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Research on Assembly Data Mining Technology of Complex Mechanical System

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Abstract

The discipline between the assembly process and the final performance of complex mechanical system is unclear and the performance target is usually reached by experienced technicians. To find out the discipline and obtain the knowledge which may be hiding in the experience of technician, data mining technology is put forward to analyze the assembly data. By establishing the structure and procedure of the data mining process and encapsulating the data mining template of the assembly data, the knowledge of the discipline and assembly experience can be extracted through a case study. These knowledge can be used for assembly quality prediction, parameter optimization, process improvement and success rate increase.

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Keywords: Assembly data; assembly process design; data mining; priori knowledge

1. Introduction

Assembly process is one of the most important links in the whole manufacturing processes of mechanical product. In the assembly process of mechanical product, the various parts and components are combined and connected to a high level mechanical assembly in accordance with design requirements according to the principle of dimension coordination. Because the performance of complex mechanical assembly involves many factors and fields which require rich experienced assembly process designers and technicians, the product is in poor consistency and the assembly efficiency is low. There exist many other problems on how to improve the performance of complex mechanical products. Ingrid A and Daniel P [1] researched on the nonlinear dynamics of bolted assemblies. Jiang S and Zheng S [2] analyzed and improve spindle-drawbar-bearing assembly dynamics. Guo Y and Parker R G [3] focused on a spur planetary gear involving tooth wedging and bearing clearance nonlinearity. Although many review papers have discussed the influence between assembly process and the product performance, they cannot propose detailed perspectives of how to improve assembly processes and parameters.

After analyzing the actual assembly process currently and considering the large amounts of data accumulated in the enterprise database, data mining technology is proposed to apply to the assembly data`.

Groger [4] presents indication-based and pattern-based manufacturing process optimization as novel data mining approaches provided by the Advanced Manufacturing Analytics Platform. Koksal G and Batmaz I [5] review the data mining applications for quality improvement in manufacturing industry. Perzyk M and Biernacki R [6] analyse the process parameters of the data mining tools in manufacturing. Although a few review papers have been published to discuss data mining applications in manufacturing, these only cover a small portion of the applications for assembly problems.

On the other hand, the universal data mining tools are not special in assembly and the data mining process control, result analysis and visualization is not suitable for assembly technicians directly. Because of these situations, assembly data mining platform can be programmed to search the parameters which are hiding in the data and responsible for the performance.

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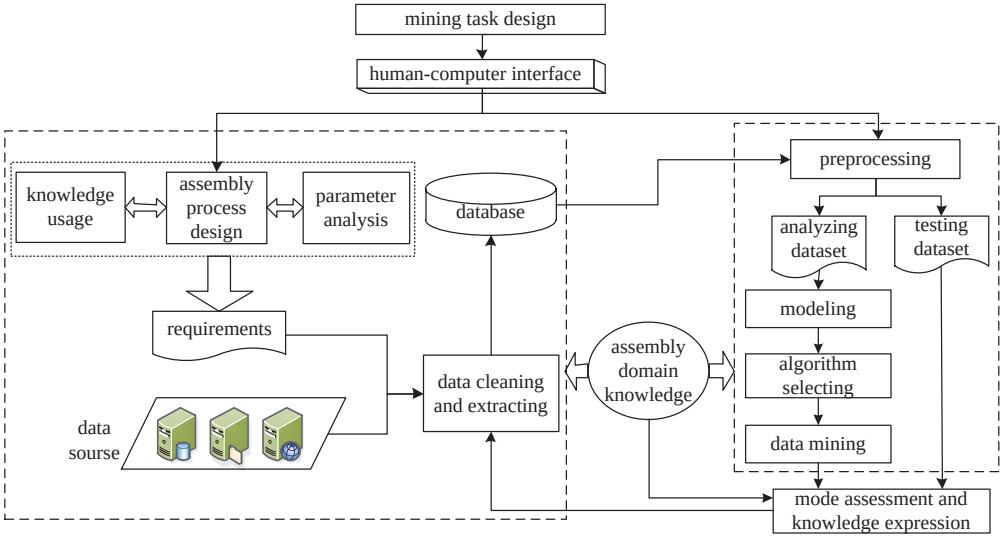

Fig. 1. Assembly data mining process.

2. Assembly data mining structure

In order to form the assembly knowledge library, guide the process design, identify the key procedure, find out the interrelated parameters and predict the performance with the existing data , assembly data mining is not only simple query to the database but also need micro or macro data statistics, analysis, synthesis and reasoning. According to the basic steps of data mining [7], the structure of assembly data mining is shown in Fig. 1.

2.1. Mining task design

The deviation and mutual dependencies of some parameters and is obvious in the part fabrication and product assembly processes, but sometimes it is difficult to give accurate values through theoretical calculations. After communication with the assembly specialists, the data mining technicians have an excellent grasp of the problems and a clear mind of the objectives with the existing assembly rules. And mining task can be designed with appropriate assumptions.

2.2. Data preparation

Data Preparation accounted for 80% of the whole data mining process. And it is the key to the success of data mining. Data preparation contains a number of methods including data selection, data cleaning, data integration, data extraction, data complement, data sampling, etc. Whether to use the method depends on the characteristic of the data [7].

2.3. Data mining

The core step in this stage is to choose appropriate algorithm by comprehensive analysis of the mining task and data style. For instance, if the task is regression and the final model is linear, the algorithm such as ordinary least squares, ridge regression and last angle regression is preferable. And the nonlinear methods like K-nearest-neighbor are apt for classification [8,9].

2.4. Model assessment and knowledge expression

Generally it is not easy to understand and apply the patterns obtained from the above step directly. Technology on visualization and knowledge representation can be used to interpret them. The specialists in the field of assembly, the assembly process designers and assembly technicians assess and judge the patterns. The knowledge which is correct and useful will be stored in the knowledge database to support the further designing and assembling.

Assembly domain knowledge runs through the entire process. Any step without considering the domain knowledge may make the final result not fit the actual assembly rule and lead to the failure.

3. Data mining templates encapsulation

The object of assembly data mining is mainly including assembly process variables, the dimensions and tolerances of the parts. The specialists in the field of assembly have to customize data mining templates because of the diversity of assembly process variables and the associated complexity

The templates are encapsulated in the database beforehand. The other assembly technicians can select the corresponding templates as sample models based on their mining target without screening the parameters. The construction and application of the templates is shown in Fig. 2.