A flexible and modular architecture for object space NC-Machining simulation

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ABSTRACT

The NC machining processes based on computer graphics is a significant part of modern Computer Integrated Manufacturing (CIM). Through simulation, it is possible to test the correctness of the NC tool paths without the need of machining actual physical parts, with the corresponding reduction of time and costs. In this paper, we present a flexible and modular architecture that describes a generic object-based NC machining simulation system. This architecture has been tested using several object-based simulation approaches, and could be successfully integrated in commercial simulation systems. This work also covers other proposed architectures found in the literature.

Keywords

NC-Machining, Verification, Material Removal, Architecture, Extensible, Flexible, Solid Representation, BREP, Octree, SIMUMEK.

1. INTRODUCTION

The simulation and verification of NC machining processes based on computer graphics is nowadays a significant part of modern Computer Integrated Manufacturing (CIM). Through previous simulation, it is possible to test the correctness of the NC tool paths without the need of machining physical parts, with the corresponding reduction of time and costs.

2. SCOPE AND PREVIOUS WORK

The NC machining simulation using computer graphics techniques can be traced back to the classical works of Anderson and Van Hook [VAN86]. Since then, several researchers have proposed different approaches, classified in two main groups: *(i)* image-based methods [SAI91] and *(ii)* object-based (or non image-based) [CRO00], [SIM04].

3. PROPOSED ARCHITECTURE

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High Level Modules Definition

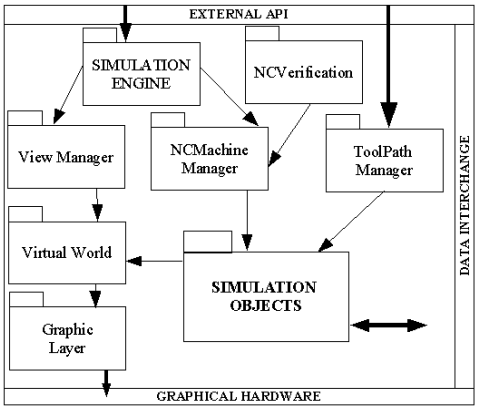

Figure 1. Architecture Main Modules

Simulation Engine	Manages the user input/output process.
View Manager	Responsible of the management of the views.
Machine Manager	Responsible of the management of the NC machines
Simulation Objects	Static objects, lights, primitives, 2D forms, etc.
Virtual World.	Objects, lights and views organized in an scenegraph
Graphical Layer	Wrapper to a graphical API like OpenGL or DirectX.
ToolPath Manager	Path for the tool

Table 1. Architecture Main Modules explanation

Input-Output Modules

External API	External interface to the user
Graphical Hardware	Rendering of the virtual world with a graphical API
Data Interchange	Load or save the geometrical information

Table 2. I/O module explanation

Simulation Objects Module

Static Objects.	Clamps, holders, arms, etc (environment)
Light.	Light source used to light the virtual world
Stock.	Stock definition
Spatial partitioning	Stock partitioning based
Tool	The tool is affected by a movement producing a sweep volume to be subtracted from the stock
Movements	Movements as outputs from the parsing process of the G-Code
Sweep.	A sweep volume of the moving tool
Material Removal.	Boolean subtraction between the Stock and the sweep volume.
Low Level Verification Module	Collision detection, feedback forces, heat transfer

Table 3. I/O Simulation object s module explanation

Simulation Engine Module

Optimized Control	Real time control
Finite State Machine	Alters the actual simulation state if necessary
Time Based Simulation	Handling of time related events

Table 4. I/O Simulation engine s module explanation

4. VALIDATION

The validation of the proposed architecture has been accomplished through the development of some heterogeneous prototypes.

a) **B-Rep Based Geometric Representation with Internal Spatial Partitioning-** Implemented in ACIS and OpenCascade

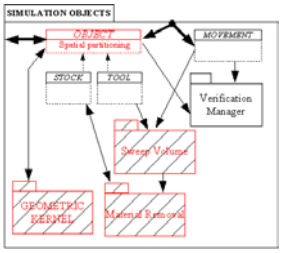

Figure 2. OpenCASCADE and ACIS Supported Object Modules

b) **CAD-Supported Octrees Geometric Representation with Implicit Spatial Partition-** Implemented in AutoCAD ObjectARX.

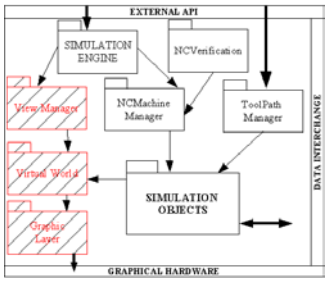

Figure 3. AutoCAD Supported Main Modules

c) **Polygonal Based Geometric Representation with Internal Spatial Partitioning**– implemented in the SIMUMEK project [SIM00].

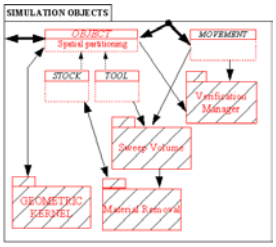

Figure 4. SIMUMEK Supported Object Modules

The SIMUMEK kernel provides an internal spatial partitioning for the stock object. The spatial partition is not based in a hierarchical representation. Its definition is closer to a hash table with a quick access to the inner elements. A nice feature is the adaptative partitioning allowing reactions at simulation time.

5. CONCLUSIONS

In this paper a flexible and modular architecture for non image based NC-Machining simulation was presented. Some of the benefits of the presented schema e.g. implementation flexibility, modularity and time saving in the development stage were proved by the presentation of various test applications. The test models were implemented in different schemas, combining different solid model representations (Octrees, B-Rep based) and different API's as well in order to show the feasibility of the architecture.

6. REFERENCES

[CRO00] Crossman, J.; Yoon, D., "A cutter motion simulation system" Transaction of the Society for Design and Process Science 2000 pp. 25-35.

[KAR00] Karunakaran K.P, Pawan K., Mondani P.K, Gupta N, Shanmuganathan P.V, Garg S, "Octree-Based Volumetric NC Simulation System" 2000.

[SAI91] T. Saito, T. Takahashi, "NC Machining with G-buffer Methods", Conputer Graphics, Volume 24, Number 4, July 1991. pag. 207

[SIM04] SIMUMEK Project Homepage http://www.vicomtech.es/ingles/html/proyectos/index_proyecto20.html

[VAN86] Tim Van Hook, "Real Time shaded NC Milling Display", SIGGraph86, Volume 20, Number 4, pag. 15-20