Research on NC Turning Simulation Based on VRML

Lianqiang NIU[1]，Yue YAO[2]

[1]*School of Software, Shenyang University of Technology, Shenyang ,China*

[2]*School of Information Science and Engineering, Shenyang University of Technology ,Shenyang, China*

E-mail: Yaoyve@yahoo.com.cn

Abstract: To solve the basic problem in the turning simulation for NC (numerical control) program verification, the NC code translator and three-dimensional kinetic model are discussed in the virtual NC machining environment. Combination of turning process characteristic, a simulation method is proposed to verify the NC program. This method abstracts the workpiece into a series of planes. Turning is accomplished and abstracted by cutting each plane by VRML (Virtual Reality Modeling Language) extrusion node. The lathe tool feed is driven by NC program. This method is tested by virtual environment, and the experiment shows that the method is available and feasible.

Keywords: turning simulation; VRML; code translation; NC verification

1 Introduction

NC program, either manual or computer-aided, should be verified before manufacture. Three methods can realize the verification. First is manual. Second is through test-turning, usually, turning non-metallic material replaces actual workpiece before actual manufacture. Third is by computer simulation the relative movement of lathe tool and workpiece. The first method is time-consuming, the second is material-wasting, tool abrasion and sometimes even dangerous[1].

NC milling process simulation by computer can detect and remove NC program errors before actual manufacture, even during the coding phase. Computer simulation makes evaluating the milling process feasible without actual environment.

At present, many commercial software can achieve the dynamic simulation of NC machining process, such as Pro/E, UG .These software are expensive and more demand on the hardware. Usually this software requires the second development. In most cases, the second development is difficult and restricted by the software platform.

Some scholars have engaged in simulating NC milling process, and some progress has been achieved. In modeling, the most popular method is using three-dimensional modeling software[2,3] , such as SolidWorks, OpenGL, 3DS MAX, etc., these software can render precise modeling conveniently, but burden the net transportation. The better method is to combine VRML with other modeling software[4,5]. In simulating NC machining process, two methods are popular. One is the play simulation method[6]. This method needs a large number of three-dimensional models, and these models are transferred continuously. The disadvantage is that a lot of memory is occupied and a certain waiting time is needed. Another method is through certain Boolean operation[7,8]. During simulation process, Boolean subtraction between two models can generate a new model, through continuous Boolean subtraction, the new model is also constantly changed.

Turning is one of the most widely used milling methods, based on turning process characteristics, a simulation method is proposed to verify the NC program on VRML.

2 Strategy

Turning is mainly used to process rotary body parts. Its processing is characterized by workpiece paralleling to the spindle, the tool moves in a plane and tool feed is stepping.

As 3D scenes described by VRML are conveniently transported over the internet, this paper combines VRML and Java to implement milling simulation driven by NC program. The whole turning simulation for NC program verification consists of three modules.

a. Three-dimensional modeling. This module consists of initial workpiece modeling and lathe tool modeling.

b. NC code translation. The purpose is to check lexical and semantic errors and acquire implied data of NC program. These data mainly include the lathe tool path (start coordinates, end coordinates, etc.), spindle speed and tool feed rate;

c. Turning process control. This module chiefly accomplishes the workpiece transfiguration going with lathe tool action. Tool movement is carried out in accordance with the data translated from NC program.

The general turning simulating process is as Figure 1.

3 Key Technologies

3.1 Three-Dimensional Modeling

To carry out remote fault diagnosis, modeling by VRML is preponderant, owning to the characteristic that VRML file can be transported like HTML and platform-independent. VRML basic units are nodes. VRML

978-1-935068-10-5

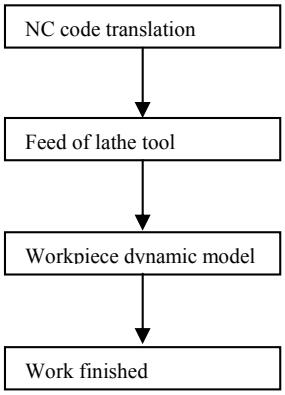


Figure1. Simulating process

supports basic geometry modeling, including the cube, cone, cylinder, sphere and several other geometries. Therefore, the complex model is divided into several simple models, each simple model is accomplished by primitive node. Then group these simple models and inline these groups. Using nodes is beneficial to reduce the program size.

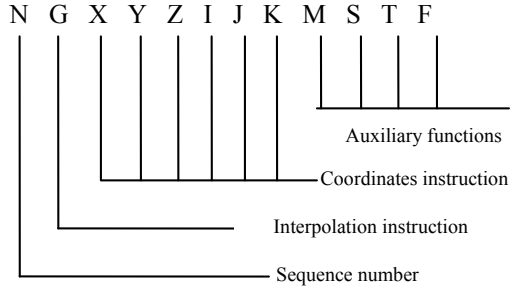
Workpiece is a regular revolving body, its initial modeling is carried out by Cylinder. The initial workpiece is defined by Cylinder node as follows:

```
Cylinder{
        field SFFloat radius 10
        field SFFloat height 100
        field SFBool side TRUE
        field SFBool bottom TRUE
         }
```

Another advantage using VRML nodes is convenient for parameter modeling. It makes changing workpiece's initial size feasible through the combination VRML with JavaScript. Factually, JavaScript changes the value of Cylinder node radius or height according to the actual needs.

3.2 NC code Translation

A complete NC program consists of a number of program segments, while the NC program segment is formed by several numerical orders. A complete NC order format is as follows.



Turning and related auxiliary functions are directly defined by the NC program. Therefore, in order to simulate a NC machine turning process, it is necessary to translate lathe tool trajectory relative to the workpiece from the NC program. NC code translation can be divided into error detection and coordinates translation.

According to NC machining rules and common sense, it is possible to set up a series of judge conditions to make computer test out the lexical errors, syntax errors, logic errors (including data and processing status of unreasonable and unfair). Then correct codes go into the coordinates translation phase.

The most of NC system are based on ISO or EIA, so some common characteristics are available:

a. NC program segment is a typical context-free grammar, grammatical unit is completely independent of its environment

b. NC program grammatical rules are simple and relatively small number.

The key data acquired in accordance with two rules:

a. In the NC program segment, we can read the value of F, S directly, and modify the tool feed rate using the value of F, modify the workpiece rotation rate using the value of S.

b. Carry out mathematical operation according to command keyword. For example, G01 is a linear interpolation instruction, while reading G01, in accordance with the end coordinates given in the instruction (the data behind X and Z) and start coordinates from former order, it makes calculating the expression of the space segment feasible. This segment is lathe tool trajectory.

3.3 Turning

Turning process simulation mainly describes the tool movement and workpiece dynamic changes. The whole turning process mainly includes the following steps:

a. Abstract the workpiece into a series of vertical planes before turning;

b. Lathe tool cuts the plane one by one in the calculated trajectory. The progress of cutting each plane is to make plane occurred compression deformation process. Cutting is squeezing from the plane edge to the tool path corresponding points, and cutting is implement by VRML Extrusion node. Lathe tool is always in contact with the outside edge of the vertical plane;

c. By squeezing the planes in the tool trajectory, workpiece deformation is associated with the lathe tool movement. Turning process is shown in Figure 2:

4 Results

We have implemented the described algorithms in software JavaScript and tested it in the scene exploited by the VRML. The turning simulation is accomplished through abstracted extrusion on certain pieces of plane in

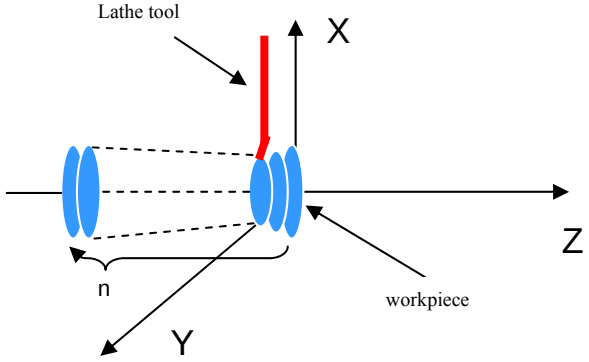


Figure 2. Workpiece is abstracted into n pieces

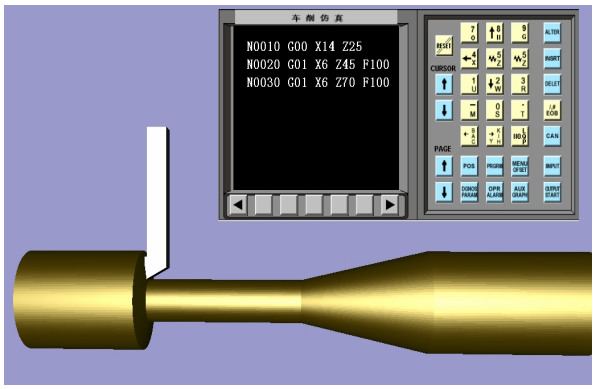


Figure 3. Simulation results

the negative X-axis direction and lathe tool linear motion in the negative Z-axis direction.

Figure 3 shows the scene for verification. According to the G demands are given by user, The lathe tool completes the orders in turn, and the new workpiece is processed.

5. Conclusions

We have adopted VRML extrusion node and JavaScript to achieve the turning simulation. The results show that the method can verify G commands visually. VRML extrusion node provides an effective and direct way to describe a variety of rotator.

Future work will concentrate on: First, Supplementation on other commands (M, T, etc.) testing logic and algorithms; Second, taking into account the interference detection.

Acknowledgments

We would like to sincerely thank professor Shengnan Zhang for useful help and discussion.

References

[1] Fang Jie, Jianghui Cao, Wen Ke, etc. Design and Development of a NC Code Proof and Simulation System, Mechanical Science and Technology, 2003,(22)4:578-580.

[2] Meiju Liu, Zhi Li, Fengyan Han. The Construction of VE System Based on VRML and 3DS MAX. Transactions of Shenyang Ligong University, 2006, 25(1): 53-55.

[3] Wenwei Zhu, Changming Yang, Sheng-en Zhang. Net-based parametric modeling and automatic assembly. Machinery Design and Manufacture, 2008,6:74-76.

[4] Fengwei Yuan, Yan Jiang. *Research on precise modeling and machining simulation of virtual NC machine tool,* Mechanical Research and Applocation,2008,(21)4:12-14.

[5] Shaoning Wei, Yuwen Zhu, Liang Xue, etc. *Precise Modeling of Virtual Device in Virtual Reality Based on Pro/E*, Computer Simulation, 2004, 21(12): 62-65.

[6] Yongjun Luo, Yanbang Ye, *Research of Simulation Method Based on Validation of NC Process Plan*, Technology and Equipment, 2009,8:99-104.

[7] Bangwen Liu. Study on NC Turning Simulation Basedon Boolean Operation. Dalian Jiaotong University,2005

[8] Jiaqi Min. Application of Boolean Operation to Turning Simulation. Dalian Jiaotong University,2004.