AN AUTOMATIC NC PROGRAMMING SYSTEM IN INTEGRATED CAD/CAM

Q. Y. Zhu, W. H. Yu, J. Y. Zhu

Nanjing Aeronautical Institute
Nanjing, P. R. China

Abstract

An automatic NC programming system that can be integrated with CAD system is introduced in this paper. This system , called KBAPS (Knowledge — based Automatically Programming System), is also an expert system. It adopts blackboard model, forward & backward bidirectional reasoning strategy and voice user interface. It is connected with CAD system by neutral file obeying the standard of IGES and used as a module of integrated CAD/CAM system to automatically generate NC programs for the NC machine tool. It also has the functions of simulating the cutter paths of the NC machine tool to verify the correctness of the generated NC programs.

I . Introduction

APT (American National Standards Institute 1980) is an effective tool for NC programming and also a sophisticated system. Sophistication is either an advantage or a disadvantage of APT. Though APT is powerful in programming the parts from simpler to more complicated, it is difficult to handle. This is not only because of over sophisticated but very strict in input stream. In fact, it is a strictly formulated language compiler, so the input of APT must be a carefully programmed programs. Also, due to the characteristic of APT itself, APT is difficult to integrated with CAD system: the data transformation between CAD and APT must be accomplished by humanbeing.

Therefore, to provide the more user friendly automatically programming tool, some new method based on new structure must be tried. Artificial intelligence(AI) provides us with many new methods to successfully solve the very complicated domain problems (Grimson and Patil 1987). Automatically Programming is one of these domain problems. So here a Knowledge — based Automatically Programming System(KBAPS) is introduced in this paper. It can automatically generate the NC programs and simulate the cutter paths of the NC machine tool to verify the correctness of the generated NC programs.

II . Brief Description of KBAPS

KBAPS is a Knowledge—based system, in fact, is an expert system, which can be used to automatically generate the NC programs for NC machine tool. It adopts blackboard model, forward & backward bidirectional reasoning strategy and voice user interface. The system structure is shown in Fig. 1.

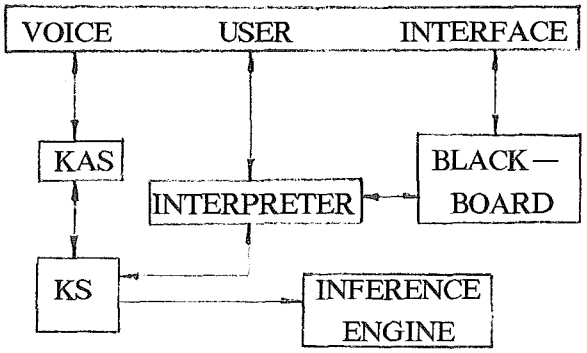

Fig. 1 The system organization of KBAPS

The KBAPS has the following characteristics:

1. Blackboard model is adopted;
2. The inference engine and the knowledge base are independent in structure;
3. The knowledge base adopts multi—knowledge source structure;
4. Forward & backward bidirectional reasoning strategy inference engine;
5. Voice user interface;

6. Integrated with CAD system through neutral file.

Ⅲ. Knowledge Representation

Effective knowledge representation is the critic point to determine if the Knowledge—based system, such as expert system, can be successfully built. At the same time, knowledge representation is also a key point that must be solved at the very beginning.

From the procedure point of view, the work of KBAPS is consisted of two successive planning procedures: when the part geometric dimensions are inputted, first, KBAPS infers out the part whole geometric structure (calculating the base point and node point), then, makes planning of the tool cutters path based upon the part geometric structure and process information, etc. It is obvious that the latter procedure is depended on the former. Therefore, the whole system knowledge can be divided into several mutually independent source of knowledge. Here, according to the difference between the two procedures of planning, the knowledge base is divided into geometric sub—base and process information sub—base, etc.

According to AI, knowledge representation can be divided into rules, frames and semantic network, etc. (Rith 1983). The rules are suitable for representing dynamic knowledge, while the frames are suitable for representing static knowledge. In KBAPS, the geometric knowledge is represented as frames. For example, the frame of points adopts the following representation:

```
frame:point
    belong to:
      layer
    definitions:
    coordinates:
      x,y
    type:
      real
    default:
      0,0
    IF point is the tangent point of the circle and line
      THEN get the tangent point of the circle and line
    IF point is the cross point of the circle and line
      THEN get the cross point of the circle and line
    IF point is the cross point of the two circle
      THEN get the cross point of the two circle
    IF point is the symmetry point of the point
      THEN get the symmetry point
  own:
      symmetry point, cross point, tangent point.
```

The manufacturing process knowledge is represented as rules. For example:

```
RULE6:
IF material is heat—resistant or material is Ti alloy or material is Al—Mg alloy
  THEN should adopt clockwise milling
```

Ⅳ. Knowledge Acquisition

The performance of the Knowledge—based system is depended on the knowledge it possesses. The more knowledge it possesses, the higher in performance it is. However, almost every software will have some drawback when it has just been finished. The knowledge system is not an exception. This leads to the necessity of the maintenance of the knowledge system, especially the knowledge base. From the view point of providing open system to users so that the users can conveniently maintain the KBAPS, the knowledge acquisition system in KBAPS is designed to be a semi—automatic knowledge acquisition system. The knowledge acquisition system that the KBAPS provided is a grammar guided (Hart 1986) knowledge editor. The user can also use the other edit tool, such as DOS EDLIN, PE2, etc., to edit the knowledge base.

Ⅴ. Blackboard Model

In modern expert system, blackboard (Nii 1986) is a very important component. Using blackboard model can enhance the flexibility in designing the expert system. In KBAPS, a multi—level blackboard model (see Fig. 2) is adopted to collect the in-

formation about facts, the intermediate states and results of reasoning and the control information. The blackboard connects the relevant knowledge sources according to the facts that are regarded as the objects on the blackboard, and carries out the inference step by step, until the problem is fully solved. Due to the knowledge sources are mutually independent in KBAPS, the only link between them is the blackboard. The knowledge sources can modify the contents of the blackboard. The control information is used to select the optimum operation during the running process.

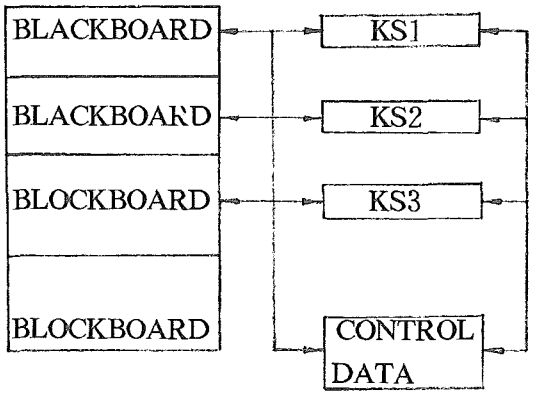

Fig. 2 Blackboard model in KBAPS

Ⅵ. Inference Engine

The inference engine is the kernel of the expert system. Its behavior determines The performance of the whole system. The main function of the inference engine is to infer out the conclusion from the information provided by the user based on the knowledge in the knowledge base. In general, there are two inference strategy: the data driven forward chain and the goal driven backward chain (Wu and Zou 1988). The advantage of the forward inference strategy is that the user can actively provide the information about the problem, while the backward inference strategy has the advantage that the reasoning has some definite goal. Of course, both of these two reasoning strategy have some disadvantages. In KBAPS, considering that both of the forward and backward reasoning strategy have advantage and disadvantage in some concrete condition, a bidirectional (forward and backward) reasoning strategy is used. At first, the initial goal is chosen by the forward chain, then, the backward chain is used to verify the initial goal, the forward and the backward chain act in turn until the solution is obtained.

Ⅶ. voice User Interface

User interface is a very important component of the software. In KBAPS, a very user friendly interface is designed. In designing the user interface, the KBAPS is supposed to be able to handle the restricted natural language oral input. This is a very important concept, since that the oral communication between man and machine is more natural and more efficient than keyboard — CRT communication for the user. The user interface in KBAPS is consisted of a speech recognizer, a command analyzing system and multi--window menu mechanism. The ASR—2(Yu et. al), the speech recognizer, which is plugged into the computer, is used to process and recognize the user's input speech. In ASR—2, a 16—channel band pass filter is used to extract the feature of the input speech. Then the recognizer matches the input speech with templates that were generated and saved during the training phase by the Dynamic Time Wrapping (DTW) (Itakura 1975) algorithm and takes the template that is least different from the input speech as the result of the recognition. It should be pointed out that the ASR—2 can only process the discrete speech. This is the drawback of the system. The recognized discrete speech string (a string of discrete utterance) then is sent into the command analyzing system of the KBAPS. The command analyzing system first parses the string to determine if the string is conformed to the defined syntax rule that is defined by KBAPS in advance. The command analyzing system also has some ability to correct some recognition errors in the string, so the system has some extent of performance of fault tolerance. Then, the system takes semantic analysis for the parsed speech string. At last, a corresponding operation is performed according to the user's command. A multi—window menu structure is also used in KBAPS. With the help of this mechanism, the user can conveniently communicate with the KBAPS.

Ⅷ. Interpretation Mechanism

Interpretation mechanism is an important compo-

nent of the consummate expert system. It can raise the affirmation of the reasoning of the expert system and help the user to find the fault in expert system. In KBAPS, the following interpretation function are provided:

1. What? It answers the question of static knowledge to the user, which is implemented by searching the knowledge base and precontext;

2. Why? It answers why the system asks the user that question, which is implemented by backtracking and backwardly searching the object tree;

3. How? It tells the user the basis of obtaining the conclusion, which is implemented by forwardly searching of the inference tree and summarizing the relevant goal.

IX. Integrated with CAD system

The KBAPS is designed as a module of integrated CAD/CAM system, which is being developed here, so the connection is realized through a neutral file. To get generality of the data transformation between the CAD system and KBAPS, the neutral file is designed based on the standard of IGES (Initial Graphics Exchange Specification). Further more, the KBAPS is designed to connected with a well known graphic software package, AutoCAD, to generate NC programs. In this regard, a simpler and more effective way of data transformation is used. It is using DXF file of AutoCAD to act as the neutral transformation file between the KBAPS and AutoCAD.

X. NC Programs Generation and Verification

The final object of the KBAPS is to automatically generate the NC programs and verify the correctness of the generated NC programs. The working process in KBAPS is as following: first, the user is asked to input the part geometric dimensions into the KBAPS, then, the KBAPS conducts the geometric planning to calculate the base point and node point; second, the user is asked to input the process parameters so that the system can carry out the cutter paths planning to calculate the Cutter Location Data(CLDATA), third, the system transmits the CLDATA into postprocessing module in KBAPS to generate the NC programs; at last, the system simulating the cutter paths in CRT to verify the correctness of the generated NC programs.

XI. Conclusion

From the above mentioned investigation, it can be concluded that Knowledge — based method may provide us with an effective tool to integrate the part geometric and process information into NC programming system and make the NC programming be more effective and more user friendly. Also, in Knowledge —based NC programming system, Frame can represent the geometric knowledge very well, while the rulers can be used to represent the process knowledge. In addition, creating user friendly interface in Nc programming system is also important, in this aspect, voice user interface is a good option.

Reference

(1) American National Standards Institute, 1980, "ANSI Standard ANSI x3. 37—1980", New York.

(2) Grimson, W. E. L. , Patil,R. S. , Ed. ,1987, "AI in the 1980s and Beyond", The NIT Press, Cambridge, Massachusetts.

(3) Hart, A. , 1986, "Knowledge Acquisition for Expert System", Anchor Brendon Limited, Tiptree, Essex.

(4) Itakura, F. , 1975, "Minimum Prediction Residual Applied to Speech Recognition", IEEE Trans. Acoust. , Speech, Siginal Processing, Vol. ASSP—23, pp. 67—72

(5) Nii, H. P. , 1986, "Blackboard System: the Blackboard Model of Problem Solving and the Evolution of Blackboard Architecture", The AI Magazine, Summer, pp. 136—151

(6) Rith, R. , 1983, "Artificial Intelligence", McGraw—Hill Publication Company, New York, Part 2.

(7) Yu, W. H. , Zhu, J. Y. , Zhu, Q. Y. , "Multi--training in Different Levels of Environment Noise and Noisy Speech Recognition", 11th ICPR, Aug. 19--23,1991, Hefei, China

(8) Wu, X. D. , Zou, Y. , 1988, "Expert System Technology" (in Chinese), Electronic Industry Press, Beijing, Chapter 4.