

Converting a pixel graphic into toolpath for machining on a CNC milling machine

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Abstract—For being able to manufacture of a 2D shaped object that drawn as a pixel graphic on a PC, an algorithm has been developed in this study, that extracts machining coordinates from the graphic and drives motors of a CNC router machine. CNC router has been directly driven by using this algorithm, without needing G and M codes.

Keywords—CNC, milling, generate tool-path

I. Introduction

A qualified person is needed for generating tool-paths for complex shaped 3D parts. This person has to use Computer Aided Design (CAD and Computer Aided Manufacturing (CAM) softwares, and have to have deep understanding of manufacturing process. Developed CAM softwares that are being sold commercially can generate toolpaths for 3 and 5 axis milling machines. When studies for generating tool-paths have been investigated, it can be seen that they focus mostly on increasing energy efficiency [1,2], decreasing surface roughness [3-7], generating toolpaths faster [8-10] and minimizing free movement of the tool [11-14]. These studies have an important role on advancement of technology as they are foundation of CAM softwares. On the other hand, generating toolpaths from a pixel graphic is not possible for CAM softwares, which needs CAD geometry. There are 2D shapes being used in industry that have to be machined on outer contours. Those shapes are usually artistic geometries, rather than mechanical parts. Artistic shapes are made by using softwares like AdobePhotoshop®, Paint® and CorelDraw®. By converting shapes that generated by using mentioned softwares into Non-Uniform Rational Basis Spline (NURBS) make them possible to be converted into G and M codes [15], but there is no direct converter for those applications.

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In this study, manufacturing of closed and contour-like geometry as a pixel graphic has been made by converting the features which obtained by using image processing techniques into commands to drive the motors has been presented

II. Material and Method

A. Working of the Algorithm

The algorithm can work with closed curves that have linear and nonlinear segments.

First of all, contour of the graphic as pixels have to be determined. Because of this, the user selects a starting point on the curve. As selected point can be an empty point as in Figure 1, algorithm searches for a pixel on the curve for 5 points at x and y directions. When algorithm finds a pixel with a color different than white, it takes that pixel as starting point for machining.

B. Segmentation of the Curve

In order to obtain machining coordinates for the curve, coordinates of pixels in image have to be converted to line segments. Thus, pixel locations were saved in an array. Pixel locations were obtained by using the method given in [16]. Then following checks were performed on points in the array.

- If y coordinates of three ordered points in array are the same, it shows that they are on $y=k$ line. In this case, second point in array is removed, and line generated between the first and the last point. Same procedure goes on points that have same x coordinates. If points are not on the horizontal or vertical order, then it means they are on a sloped line.
- Slope of the line from third to second point, and from the second to the first point is calculated. If their slopes are equal, then a line segment generated from the third point to the first point. Otherwise two line segments are generated from the third to second and second to the first point.

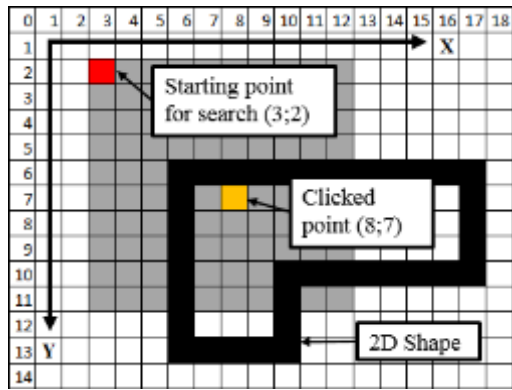


Fig 1. Definition of the pixel graphic

After the checks have been completed, starting and ending coordinates of the lines were obtained. Slopes were calculated according to Equation.1

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad (1)$$

Segmentation ends when all positions in the array has been scanned.

C. Obtaining Machining Coordinates

To obtain the machining coordinates, obtained coordinates which are stored in array have to be converted from image coordinate system shown in the Figure 1 to coordinate system of the CNC machine as shown in Figure 2.

As shown in the Figure 2, coordinate system on image have to be rotated 180° about X axis first, and have to be rotated about Z axis -90° to be matched with coordinate system of the milling CNC.

x_{gi} and y_{gi} in Equation 2 are the coordinates in pixel image, respectively. Thus P_{gi} is the point on the image. In order to convert this coordinate to machine coordinate system Equation 4 was used.

$$P_{gi} = [x_{gi} \quad y_{gi} \quad 0 \quad 1]^T \quad (2)$$

$$R_z(\theta) = \begin{bmatrix} \cos \theta & -\sin \theta & 0 & 0 \\ \sin \theta & \cos \theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & k \end{bmatrix} \quad (3)$$

$$P_{ti} = R_z(-90^\circ)R_x(180^\circ)P_{gi} \quad (4)$$

In Equation 4, indice t represents the coordinate of the point referred to machine coordinate system, and indice i represents the point at order i in the array.

D. Driving the Motors

For generating the commands that will drive the motors, the distance between ordered P_{ii} points have to be calculated.

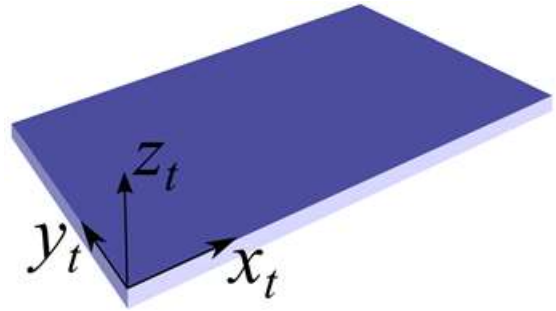


Fig 2. Coordinate system of the CNC

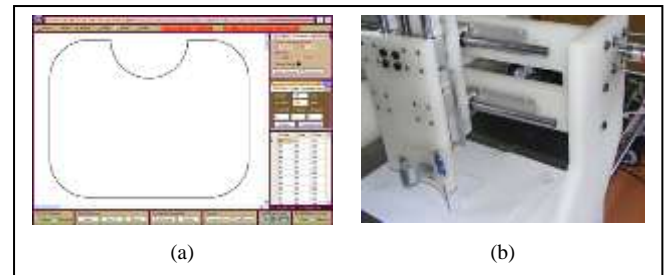


Fig 3. Drawn shape on computer (a), drawn shape on CNC (b)

These distances have to be converted to pulses which drives the motors. The distance on the X and Y axis was calculated using Equation 5 and 6, respectively.

$$D_{1i} = (x_{ti} - x_{t(i-1)}) \frac{10000}{5} \quad (5)$$

$$D_{2i} = (y_{ti} - y_{t(i-1)}) \frac{10000}{5} \quad (6)$$

The number 10000 in Equations 5 and 6 represents pulse generated in one revolution by the encoder of the motor. 5 is the pitch of the ballscrew of the machine in millimeters.

Motors were driven using AdTech AD8948 control card. X axis was connected to the first input of the card. Indice 1 in Equation 5 and indice 2 in Equation 6 represents the connection port of the X and Y axis, respectively.

Commands were sent to the AdTech AD8948 control card after positions have been obtained. Drawn shape and machining of it is shown in Figure 3.

III. Results

By using presented algorithm, manufacturing of images which consists of pixels has been possible. In addition to models generated on CAD/CAM softwares, pixel images generated in softwares like AdobePhotoshop®, Paint® and CorelDraw® can be manufactured by using this algorithm.

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