The Research and Application on Hybrid Intelligent CAPP System Based on Object-oriented Model Driving

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Abstract- The characteristics of interactive, variant, and generative principles applied for Computer Aided Process Planning (CAPP) are discussed in detail. Based on the CAPP platform (CAPPFramework) supported by 863CIMS in China, the key techniques of object-oriented model driving, object-oriented manufacturing-domain knowledge processing technology and hybrid intelligent process planning are presented in detail.

Key words: CAPP, object-oriented model driving, hybrid intelligent

I. Introduction

With the research of advanced manufacturing technology, the reconfigurable, reusable, scalable characteristics of computer application systems in manufacturing enterprises are emphasized, which can make manufacturing system suit marketplace rapidly in rational cost and way. Computer Aided Process Planning (CAPP) system is in the same situation as other computer application systems. Practicality, engineering, integration, intelligence have become the precondition to the wide application of CAPP system.

Now almost all CAPP systems adopt interactive process planning way, intelligent decision function is neglected. The quality of process planning depends on the knowledge and experience of process planning engineer wholly. The workload of process planning engineer is still burdensome. Criterion, quality, integrality, consistency of process planning could not be ensured. The process data and knowledge accumulated by enterprise could not be used sufficiently; this situation is not propitious to the information integration. Variant CAPP system uses process search technology to design process, it can reduce the workload and dependence of salted engineer, the inheritance and reuse of product process are improved also. Variant CAPP system can solve the specification and standard of process planning problem. But the traditional way of summarizing typical process is a time consuming work, it needs many people to do, the inflexible can not meet the variational marketplace. For the complexity and diversity of process planning environment, generative CAPP system although has high intelligence, good specification and high efficiency, it can not realize general process decision procedure, the acquirement and maintenance of process knowledge become a bottleneck in development and application of system. Generative CAPP system has narrow application environment and long developing period. Both the interactive, variant, generative CAPP system has its merit and defect respective. In order to exerting the advantage of engineer and computer, we presented the hybrid intelligent CAPP system based on object-oriented model driving to ensure the characteristic we mentioned above.

CAPPFramework is a application framework and developing platform based object-oriented model driving supported by 863CIMS in China, it adopts hybrid intelligent process planning technique and integrates many application support tools. Process knowledge and product process data are kernel of CAPPFramework. CAPPFramework could be applied in different type enterprises and different process department; it supports the gradual development and implements way. The research work reported below will describe the object-oriented model driving method and hybrid intelligent process planning platform.

II. System building based on object-oriented model driving

A. System modeling of object-oriented

System building based on model driving is the guarantee to the universal, maintenance, expansion of CAPP system, CAPP system could running in uniform information model; it can realize the dynamic change of data structure, data flow by the change of model to adopt the change of environment. The modeling of CAPPFramework uses object-oriented technology as it's basic. Object-oriented method is a way that uses object, class, instance, etc concepts to describe software system in software development, it's fundamental is to understand research domain in natural way, the definition and identification of entity are in human's impersonality thinking way. Object-oriented method is an intuitionistic, natural and easy understanding modeling method. Object-oriented process information modeling in CAPPFramework adopts object-oriented method to describe the relation and manipulation of entity structure and object in CAPP system, the model of process procedure is described in right object.

1) Object

Object is an absolute entity that encapsulates the attribute and method of object. In manufacturing domain, impersonal entity such as an enterprise, a shop, a machine, a tool, a product, a part are object, professional concept such as a process procedure, an operation, a step, a decision procedure are object also.

Object attribute and object method are the two key factor of object. Object attribute is the description of object structure. In general, an object has many structure

characteristics that form the object attribute set. For example, we can use model, name, maximal machining diameter, maximal machining length and so on to describe lathe object. Object method is the description of manipulation that the objects can perform. In detail, object methods are procedure defined in object. In general, an object has many methods, which form the object method set. For example, we can use machine selecting, assistant operation arranging and operation sorting and so on to describe manipulation of an operation object.

In general, the types of object attribute are integer, float, string and so on. In order to describe the relation of object and engineering data, CAPPFramework created the data types of object, object list, drawing, text, etc. Object type describes the relation in 1:1 of object class, such as a operation to its machine. Object list type describes the relation in 1:n of object class, such as a operation to its step.

An object can be a simple object or very complex. Complex object usually aggregated by simple objects. In process planning, machine and tool are simple objects, operation and step are complex objects.

2) Class

Class is an important concept in object-oriented. Class is the abstract of a group impersonal object. Class collects the common characteristics (structure and behavior) of the group impersonal object in order to describe the character and capability.

An important character of class is hierarchy. A class may have super class as well as subclass, such hierarchy is inheritance. This way is the sane as the procedure of human does. Human know things by classifying, the hierarchy of class is essentially equal to Human.

3) Instance

The objects of a class are instance of the class, in other words, class is the abstract and synthesis of some instances and instance is the actual object of class. For example, when we see a machine of C620 model, we may say, "This is a lathe", in object-oriented language we can express in such words: "This is a instance of lathe class", namely lathe class is a class, C620 is a actual object, it is a instance of lathe class.

4) Object-oriented analysis

The key of object-oriented analysis is to identify the object, class and its relation in research domain. Now in the research of CAPP, we use object-oriented to analyze process planning problem, in part description and programming we use object-oriented also. Most of all, we must adopt object-oriented analysis and modeling in a systemic way for CAPP system.

B. Basic model system of CAPPFramework

Process planning is a typical complex problem, its content is very widely, the information and knowledge used in process planning is very huge. We can divide the information and knowledge into process information model, procedure model, process data model, process decision model and decision control model according to

the role of knowledge. We set up process information model using object-oriented method. Process data is
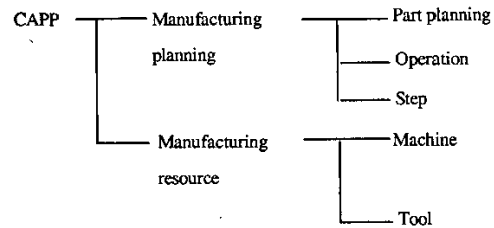

Fig.1. CAPP class tree (part)

stored in knowledge base and engineering database in the form of instances of classes. Decision control model and process decision model are express by rules. Because the knowledge describes the relation of classes and its attributes, the knowledge is integrated into process information model in the form of class method.

1) CAPP class tree (CAPPCT)

We use CAPPCT to describe the structure and relation of objects in CAPP system. In CAPPCT, every node represents a class and is identified by class name, the subclass of a class is marked up in sequence $(.1 ,.2, \cdots)$. For example, the hierarchy of machine class in CAPPCT is demonstrated as Fig.1.

2) The expression of CAPP class

Class can be expressed in figure as demonstrated of Fig.2, it can help the communication of user and documentation of CAPP system.

In such figure, class is expressed in three sections: class name/class code, class attribute set, class method set, the attribute of class has type and value (actual value and default value).

3) CAPP object relation graph (CAPPORG)

We use CAPPORG to describe the relation of object in CAPP system. Part planning, manufacturing operation, manufacturing step are basic object of process planning. They are basic nodes of CAPPORG
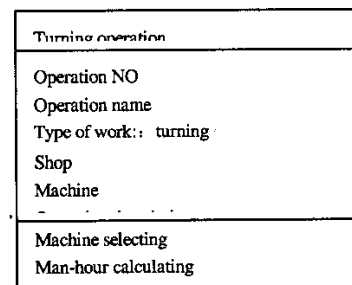

Fig.2. Expression of class

In CAPPORG, square denotes the object of class, the name of object is titled in the square. The line with arrow denotes the relation of two objects, in the left or above of line we use 1 or n to denote the relation of 1:1 or 1:n. For example, the CAPPORG of the machining process planning

of an enterprise is showed as Fig.3.

When we build model of CAPP application system, we must synthesize and analysis all kind of process planning file and specification. The definition of class must ensure the integrality of process planning specification system. The name and sequence of class's attribute may follow the habit of enterprise and be consistent with process planning file. The hierarchy of class may keep simple and conciseness, avoiding unwanted complexity. The CAPP application system is running based on object-oriented model driving, so the model's correctness and validity will affect the running of system directly.
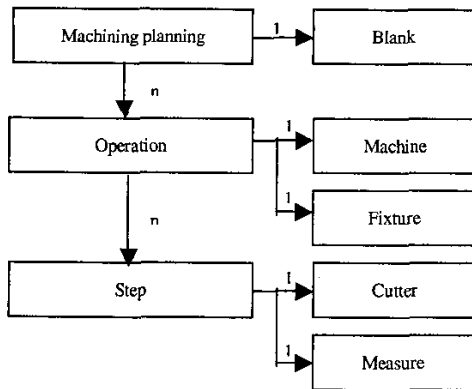

Fig.3. Machining planning ORG

III. Process knowledge managing and decision model

Process knowledge managing includes acquiring, organizing, maintenance and use of process knowledge. So we use object-oriented method, expert system, knowledge base and database synthetically to realize object-oriented process planning managing based on CAPP system model.

1) Expression of process decision knowledge based on object-oriented model

Process decision knowledge describes the logic relation between process classes and attributes. It has strong connection between process decision knowledge and object model. CAPPFramework uses rule to express process decision knowledge, rules that have the same decision function are organized a method of a class.

2) Class method

Class method is the organic unit of process decision knowledge, it is a set of rules that have the same decision function. A class could have many methods, every method includes many rules for a decision task. In the definition of class method, method name, reasoning way (single reasoning, multiple reasoning) , starting types (initiative method, passivity method) need to be confirmed. For example, operation class has machine selecting method, fixture selecting method and operation sorting method, etc.

3) Rule

The expression and management of process decision

rules need standardization according to the need of expression and reasoning. Rule element, key words and command words must be confirmed.

Rule element is the basic unit of rule, it is a instruction or judgment that has specific meaning. Rule element can be divided into condition rule element, command rule element, evaluate rule element etc. according to the intention and expression form. Condition rule element is used in the condition section of rule, command rule element, evaluate rule element are used in the conclusion and else section of rule.

In the expression and reasoning of process decision knowledge, corresponding words are needed to substitute objects of classes, we use key words to solve the problem. For example, operation is used to represent operation object, step is used to represent step object, tempobj is used to represent the temporary object we needed.

At the same time, in order to describing some decision behavior or providing the manipulation of human-machine interactive, command words are introduced. For example, create is used to describe a create process of a object, queryobject is used to describe a query of a object data, getchoice is used to describe the asking for user to input data according to the prompt.

In order to assuring the correctness of process decision rule in syntax and semantic, the precompiler of rule is needed when we do the maintenance of class method.
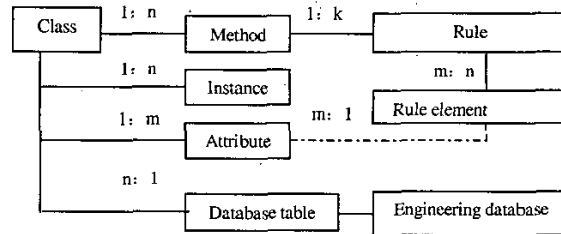

Fig.4. The relationship between process information model and process

4) Intelligent decision

Process decision procedure can be divided into many decision subtask, the decision of every subtask is running based on a main control class and attribute value of interrelated classes. In term of the hierarchy of decision, process decision can be divided into class reasoning, subtask reasoning, procedure model reasoning etc. Class reasoning is a reasoning procedure of a class method for a class object. Subtask reasoning is a reasoning procedure of a class method for all objects of. a class. In reasoning procedure, the key problems are coordinate and setting of object data, circulating setting current decision object, calling the object reasoning function. Procedure model reasoning is the reasoning procedure of all subtask reasoning in term of decision procedure model.

Decision procedure model is the knowledge of controlling decision procedure. In order to facilitating decision control

of decision expert system, the whole process decision task is divided into many decision subtasks, every subtask has a main control decision object and its method. Decision expert system executes every decision subtask by procedure control knowledge.

Decision procedure model :: = <[prior subtask], [current subtask], [current class], [contained class], [current class method]>

IV. Hybrid intelligent process planning

Hybrid intelligent process planning is a process planning pattern by using interactive, variant, generative etc. synthetically, it can exert the specialty of computer and human, improve the quality and efficiency of process planning at its maximum, ensure the integrality and consistency of process information, buildup the integration of CAPP system. The synthetically using of interactive, variant, generative is not compounding them simply, it is a procedure of infiltration and amalgamation organically. The user is the main body of process decision, the realization of system intelligence and exertion of human intelligence will assist process planner effectively in the application process of CAPP system, in this manner the efficiency of CAPP system can be improved effectively. For example, we can use the human intelligence to solve the programming decision problem of process route arranging and use the computer intelligence to solve cutter selecting and calculation problem. Figure 5 shows the meaning:

1) Interactive process planning based on process knowledge base

The manner of user interactive input is keep close relation with process information model, the basic ways are: automatic association and display class instance in knowledge base for user's selecting by the current class using, selecting input by the restriction of attribute value, automatic association and display class instance in knowledge base for user's selecting by the association definition of class attribute in knowledge base, automatic calculating attribute value by the calculation formula definition.

Knowledge base can realize the dynamic information integration and share with engineering databases by the database association condition of class definition. These engineering databases can be regarded as object instance database outside process knowledge base, the data of engineering databases is the same as process knowledge base in logic. In this way we realize the dynamic information integration and assure the consistency of process information.

2) Variant process planning

Typical process database is the basic of variant process planning. We can use group coding to describe typical process or use graphical typical process display, namely, by the use of graphics of part and some explanation to make the use of typical process easily.

If the typical of process is strong, we can use parametric process planning method based on typical process to realize process planning. This method is the same with the strong

typical process of parts, we modify some process parameter or do partial modify by part's attribute in the process planning procedure.

3) Intelligent decision

In the basis of information model and decision procedure model, we can use expert system ·based on rule to accomplish corresponding decision task in all or partial of process planning procedure, in the decision procedure, the user can participate in decision procedure by interactive way, the result of decision can be edited and modified by user.

4) Dynamic knowledge acquirement based on instance

The sum up of typical process and acquirement of process knowledge are the bottleneck of variant and generative process planning. CAPPFramework realizes dynamic knowledge acquirement based on process instance, in this way, knowledge can be consummated gradually in the running process of CAPP system. With the deep and wide application of CAPP system, an abundant product process database will be formed, it can provide a new way to improve intelligence for CAPP system.
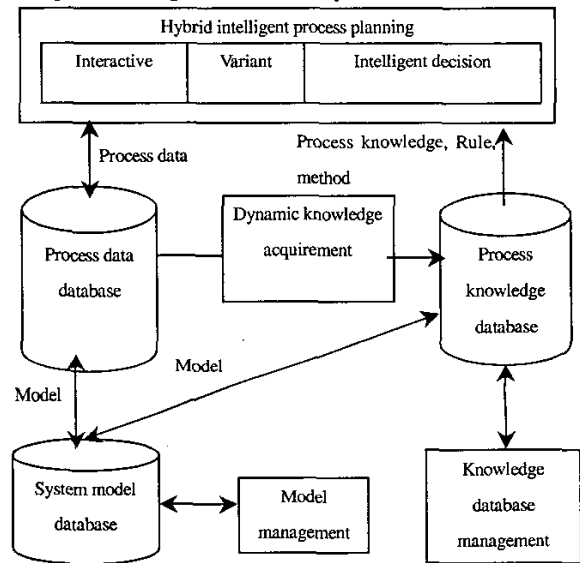

Fig.5. Hybrid intelligent process planning based on object-oriented model driving

V. Conclusions

In the thought of object-oriented model driving and hybrid intelligent process planning, the CAPP application framework and developing platform (CAPPFramework) adopts hybrid intelligent process planning technique and can integrate many application support tools. Process knowledge and product process data are kernel of CAPPFramework. CAPPFramework can apply in different type enterprises and different process department, it supports the gradual development and implement way. In the implement of CAPPFramework in different trade, we

can setup CAPP basic framework, basic procedure and basic function oriented different trade, it can become CAPP system platform of a trade.

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