OpenGL based Real Time & Inline Simulation of CNC Cams Grinding

Hu Zhanqi*[1], Xie Mingli[2]
[1,2]Mechanical engineering college of Yanshan university, Qinhuangdao China, 066004
*Corresponding author, e-mail: ronghu118@163.com

Abstract

OpenGL based NC machining real time simulation model is proposed in the paper, and some key techniques of the system are investigated, including input and compiling of NC program, building of display model, real time displaying procedure of machining. With this technique, operator can view the machining process at screen of CNC machining real time, without stopping machine tool, which is very convenient for operating of machining. At last of the paper, an example of CNC cams grinding machine tool is given in order to proving the algorithm.

Keywords: OpenGL, numerical control, cams grinding, real time simulation, inline

1. Introduction

In machining process, operators need to observe the machining situation often, for determining what should be done next step. Modern NC machine tools are general close structure, machining process takes place in a closed space, and cooling fluid is also required, therefore it is very difficult for operators to see machining region directly. Sometimes, they have to stop machining for observing the machining situation. Often stopping machining not only leads to reducing of machining efficiency, but also reducing of surface smoothness, which are very important performance of machining. It is therefore tentative planed that if machining process can be shown at screen of CNC system, this problem will be solved.

Development of computer graphics, computer image processing, computer graphical displaying and computer vision technology gives technical support to this idea. Many domestic and abroad scholars have done many researches in dynamic displaying of machining process, and many progresses have been achieved. Hoshang Kolivand, and Mohd Shahrizal Sunar give an overview on real-time hard shadow techniques in virtual environments, which summarizing the progressing in computer displaying techniques in recent years [1]. Jochen Hirth etc. discussed development of a simulated environment for human-robot [2]. Usman Akram researched background and noise segmentation in retinal image preprocessing [3], which makes displaying on computer more vivid. Some other researchers also give different examples of real time simulation of machining process [4-6]. But these researches mainly are aimed at simulating and proving of NC codes offline [7, 8], few of which can display machining process real time when machining takes place. Therefore development of NC machining technology requests real time and dynamic displaying of machining process [9].

Authors of the paper conduct many researches aiming at developing real time and dynamic display of machining process based on OpenGL under windows operating system. Model of simulating system is built, some key techniques are investigated, and a prototype system for cams grinding machining is developed, which proves the algorithm in the paper is feasible. With This system, operator will be able to observe grinding process on screen which is the same as the process taking place in closed and flood filling space,

2. Real Time Simulation Model of NC Machining Process

OpenGL is a software interface with graphic functions running at windows platform, including a 3-D graphic and model library, which provides great many basic graphic operating functions to programmers, and makes them can build geometric model of an object quickly and

display the object continue and dynamic with double buffer technique [10]. The library provide also such graphic functions as transformation of graphic, light and materials, rendering, anti-deformation, mixing, texture mapping, all of which make the displaying more vivid and looking like true. In order to meet the require of real time displaying of machining process, a real time dynamic displaying system is constructed based on OpenGL and running on windows platform, which is shown in Figure 1.
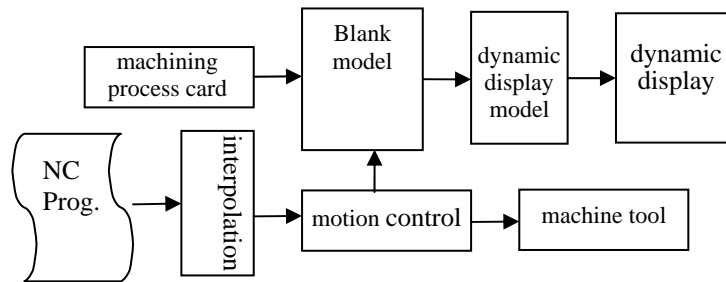

Figure 1. Model of Real Time & Dynamic Display for NC Machining

Building of display model is a key technique for real time display of NC machining. Display model is a special geometric model built for real time and dynamic display, which is a changing geometric model. Starting from blank into finished work piece, uncut chip layer is real time changing during machining process. Original Information for building of display model is NC program and blank information, output information is a dynamic and real time changing geometric model. Building of display model is reverse process of NC programming, which abstracting geometry information from NC program instead of producing NC program from geometry model of work piece. Data structure of display model in computer can be designed with solid model, surface model or lines model, depending to the complexity of the work piece. Lines model is used in simple machining process like wire cutting, and solid model is used in complex surface machining like 5 dimensions milling machine.

When machining begins, work piece blank geometric model is built first, which is initialization of display mode. During machining, cutting tool position information is gotten from interpolation, then correcting of display model is made, result of Bole subtraction is just display model. This process will be conducted periodically, which cycle is called display cycle. After display model is corrected, displaying is conducted with double buffer mechanism of Open GL. Display cycle is generally longer than interpolation cycle, depending on processing speed of computer.

3. Programming of Real Time Display System
During displaying, there are two solid entities in computer, one is display model in last display cycle, another is cutting tools group, shown in Figure 2. Cutting tool group consists of a number of cutting tools entities (from T1 to Tn), the number of cutting tools depending on the computer's speed and displaying precision requirement, and position information of each tool comes from motion control program. During display cycle computer subtract a cutting tools group from previous display model, and produce a new display model, which will be cent to screen of CNC system.

Subtract calculation is important step in each display cycle. Main code of the subtracting routine is as follows. In the routine, *cutting_tools_group is the function pointer to cutting tools group, *display_model is the function pointer to precious display model. Face and test are flags affecting displaying performance.

void inside(void(*cutting_tools_group)(void), void(*display_model)(void), GLenum face, GLenum test)

```
{
GLint i ;
    glEnable(GL_DEPTH_TEST);
glColorMask(GL_FALSE, GL_FALSE, GL_FALSE, GL_FALSE);
cutting_tools_group();
    glCullFace(face);  //back is culled
  glDepthMask(GL_TRUE);
 glColorMask(GL_TRUE, GL_TRUE, GL_TRUE, GL_TRUE);
 glStencilFunc(test, 0, 1);
 glDisable(GL_DEPTH_TEST);
 glCullFace(face);
 cutting_tools_group();
 glDisable(GL_STENCIL_TEST);
}
```

Animated drawing is an important aspect to evaluating a 3D graphics system, double buffer technique is used in OpenGL to realize real time animated drawing. There are two buffers in memory of computer, when the content of a buffer is putting on screen, the other is filled with data calculated by CPU. Double buffer technique is very important for real time display of machining process. Working procedure of OpenGL is shown in Figure 3.
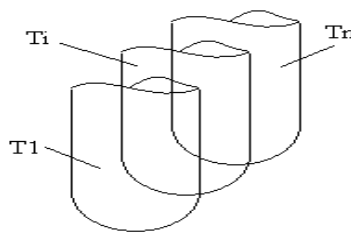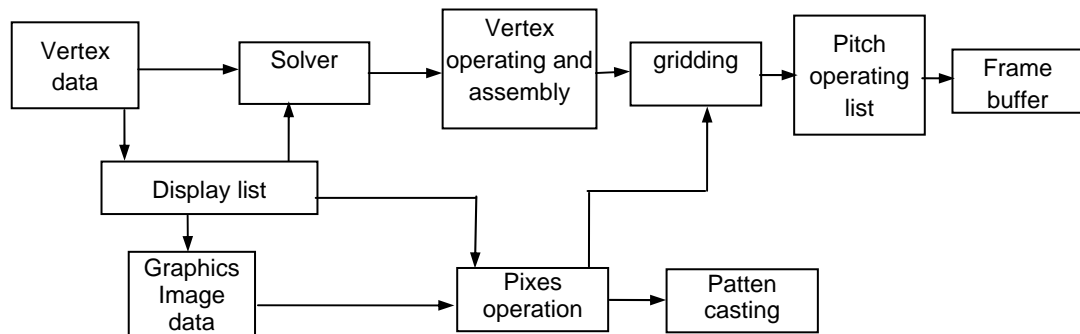

Figure 2. Cutting Tools Group

Figure 3. Flow Chart of OpenGL Running

4. Implementation of Cams Grinding Process Real Time Displaying

An example of cams grinding process is given in this part. This machine tool is reconstructed from a poly functions round grinding machine tool, and used to conduct grinding of plane cams Figure 4(a). For the simple situation like this, some simplifying is made in the procedure, in order to make the calculation process faster.

4.1. Input and Compile of NC Program

When NC program is read in system, it is first compiled into tool position data, which include coordinate of 360 points on contour of cams, which is information source for model building of cams. Train list data structure is adapted, and there are two data train lists used in the system. NC program is read in and saved in first train list block after block. Then the coordinate data is extracted in each block, is transformed into data structure of OpenGL, and saved in second data train list.

After a block of NC program is read in, redundant information in the program is first removed for example returned code, M code information and other information unrelevant to motion of cutting tool. In other hand, information of grinding wheel is input from controller on interface.

4.2. Building of Display Model

After reading in data group in second train list, and approximating cams contour with polygon, cams geometrical model can be built. In order to make the simulation program running faster, display list technique is adapted when modeling. Display list is a group of Open GL command sequence saved in buffer. When a display list is activated, saved command will run according to the sequence they saved. This method makes displaying more efficient.

4.3. Displaying Procedure

When machining process simulation, data in second train list are read in time period of display cycle, and screen motion of cams is driven with the data. The length of time period is controlled by time function provided by windows XP operating system which is called simulation timer. Through the setting of parameters of the timer, the time interval can be adjusted. The procedure of display is as following:

(1) Extracting second train list, transforming the machining information into coordinate of cam and grinding wheel, than return the coordinate to second train list again.
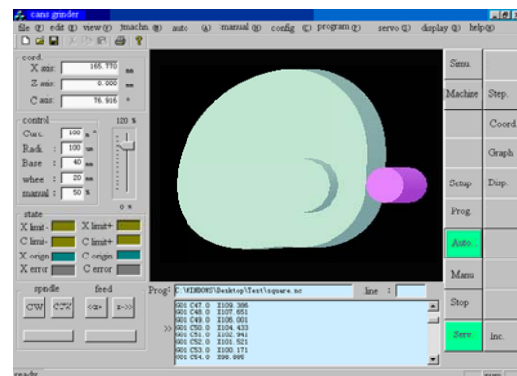
(2) Read in position coordinate of second train list. When position information of a node in second train list is read in, display function of Open GL is called, and grinding situation of this moment is put on screen of CNC system.

(3)When all data in second train list is read, close the timer, and prepare next cycle.

Figure 3 is two examples of cams grinding.

(a) inline simulation   (b) interface

Figure 4. Inline Simulation of Machining Process

5. Conclusion

Open GL can be used as a platform for real time simulation of NC machining, which graphic functions meet the requirement of simulation of machining. Display model built in this paper is convenient and simple can meet the real time requirement of general NC machine process, widows timer can be used to control the time period between two refresh of displaying. With This system, operator will be able to observe grinding process on screen which is the

same as the process taking place in closed and flood filling space. Simplified method used in the prototype system can be referenced in other similar system.

Acknowladgement

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