CAD system.

1) Management and application of typical example processes: The generation, management and reference functions of typical processes and typical examples can accumulate and continuously enrich system process knowledge in applications. The system has primary intelligent human-computer interaction and self-learning functions.

2) Planning and design of the assembly process: The planning, design, processing and modification of the assembly process of the product to be assembled are stored in the database and provided to the process designer according to their respective authority. Process query: You can query the existing assembly process in the database, and use the tree view to query the detailed statistical information of each process.

3) Process output: electronic process documents can be provided, and various assembly process cards can be printed after processing. Assembly resource management: save assembly resource information such as equipment, auxiliary tools, and auxiliary materials used in the assembly process, and can perform operations such as addition, deletion, modification, and inspection.

4) System maintenance: Authorized users can modify the password and permissions of the logged-in user. The system administrator has the right to assign a password.

Task-based assembly process design: The design of the product assembly process is assigned as a general task to a specific manager of the assembly process, and then he decomposes the superior tasks into sub-tasks and assigns them to other process designers.

5) Process document management: According to the process information generated by the assembly process design, the assembly process drawing is automatically generated, and the equipment information, tool information, machine information, tool and auxiliary material information are summarized.

(2) System structure
The specific architecture of the computer-aided assembly design system is shown in Figure 1:
Figure 1. The Architecture of Computer Aided Assembly Design System

1) Basic layer: the basic theories and methods on which the system development is based.
2) Data layer: used to store and manage all kinds of data and information needed and generated in the working process of the system.
3) Tool layer: including data management, typical process maintenance and assembly process management.
4) Functional layer: The system takes data information as the main line, and the data transmission and exchange between modules is based on the engineering database, which is suitable for data exchange and reduces equipment redundancy.
5) Interface layer: The interactive interface between the system and the user, which implements information input and output, human-computer interaction and other functions.

3. Development Experiment of Assembly Accuracy Prediction System

3.1. Development Tools
The system is based on the Pro/TOOLKIT development kit, Microsoft Access is used as the database support software and the MFC of Microsoft Visual C++ 6.0 is used to develop a set of assembly precision system. To start the system, you need to start Pro/ENGINEER first, and then register the assembly accuracy prediction system AAA_Engineering under "Auxiliary Application" in the system, and the registered system menu will be displayed on the menu bar of Pro/ENGINEER.

3.2. System Structure
The structure of the assembly accuracy prediction system can be divided into levels: operation layer, storage layer, input layer and output layer. The operating layer is the most important functional part of the system software, which realizes the processing and transmission of data: the input layer and output layer are the main channels of human-computer interaction, responding to the user's operation under Pro/ENGINEER and the input and output of other data: The storage layer plays a role in data storage and data transfer between and within the layers. This hierarchical structure is conducive to the effective transmission of data and improves the accuracy and reliability of the system.

3.3. Verification Experiment Process
In this paper, two verification experiments are designed to prove the accuracy and reliability of the
assembly accuracy prediction system. Under normal temperature environment and variable temperature environment, respectively analyze and compare, for the same mechanical product, the assembly accuracy prediction system obtains the assembly prediction under the CAD model. Accuracy and assembly accuracy obtained by actual measurement.

Assembly tolerance is an important indicator reflecting product accuracy. The main purpose of assembly accuracy prediction is to estimate the assembly tolerance when the tolerance or deviation of the component ring size is known, that is, to achieve tolerance analysis. At present, there are mainly two commonly used tolerance analysis methods: extreme value method and statistical method.

The extreme value method, also known as the complete interchange method, is calculated from the limit value of each link of the dimensional chain. Based on the previous content, the basic size of the closed ring can be obtained:

$$Q_0 = \sum_{i=1}^{m} l_i Q_i$$  \hspace{1cm} (1)

In the formula, $l_i$ meets $1 \in \{\varphi > 0 \cap l \in l_i\}$.

This method does not consider the actual size distribution of each link, and calculates according to the limit value of the component ring, so the assembly tolerances obtained can be completely interchanged, which is suitable for the tolerance calculation of single or small batch assembly production.

The statistical method, also known as the interchange method of large numbers, is based on the rules of probability theory on the synthesis of independent random variables. The dimensional chain is calculated based on the 99.73% confidence level to ensure that most products meet the requirements of assembly accuracy. According to this requirement, the tolerance of the statistical method is obtained:

$$T_{ge} = \sqrt{\sum_{i=1}^{m} (l_i T_i)^2}$$  \hspace{1cm} (2)

Among them, $T$ stands for temperature and $m$ stands for quantity.

The normal temperature environment involved in this article refers to a general environment that does not consider the effect of temperature on assembly accuracy or the temperature effect is very small. The purpose of the experiment is to verify whether the system can obtain the correct assembly dimension chain and reliable assembly accuracy prediction values for complex assembly situations.

4. Test Data results of the Assembly System

4.1. Analysis of Assembly Dimensional Change Data at Different Temperatures

Due to the small linear expansion coefficient of metal materials, in order to measure a more obvious change in temperature vs. assembly accuracy, this paper selects a larger temperature difference for experimentation. According to the results of the experimental test, the data collected in this article is shown in Table 1:

| Temperature | Measurement size | Forecast size | Absolute size difference | Relative size difference |
|-------------|------------------|---------------|--------------------------|-------------------------|
| 30          | 230.51           | 230.49        | 0                        | 0.03                    |
| 60          | 231.05           | 231.07        | 0.04                     | 0.04                    |
| 90          | 231.12           | 231.15        | 0.11                     | 0.05                    |
| 120         | 231.17           | 231.19        | 0.18                     | 0.06                    |
| 150         | 231.24           | 231.27        | 0.20                     | 0.05                    |
As shown in Figure 2, we can see that there is not much difference between the predicted result in the low temperature zone and the actual measured result, but as the temperature rises, the error becomes larger and larger. This is because the assembly is susceptible to thermal expansion and contraction when measuring dimensions at high temperatures, so it will be subject to more interference.

5. Conclusion
Rapid assembly technology is also called CAD/UI processing. It is an advanced production method. Through the use of various advanced mechanical equipment to complete the functional modularity required for product design, in order to achieve high efficiency and high quality requirements. Rapid assembly is the conversion of 3D information such as CAD drawings and solid part models into actual geometric dimensions or shape parameters to achieve product quality and cost control and optimize resource efficiency goals. According to the experimental test in this paper, the predicted result is close to the measured result and meets the error range, which shows that the reliability of the system and the accuracy of the assembly model proposed in this paper are guaranteed.

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