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Creation of Computer Aided Manufacturing software from Computer Aided Design software in the milling process

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Abstract

The purpose of this paper is to describe a new Graphical User Interface (GUI) for Design and Computer Aided Manufacturing (CAD/CAM) applications for academic context uses. This application, created by the author of this paper, is developed for automatic generation of Computer Numerical Control (CNC) code of two dimensional drawing created in the commercial software Autocad and using the Visual Basic programming language.

In production environments, the machining of complex parts such as molds and die cast that require high production rates and quality are tested before they are manufactured using CAD/CAM applications, where numerical control is coded automatically and is transmitted to the milling machine. These applications are characterized by high accuracy.

The intuitive GUI proposed in this work is an easy to use interface that transforms two dimensional drawing saved in the proprietary AutoCAD file...
1. Introduction

At present, most metalworking projects are drawn up and tested prior to manufacture, supported by powerful computational tools such as Design and Computer Aided Manufacturing (CAD/CAM). This technology is used in many machining processes with or without metal removal in the manufacture of complex parts, molds, dies, and prototypes that require a high dimensional accuracy and quality of manufacture. There are a wide range of CAD/CAM softwares in which pieces are drawn, the machining is simulated and generated automatically the CNC code to transmitting it to a machine for subsequent machining. As a reference of this kind of software, we can find Mastercam, Bob CAD/CAM, VX CAD/CAM (Carrasco, 2006). These applications are very effective for machining by computer.

There are CAD software such as AutoCAD, that allow to design the model and save the drawing in DXF format (Drawing Exchange file format), which is a sequence of ASCII values from where it can obtain the model's characteristics such as the coordinates, radius, angles, lengths, layers, colors, etc. AutoCAD was chosen because it is extensively used in academia and in the industry. Furthermore, AutoCAD allows to save in ASCII format the coordinates and characteristics of the entities drawn (Ochoa, 2006).

The information of the entities in the DXF file extension can be obtained by programming software such as Visual Basic and convert this information into codes Computer Numerical Controlled (CNC) codes, for simulation and milling of the workpiece.

The CNC program is a set of codes representing orders given to the machine's movements, such as the movement of the tool in the XYZ axis, the spindle rotation speed, written in a special language (code) composed of letters and numbers. The numerical control (NC) interprets the program's instructions, and they are converted into signals that move the devices of the machine. This program can be obtained in two ways: through manual programming, in this case, coordinates are calculated manually and written in a CAM software from which it transmits to the control. On the other hand, it could be obtained through a CAD/CAM software, where the part is drawn on the computer, the simulation of machining is done and allow to get ‘automatically’ the CNC program (Ochoa, 2006; Pacheco, 2001).

The following is an example of a small CNC program that is transmitted to the CNC machine to mechanizing the model (CNC Software, 1998; Carrasco, 2001).

```
G90 G71 M3 S1200
G0 X0 Y0 G1 Z-5 F50
G1 X10.0 Y10 F100
G2 X 15 Y15 R 5
G1 Y30
G1 X0 Y0
G0 Z2
M5
M30
```

Here:
G90: Absolute programming
G71: Units in millimeters
M3: Spindle ON
M5: Spindle OFF
S: Revolutions/Minute
G0: Lineal interpolation with fast movement
G1: Lineal interpolation with feed rate
G2: Clockwise circular interpolation
M30: End program

The coordinates X, Y, Z represent the tool's displacement.
2. Instructions of programming and use of software

Initially the bidimensional sketch of the piece is drawn in AutoCAD, then extract the coordinates of the displacement of the tool into the work piece to be milled. These procedures are detailed in the following 3 steps:

- Drawing of the work piece and creation of the toolpaths mechanizing in AutoCAD.
- Conversion of coordinates to Numerical Control (NC) codes.
- Use of AutoCNC Mill software and its connection with the software Benchman for milling.
- Milling the parts.

2.1 Drawing of the work piece and creation of the toolpaths mechanizing in AutoCAD

Below is how to get the Toolpath of milling on the AutoCAD taking into account the recommendations of (Ochoa, 2006; Pacheco, 2001; Sarma, 1999; Lin & Liu, 1998; Togores & Otero, 2003):

Create 4 layers of drawing named D1, A1, PERIFERIA and PIEZA.

D1: Name of the layer of the first roughing mill (if more roughing create layers D2, D3, etc.).

A1: Name of the layer of the first finishing mill (if more finishing creates layers A2, A3, etc.).

PERIFERIA: Name of the layer for the roughing limit.

PIEZA: Name of the layer for the final drawing piece.

Draw a rectangle for the stock in the point 0.0 on the layer named "0". See Figure 1.

Draw the piece 1 in the PIEZA layer (the length units are in millimeters). Convert the piece into a polyline using the command PEDIT AutoCAD (Pacheco, 2001), in the A1 layer create an equidistant contour of the part 1 with a distance equal to the radius (r) of the mill, generate in the PERIFERIA layer the equidistant 3 of the work piece 1 equal to the sum of the oversize for finishing (a) and the mill radius (a + r), create the hatch 4 in the D1 layer between the contours of PERIFERIA and the rectangle of the stock, that hatch should be selected as horizontal lines and spacing line equal to or less than 80% of the diameter of the cutter mill.

Select the D1 layer entities, ungroup them using the command Modify/Explode (Carrasco, 2005).

Save the file with a DXF extension by selecting Save As command ... and selecting file type AutoCAD 2004 DXF (*.Dxf).

The DXF file has the information about lines and arcs present in the drawing as follows:

For roughing lines:

```
AcDbEntity
D1 : Name of the layer
100
AcDbLine : Type of entity, in this case a line.
10
136.65 : (Xi) X coordinate of line start point
20
136.91 : (Yi) Y coordinate of line start point
30
0.0 : (Zi) Z coordinate of line start point
11
```

Source: by the author (drawing done in Autocad V2012© software).
192.92 : (Xf) X coordinate of the endpoint of the line
21
136.91 : (Yf) Y coordinate of the endpoint of the line
31
0.0 : (Zf), Z coordinate of the endpoint of the line

For the arcs in polylines finishing:

AcDbPolyline
10
28.61 : (Xf) X coordinate of the endpoint of the arc
20
43.72 : (Yf), Y coordinate of the endpoint of the arc
42
0.22 : Tangent of a quarter of the angle swept by the arc

2. 2 Conversion of coordinates to Numerical Control (NC) codes

Using the Basic Language for Visual Basic 6.0 was developed software named AutoCNC Mill. The programming is described below.

The coordinates of the lines, the centers, radius, angles of the arcs and circles was read from the DXF file using the LINE INPUT command (Reselman, Peasley & Prunchniak, 1999):

ArchivoDXF Open For Input As # 1
Do While Not EOF (1) = True
Line Input # 1, variable
Loop
Close # 1

The main cutting parameters are introduced as variables in text boxes of the application. These parameters are: Total depth of the work piece, feed rate of the tool in the XY plane and depth in the plane Z, Speed of rotation of the cutter mill, approaching distance, and diameter of the cutter mill.

Then in the AutoCNC Mill, taking into account the above coordinates and parameters, the piece automatically was drawn. Using the PRINT command, proceed to the generation of Numerical Control codes (NC).

For example to generate the codes for an anti-clockwise arc was programmed as follows:

Print # 2, "G3" & "X" & Val (Xf) & "AND" & Val (Yf) & "R" & Val (R)

Where,

Xf, Yf: X, Y coordinates of the end point of the arc.
R: Radius of the arc.

2. 3 Use of Mill AutoCNC Mill software and its connection with the software Benchman for mechanizing

Runs the AutoCNC Mill Software. See Figure 2.

Figure 2. Drawing part and generating CNC codes in AutoCNC Mill software

Complete the following dialog box to introduce the cutting parameters.
In the Figure 3, the parameters have the next units:

- Avance en XY (Feed rate in XY Plane), Avance en Z (Feed rate in Z axis): [mm / min].
- Distancia de seguridad (Distance of approach), Profundidad total (Total depth), Profundidad de pasada (Depth of cut), Diámetro de fresa (Mill diameter): mm. Rev/min (Revolutions per minute): rev/min.

Click on the Abrir DXF button, to open the AutoCAD file. Select Generar CNC button to generate the CNC code. See Figure 4.

The drawing area displays the sketch.

After the simulation, mount the piece in a CNC mill for machining.

2.4 Milling the parts

The piece with dimensiones 70 x 60 x 30 mm. is mounted in the Machining Center Benchman VMC 4000 located in the Robotics Laboratory at Universidad Autónoma del Caribe.

The original set point is established in the piece to proceed to mill with an end mill 6 mm. in diameter. See Figure 8.
3. Results

In AutoCAD was created the methodology of route generation of displacement of the mill.

It was developed the AutoCnc Mill software to convert the CAD software AutoCAD into a CAM software, allowing generate the CNC codes from the bidimensional drawing of the piece.

As can be seen in Figure 7, the simulation did not generates errors displacement of the tool, which motivated us the mechanizing of the piece.

It can be seen the real machining and the resultant piece in the Figure 8 and 9.

![Figure 8. Milling the piece in the Mechanizing Center](image)

Source: by the author (image: Robotic Labs at Universidad Autónoma del Caribe).

![Figure 9. The milled wokpiece](image)

Source: by the author (image. Robotic Labs at Universidad Autónoma del Caribe).

4. Discussion

It is very important to work with Autocad because it allows to obtain the coordinates and characteristics of entities drawn from DXF format, as this is the information needed to develop applications that process the data and generate results from-CAD-Software.

The machining was successful with the quality and the expected parameters.

Software AutoCNC Mill, the product of this research shows that in Colombia is possible to manufacturing.

Using this methodology it is possible to create other applications in the areas of Architecture, Civil Engineering, Robotics, Mechanical Design, Turning Process among others.

AutoCNC Mill can be enhanced in the following aspects:

- Make it independent of AutoCAD. Drawing the part within the same software.
- Generate 3D simulation software within the AutoCnc Mill or AutoCAD.
- Generate the toolpath of three-dimensional surfaces.
- Generate Calculating Application for machining times and costs.
- Extending the program to accept other CAD format, such as the parasolid kernel used by Solid Work and Solid Edge.

References


