Multi tool path managing and NC programming aided software based on UG

Gao Zihan\textsuperscript{1}, Lan Yingduo\textsuperscript{2}, Zhang Yidu\textsuperscript{1*}, Wu Qiong\textsuperscript{1}, Zhang Sentang\textsuperscript{2}

\textsuperscript{1}State key Laboratory of Virtual Reality Technology and System, School of Mechanical Engineering & Automation, Beihang University, Beijing, 100191, China
\textsuperscript{2}Shenyang Luming Aero-Engine (Group) Ltd., Shenyang, 110043, China

\textsuperscript{*}Corresponding author’s e-mail: ydzhang@buaa.edu.cn

Abstract. UG is a universal CAD and CAM software which lacks of modules for specific applications. For some specific types of workpieces, a professional software can be developed to improve programming efficiency and quality using UG application program interface. A NC programming aided software is developed through UG secondary development method with the function of reorganizing application menus, creating programs using group technology, translating and managing tool paths created by hypermill. All these functions of the aided software can increase the range of UG applications and make it easier and more efficient for specific problems.

1. Introduction

With higher quality and efficiency requirements for aeroengine casing parts, many new NC programming algorithms and softwares have been developed. UG is widely used in aviation enterprises and a lot of aided tools are developed based on UG using UG secondary development method.

UG secondary development had been widely applied in parametric modeling. Parametric modeling of face milling cutter was achieved using UG template model-based parametric design method \cite{1}. A model-updating program was developed based on MFC and UG/Open API and it could be effectively applied to engineering optimization design \cite{2}. To improve working efficiency, Cui simplified the method of creating synchronous ring spline tooth model through parametric design \cite{3}. At the same time, many applications were also focused on CAM. An automatic feature recognition system with STEP standard format was proposed. And geometric information was extracted from STEP AP 203 file created by CATIA and machining features were successfully recognized \cite{4}. A feature recognition algorithm which could extract simple features was developed to recognize different features of the IGES format model \cite{5}. Tool information was saved to the database and automatically invoked in subsequent operations to generate NC programs \cite{6}. It could save a lot of time and improve efficiency. A rib feature recognition method based on graph and knowledge was proposed. And a fast CNC programming system for rib feature of aircraft structure based on CATIA was developed which could recognize most of the simple rib feature of aircraft structure, but there were still some problems for the complex features \cite{7}. An advanced method was proposed to simultaneously increase the accuracy and decrease the calculation time for complex tool path programming in 5-axis machining \cite{8}. Parametric programming based on group technology could improve the efficiency for the similar problems \cite{9}.
There are some new softwares of CAM such as hypermill which can generate high-quality tool paths for specific complex part of the model.

UG secondary development technology has been widely used in parametric modeling, database applications and NC machining. And feature recognition was also considered in these applications. Feature recognition can have a good effect for simple features, but it can’t recognize all the pre-defined features particular complex features. Aeroengine casing contains many intricate features which are hard to be defined and recognized. Therefore, the feature recognition technology has some difficulties in the application of aeroengine casing machining. But there are many new methods and softwares with different advantages. If an aided software can combine these advantages form different softwares, it will largely increase the efficiency and quality. So, we develop an aided software which combines the advantage of hypermill.

The aim of this research is developing several useful auxiliary programming tools to simplify UG and increase the efficiency and accuracy. It can translate the tool paths of hypermill and manage all the tool paths in UG. The original menus of UG are simplified and rapidly programming tool are developed using group technique. All these modifications will increase the efficiency and generate high-quality programs based on the existing UG project.

2. Tool path translation

Hypermill software is an integrated NC programming CAM software developed by German OPENMIND company, which is fully integrated in hyperCAD and SolidWorks to provide users with complete integrated CAD and CAM solutions. It integrates Windows interface and using intuitive dialog box, reasonable default values, logical menus makes this software work quickly and efficiently. Especially for some difficult corners and surface features, the algorithm has great advantages while reducing the risk of tool damage, vibration and cutting time.

As discussed before, there are many softwares such as hypermill that can create high-quality tool paths with unique algorithms. However, many enterprises’ projects rely on UG deeply and using other high-quality tool paths created by other software based on UG becomes very necessary. A big problem occurs when we combine two different tool paths that are using different formats and UG can’t import tool paths in other formats. Because the post-processing is using the CLS tool path files, this kind of tool path should be translated from the other formats. In order to manage tool paths with the format of CLS and simplify the post-processing of NC programs as before without adding extra cost, an aided translation tool is developed to translate POF tool paths created by hypermill into CLS format. The corresponding rules of the two kind of tool path formats are studied and the original tool path(left) and translated tool path are shown in Fig 1.

![Figure 1. Tool path in hypermill (left) and translated tool path in UG (right)](image)

It is found that the hypermill tool paths are better but more complex than the tool path of UG through comparing the two tool paths. And it takes a long time to import the new tool path into UG. The correctness of the tool path translation is verified and a better way to solve that problem is only
displaying the tool paths in a correct order and not importing tool paths into UG. As a result, a program management tool is necessary to deal with the UG programs and CLS tool paths translated from aided tool translation tool.

3. Tool path management
A tool path management tool is designed to manage two different programs. For one thing, it can get the programs from UG operation navigator and display necessary information to help users better understand the selected program. For another, it can show the tool paths translated from POF tool paths created by hypermill. Manage the two different programs using the strategy as shown in the Fig 2 below. The programs of UG can be get and updated through circling the operation navigator of UG and the programs of hypermill are from database or translation tool. When updating the programs, it should be judged what kind of program next and insert it to the tree node. The sequence of the programs is stored in the database while reading programs form UG operation navigator or translating tool path.

![Figure 2. flow chart of refreshing multi tool paths](image)

4. Group technology in UG
UG is a universal CAD and CAM software. Dozens of parameters are required for each program to generate tool path using UG CAM for NC programming. However, the workpieces machined in the factory often have the same or similar features, the processing process and parameters of the features are the same. The existing NC programs in the factory contain large amounts of parameters set by experienced technologist. They can be divided into several group based on features and saved in database. Thus, the empirical data are digitized. And the programs can be created using group technology as shown in Fig 3 to save time and improve accuracy.

Features are divided into two types including part features and machining features. Part features are the geometric features of the model such as convex platform, beam, installation edge, reinforcing rib, cavity, etc. And machining features refer to the specific parts of the features to cut, such as upper surface, lower surface, side face, circular bead, etc.

Although feature recognition is a useful developing technology based on 3D model with the format of STEP or IGES. It can only recognize some simple features and its recognition accuracy is not well enough to satisfy the factory’s requirement. And lots of features of aero-engine casing should be predefined properly and that makes things more complex. For these reasons, features are defined by company’s specialists when they extract information from UG programs to database Access. The information contains about 50 parameters including tools, cutting parameters, noncutting parameters, speed, drive method, method, etc. Then a single new program can be created with predefined parameters based on the same or similar features quickly. Feature-based group technique are applied
to storage information and create programs. Then a group of programs can be created based on features. All these functions are implemented through UG OPEN/NET API.

![Flowchart of inherited knowledge](image)

**Figure 3. A flowchart of inherited knowledge**

5. **Results and discussion**

   As described above, the aided NC programming tool based on UG is developed and the original functions of UG are embedded and optimized. All the operations can be achieved in the NC programming tool which contains all the above functions. The UI has been developed by MFC.

   The original menus are simplified and only the most common items are remained in the menu bar at the top of UI as shown in Fig 4. They are categorized into seven categories including Files, Main, Sketch/Curves, Assembly, Analysis, Module and Step Card. The right clicked menu items are shown in Table 1.

| Program group          | Program     |
|------------------------|-------------|
| Insert Program Group   | Insert Program |
| Edit Program Group     | Edit Program |
| Copy                   | Copy        |
| Paste                  | Paste       |
| Move Up                | Move Up     |
| Move Down              | Move Down   |
| Rename                 | Rename      |
| Delete                 | Delete      |
| Insert Program         |             |
| Save to Database       | Save to Database |
| Insert form Database   | Insert form Database |

   The ug part storage path is displayed in the title bar. In the tool path management tab, the programs are displayed in a tree structure, including program group nodes, program nodes and function nodes. Function nodes are under program nodes, containing features, operations, tool and geometry. The important information is displayed on the right of the dialog to make it easier understand for users. The POF tool path can be translated when the file is selected. In the mean while the CLS path will be automatically filled according to the POF path. When the Translation button is pressed, the program automatically converts tool path from POF to CLS and extracts the corresponding tool information which display at the bottom of the dialog. The position should be selected before creating it by pressing OK bottom.

   Group technology is used to save information and create programs. It can be realized in the right clicked menus with the item of save to database and insert from database. The application of group technology can greatly reduce the time of creating programs to improve efficiency.
6. Conclusion
This paper proposes several improvements based on UG which can greatly reduce the time and improve accuracy. It can make use of the advantages of hypermill to make up the deficiency of UG for special parts. All the programming operations can be realized in the programming aided tool with reorganized menus and tree program management. Feature-based group technology is used in batch creation programs to reduce parameters setting and improve programming efficiency.

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