The Extraction of Product Assembly Feature Information for Intelligent Assembly Sequence Planning

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Abstract. The assembly feature information contained in the CAD model of the product is an important basis for the generation of intelligent assembly sequence. Taking the assembly model of the product as the research object, the research on the acquisition of assembly feature information of the product by intelligent assembly sequence planning is proposed in this paper. Microsoft Visual Studio 2005 and SolidWorks API are used as implementation means to access the internal data of the product CAD model and realize the extraction of the hierarchical information, mating relation and mating line and surface assembly features of the assembly model. An application example of product assembly feature information extraction for the locking device of an elevator landing door shows that the established method of acquiring product assembly feature information is effective and provides a theoretical and technical basis for the establishment of product design and assembly sequence planning knowledge base.

1 Introduction

As a key technology of advanced manufacturing technology, intelligent assembly sequence planning has received extensive attention from academia and industry. Because the intelligent assembly sequence planning of products is a complex process, it needs to get a large amount of assembly knowledge and information, and the current 3D CAD model is difficult to express the invisible knowledge in product design [1]. A large amount of information is contained in the assembly process, and the data transmission in the process of personnel information interaction is uncertain and random, it will inevitably cause certain difficulties in intelligent assembly sequence planning. Therefore, how to provide necessary product assembly feature information for intelligent assembly sequence planning is a problem that needs to be solved urgently.

The 3D assembly model of the product contains a lot of rich resources [2]. The secondary development of SolidWorks through secondary development tools that support COM programming can effectively improve its sharing and reuse. In recent years, many scholars have carried out related researches on the extraction of 3D assembly model resources. In the process of identifying and extracting the connection relationship of the
parts assembly of the product model in literature [3], for the shortcoming that the assembly relationship cannot be directly acquired in the 3D CAD model, a method is proposed to extract the connection relationship by using the neutral product model data exchange standard. A template-based method for extracting point cloud edge assembly features under the condition that the computer-aided design model has been determined is proposed in literature [4], and the pose deviation between components is calculated quantitatively, laying a foundation for further assembly processing.

According to the research and analysis, from the perspective of the establishment of the knowledge base of assembly sequence planning, the concept and level of assembly feature information of product assembly can be considered uniformly, so as to better and effectively support the acquisition of assembly feature information knowledge.

2 Ideas for product assembly feature information extraction

For the extraction of product assembly feature information of intelligent assembly, firstly a 3D model of the part in the product CAD modeling software SolidWorks is established and each part is assembled to generate an assembly. Microsoft Visual Studio 2005 is used to access the data of SolidWorks 2013 with the help of SolidWorks API. Access to the internal data of the CAD model, and generate plug-ins in *.dll format. The generated plug-ins extract the level information, mating line and surface features, and mating relations of the assembly. The flow chart of assembly feature information extraction is shown in Figure 1.

![Figure 1. Product feature information extraction.](image)

3 Extraction technology for product assembly feature information

Product assembly feature information refers to a collection that can completely express the relationship between parts and sub-assemblies. The analysis of the product assembly model structure and the hierarchical description of assembly information shows that the general assembly and its parts and sub-assemblies and their parts have the same data structure. Recursive methods can be used to traverse the product assembly model tree to identify and
extract the assembly information of SolidWorks products [5]. The algorithm flow of traversing the SolidWorks product assembly model tree is shown in Figure 2.

Figure 2. Algorithm flow traversing SolidWorks product assembly model tree.

Extract product assembly feature information by taking the elevator landing door locking device as an example. The operation interface is shown in Figure 3. Where, "the name and level of assembly parts and sub-assemblies" function module gets assembly level information; the "traverse assembly relations" function module realizes the extraction of matching relations among parts; the "mating line and surface feature extraction" function module gets the mating features among parts; "input data to Excel" function module realizes the storage of product assembly feature information.
3.1 Assembly level information extraction

Complex assemblies are often composed of parts and sub-assemblies at different levels. This hierarchical relationship clearly expresses the hierarchical position of parts and sub-assemblies, and also describes the subordination relationship between parts and sub-assemblies in the assembly. The extraction of assembly level information is an indispensable part of product assembly feature information for intelligent assembly sequence planning.

To extract assembly level information, firstly, use the function IGetActiveConfiguration and function IGetRootComponent to get the configuration of the current assembly and the currently configured assembly group, and use the function TraverseChildren to traverse the assembly to get the level information of the current assembly. For sub-assemblies, call the traverse sub-function to get the assembly level information [6].

The assembly level information extraction is shown in Figure 4. In the process of assembly sequence planning, the assembly level and contained parts can be got through the retrieval of product assembly feature information, which can be hierarchically reasoned, reducing the difficulty of reasoning about the assembly sequence.
3.2 Mating relations extraction

The assembly is composed of several parts or sub-assemblies. Related constraint relationships are given among parts. Such constraint relationships are called mating relations. Mating relation cannot only clearly describe the mutual position and mutual constraint among parts and sub-assemblies qualitatively, but also quantitatively express the complexity of parts and sub-assemblies. This complexity is expressed by the quantity of mating relations, which means that the parts with a large number of assembly mating relations are more complex.
relations have more spatial constraints in their spatial positions, and assembly sequence planning should be prioritized for assembly [7].

In the SolidWorks API function, the following mating types are defined in the swMateType_e list:

a. (superposition) swMateCOINCIDENT
b. (concentric) swMateCONCENTRIC
c. (vertical) swMatePERPENDICULAR
d. (parallel) swMatePARALLEL
e. (tangency) swMateTANGENT
f. (distance) swMateDISTANCE
g. (angle) swMateANGLE
h. (unknown) swMateUNKNOWN

In the program to get the mating relation, the configuration of the current assembly and the assembly group of current configuration need to be got first, and the assembly is traversed on the basis of the current configuration and the assembly group of current configuration. For sub-assemblies, call the traversal subfunction until the parts that form 3D model assembly are got. 3D model parts of each part are traversed. The function get_Type is used to identify the type, for example, if it is a coincident fit, output a coincident fit. The function MateEntity is used to call out the parts of a coincident fit, and get_Name2 is used to get the name of the mating part, and the extraction of the mating relation is realized.

The extraction of mating relations is shown in Figure 5. The extracted mating relations can get the number of constraint relations among parts through knowledge retrieval of product assembly feature information, determine the priority assembly order of parts, and also provide basic information support for assembly sequence reasoning.

3.3 Extraction of mating line and surface feature

The mating line and surface feature information is the foundation of the mating relation and an important part of the product assembly feature information in assembly sequence planning. In a common assembly, there are several basic ways of mating among parts: the
mating of the surface of the parts, the mating among the edges of the parts, the mating among the reference axes, and the mating among the reference surfaces. After the assembly is completed in SolidWorks, it is difficult to observe the geometric relationship among the parts through which the parts are assembled. It will cause that it’s impossible to find accurate reference for assembly in the actual assembly process, which will inevitably lead to assembly decline in accuracy. In addition, in the process of assembly sequence planning, the geometric relationship among parts is the most concerned object for assembly sequence planning.

In the program of mating line and surface features extraction, firstly, the function get_IActiveDoc2 is used to get the currently active object. On the basis of the object, the selection manager object is got, and the function GetSelectedObjectOfType2 is used to get the type of object selected by the user and determine the type. The selected object is the edge of the part, the surface of the part, the reference axis or the reference surface, and finally the selected object type is output.

The extraction of mating line and surface features is shown in Figure 6. In the process of extracting mating line and surface features, this paper uses an interactive method to extract line and surface features, which intuitively shows the geometric relations among parts and reduces the difficulty of line and surface feature recognition.

![Figure 6. Mating line and surface feature extraction.](image)

### 3.4 Storage of product assembly feature information

The extracted product assembly feature information is displayed in a dialog box, which cannot be called and processed for multiple times. In order to improve the utilization rate of product assembly feature information, Microsoft Visual Studio 2005 is used as a tool to access Microsoft Office Excel 2003, and the acquired product assembly feature information is stored in an Excel table.

The product assembly feature information got in the 3D CAD model is stored into an Excel table. Take partial information of the elevator landing door locking device information in Figure 7 as an example to state: in the stored assembly level information, the assembly Door locking device. SLDASM is at the first level, and the subassembly bolt group-two-subassemblies-1 is at the second level. The part Bolt rod-two-1 is at the third level. The second and third levels use the symbol "/" to indicate the subordination relation;
the mating relation and mating line and surface feature information, the part frame-1 and the plastic cushion-1 realize coincident fit by mating feature surfaces.

![Assembly level information extraction](image)

**Figure 7.** Assembly level information extraction.

### 4 Conclusion

The comprehensiveness and perfection of product assembly feature information extraction is the key factor to realize the feasibility of assembly sequence intelligent planning. By using VS2005, SolidWorks is secondary developed with the assistance of Solidworks API, and a product assembly feature information extraction technology oriented to intelligent assembly sequence planning is used. Compared with traditional product information extraction methods, this method finally extracts the names and level, mating line and surface assembly features and mating relations of assembly parts and sub-assemblies are extracted more comprehensively and completely, and stored completely in Excel, to prepare for the establishment of further assembly knowledge base and subsequent development and call. This method effectively reduces the difficulty of information acquisition in the assembly process, simplifies the process of assembly information extraction, and lays the foundation for the intelligent planning of assembly sequence.

### References


