Automatic Tool Path Generation for Parametric Surfaces in Terms of Bezier Patches

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***Abstract*— The present work is an attempt to develop a reverse engineering tool for CAD/CAM applications. Tool path generation, which is the most important aspect of Computer Aided Manufacturing (CAM), has been discussed along with various methods of tool path generation. A generalized surface has been developed in the presented work in terms of Bezier Surface using control points.**

Keywords— Reverse engineering, control points, bezier surface.

I. INTRODUCTION

A machine tool is a machine, typically powered other than by human muscle (e.g., electrically, hydraulically, or via line shaft), used to make manufactured parts (components) in various ways that include cutting or certain other kinds of deformation. All machine tools involve some kind of fundamental constraining and guiding of movement provided by the parts of the machine, such that the relative movement between work piece and cutting tool (which is called the tool path) is controlled or constrained by the machine to at least some extent, rather than being entirely "offhand" or "freehand".

Machine tools archetypically perform conventional machining or grinding on metal (that is, metal cutting by shear deformation, producing swarf), but the definition can no longer be limited to those elements, if it ever could, because other processes than machining may apply, and other work piece materials than metal are common. The precise definition of the term varies among users, as detailed in the "Nomenclature and key concepts" section. It is safe to say that all machine tools are "machines that help people to make things"; although not all factory machines are machine tools.

Kruth and Klewais [2] used curvature matching as a first approximation for their tool inclination calculation. The authors recognized the importance of the work piece global geometry and not just the local curvature at a point.

Bedi [1, 3] proposed a tool positioning strategy called multipoint machining, MPM, which matches the geometry of the tool to the geometry of the surface by positioning the tool in a manner that maximizes the number of contact, points between the surface and the tool. Yau [4] has presented the generalized cutter, in which the tool path algorithm is made for generalized cutter. The cutter profile varies with the variation of parameters of generalized cutter.

Work has been done in parametric and non-parametric tool paths. A brief history has been discussed by Dragomatz [6]. The tool path is defined by two or three parameters which represents the complete surface.

II. METHODOLOGY

In the present work a problem is defined as Generation of Surfaces, the part of reverse engineering and now a day's reverse engineering has been used as a tool for CAD/CAM applications.

A. *Generation of Surfaces*

Designed surfaces are presented using Bezier curves and surfaces with two parameters (u and v). In parametric surface, holding one parameter constant defines an iso-parametric curve. If one of the parameters reaches zero or one, the curve becomes exactly one of the boundary curves surrounding the surface. If both parameters are held constant, a point is specified on the surface patch [7].

B. *Bezier Curve*

The degree of polynomial defining the curve segment is one less than the number of defining polynomial points. The curve generally follows the shape of the defining polygon. The first and last points on the curve are coincident with the first and last points defining polygon points. The tangent vectors at the ends of the curves have the same direction as the first and last polygon spans respectively.

Mathematically a parametric Bezier curve is defined by Equation (1) and Equation (2) as given below:

$$P\ (u) = \sum_{i=0}^{n} Bn, i(u)Pi \qquad (1)$$

For….n=3

$$P\ (u) = [1\ u\ u2\ u3] \begin{matrix} 1 & 0 & 0 & 0 & P0 \\ -3 & 3 & 0 & 0 & P1 \\ 3 & -6 & 3 & 0 & P2 \\ -1 & 3 & 1 & -3 & P3 \end{matrix} \qquad (2)$$

C. *The Proposed Algorithm*

The proposed algorithm that used to generate surface, the algorithm steps are summarized in the flowchart shown in Fig. (1).

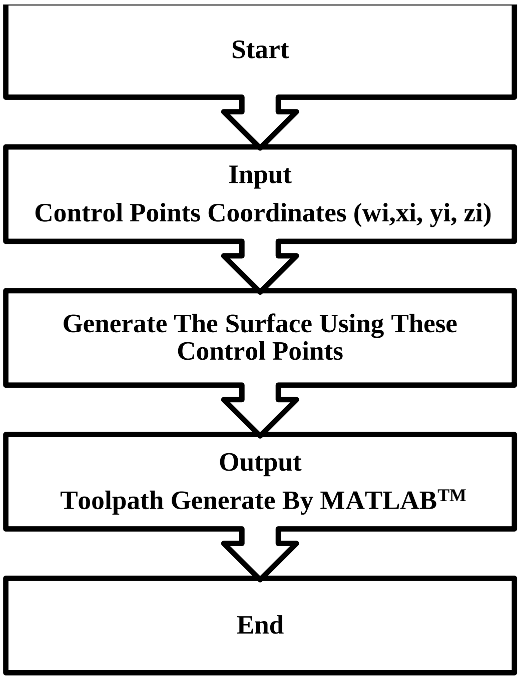

Fig. 1. Flowchart of Proposed Algorithm.

III. RESULTS AND DISCUSSIONS

In the present work a definition of Bezier surface using control points have been proposed using MATLABTM Software (Version 7.8.0.347, R2009a).

A. *Generation of Bezier Surface*

A parametric shaped part has been prepared. Several bi-cubic Bezier patches were designed and tested to generate the tool path, as shown in the following examples.

B. *Example*

A bi- cubic Bezier curve with the following control points:

$$px = [0,0,0,0; 50,50,50,50; 100,100,100,100; 150,150,150,150]$$

$$py = [0,50,100,150; 0,50,100,150; 0,50,100,150; 0,50,100,150]$$

$$pz = [0,18,24,28; 0,18,24,28; 0,18,24,28; 0,18,24,28]$$

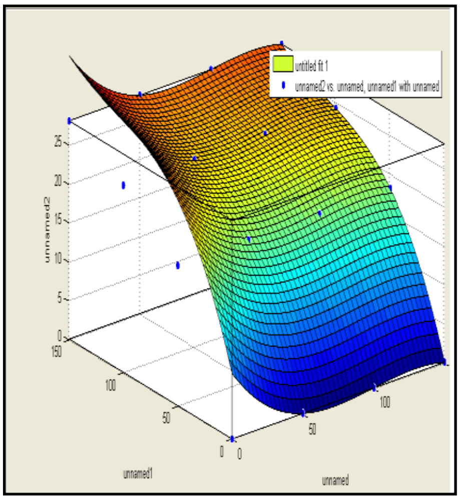

Fig. 2. A bi-cubic Bezier Surface.

IV. CONCLUSIONS

The aim of surface generation is to approximate the part being processed with a number of curves that can be approximated by line segments. Parametric surface representation is most widely used to model engineering surfaces in CAD/CAM systems, their capabilities to model complicated surfaces are better than other types of representation such as explicit and implicit representation.

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