A Level-based Geometric Representation for the Real-time Simulation of NC Machining Processes

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ABSTRACT

In this paper a level-based geometric representation for a real-time material removal simulator is presented. It will be embedded into a commercial NC machine. The representation and its accompanying architecture have been used for the generation of an interactive simulation of a part being machined, taking the NC machine feedback as input. The simulator complies with the following restrictions: *i*) The virtual simulation and real machining process must be synchronized; *ii*) the internal representation of the objects must be as accurate as possible.

Keywords

NC-Machining, Verification, Material Removal, Solid Representation, Simulator, Interactive Rendering.

1. INTRODUCTION AND PREVIOUS WORK

Numerical Control (NC) machining simulation using Computer Graphics techniques is a widely extended research topic.

Traditional approaches do not store geometrical information during the simulation; they simply modify the drawing screen using an image-based approach. This technique is the basis for several commercial systems for NC machining simulation.

In the other side, there are solutions that store the intermediate result in the computer's memory, storing an internal 3D geometric representation of the object that is changed dynamically during the simulation, for example, B-Rep, CSG and Hierarchical Space Decomposition.

A straightforward implementation with these kind of methods is very time consuming. To cope with this problem, the approximation of the exact geometry, and the partitioning of the object in suitable regions has been proposed by several authors [Jerard89].

In this paper, a level-based solid representation is proposed as the geometrical kernel of a NC material removal simulator.

2. PROPOSED APPROACH

The chosen geometrical representation for the manufactured objects is a level-based representation, consisting of a set of parallel levels to represent the 3D object. Each level is a set of non-intersecting and coplanar polygons with at least three vertices.

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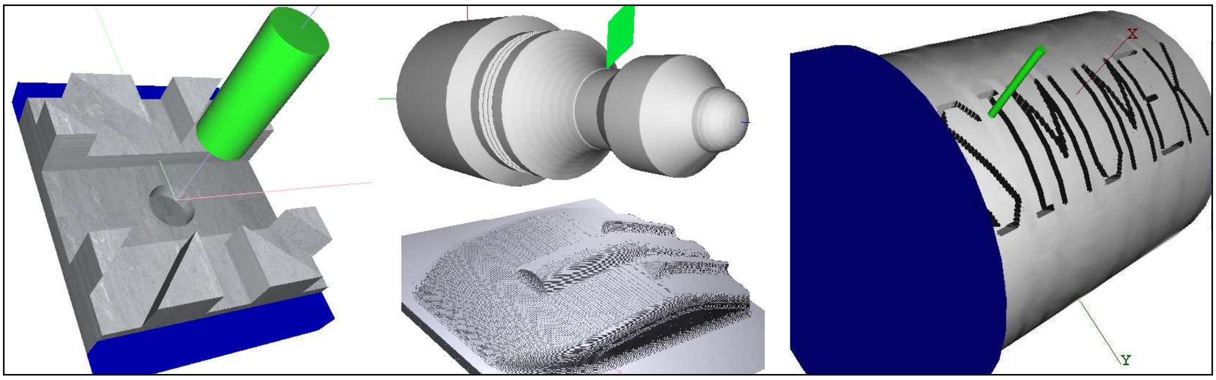

Figure 1: Some simulation results. From left to right: 2D milling, 2.5D lathe, 3D milling and C-axis lathe

The distance between the levels defines the maximum detail that can be perceived. This representation will be called Level-Based Representation (LBR). Thus, LBR object is the object represented using the LBR representation (see figure 2).

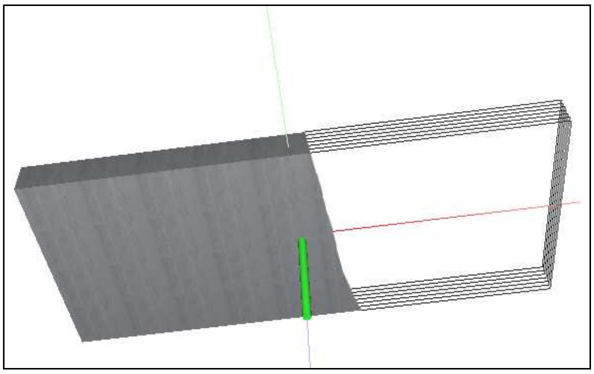

Figure 2: A LBR parallelepiped is shown in solid mode (left) and its approximation in levels (right).

The LBR is a direct way to perform boolean operations between LBR objects: a 3D boolean operation is simplified in a set of 2D boolean operations between two 2D polygons. This approach is a well reviewed research topic [Vatti92] .

As the simulation goes on, the complexity of the manufactured piece increases, which makes the number of points and contours to grow as well. In order to limit the number of points and contours that would increase the boolean operation time, a high-level partitioning system is added to the object definition.

This spatial partitioning decomposes the objects into a set of smaller regions, each of them being a set of parallel levels, as described previously.

The overall computational cost is reduced since the classical boolean operation between geometrical objects is $O(n^4)$ [Pourt01]. This approach reduces the computational cost to $O(n*m)$, where n is the number of levels and m the number of contours per level.

3. RESULTS

We have developed a simulation system embedded in a NC machine using the proposed approach as the internal representation. Taking the feedback of a NC machine as the input for the simulator, the results show that a synchronized simulation is achieved with small and medium NC programs, obtaining an interactive visualization. The tests have been made on an AMD K6 1500 processor with a GeForce 2 graphic card with 32Mb and a 800 x 600 resolution. The NC machine is a 8070 CNC from Fagor Automation (www.fagorautomation.com).

4. CONCLUSIONS

The paper presents a level-based geometric representation as the kernel of a material removal simulator for real time execution when embedded in a real NC machine (see figure 1).

The results have confirmed that a proper real-time simulation is achieved with interactive rates and a high image quality taking into account that the simulator takes its input directly from the NC machine, with no knowledge of the high level NC programming.

5. REFERENCES

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