IMAGE PROCESSING APPLIED TO CNC PROGRAMMING IN DRILLING PROCESS

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Abstract. *The aim of this study was to test a methodology of image processing applied to drilling process based in the CNC systems. The methodology involved the recognition of the dimensions of a part, based in a digital photo, being analyzed the diameters and positions of the hole in an application developed in IDL®. This information was analyzed in an application developed in a CAD system and used for the automatic generation of the CNC program for the industrial process. The methodology showed efficiency and capacity of allow more flexibility and freedom to industrial process, mainly for not need of the drawing of the part in CAD system.*

Keywords: *Image processing, CNC programming, Reverse engineering, Drilling process.*

1. Introduction

The application of computerized numeric command (CNC) system on the industrial process of manufacture, well as the optimization of existent systems, have the principal objective of improved the flexibility in the production process. The CNC machines works in programmable form and the operations to accomplish the task are written in codes, called CNC program.

The CNC drilling process is widely used for sculptured surface machining of dies, impeller blades, and other complicated parts. To provide productivity and precision, many researchers have been accomplishing experiments and developed models for tools controlled by CNC machines with use of new configurations or technologies (Kim *et al,* 1997; Yang *et al*, 2002; Fortin *et al*, 2004).

With the use of computer tools for integration between the steps of project and manufacture (CAD/CAM systems), some methodologies are developed to generate CNC programs automatically from the file with the drawing of the part, presented initially in CAD systems.

The modification in the design of a product existent or prototypes requires the extraction of the geometric parameters of the part, and this information can be obtained with the extraction of the coordinates of the surface based in an image of the part, especially in cases where a CAD model of the part doesn't exist. In these reverse engineering situations, an automated CAD model generation method could be used to accomplish the objective (Haung and Motavalli, 1994).

The image process is a computer tool applicable for the optimization of CNC programming because allow get the information of the geometry of a part. Therefore is important for the automation process (automatic recognition, machine vision and quality control) (Medeiros *et al,* 2002). The aim of this work is implement a methodology of image processing to aid the automatically generation of CNC programs for the drilling process. The technique involves the conversion of image model of a part to entities of a CAD system.

2. Methods

The methodology presented in this study has the purpose of generate a CNC parameterized program without the necessity of drawing of the part in a CAD system, according the inverse engineering method (Haung and Motavalli, 1994).

The first step was the image process of a photo of the part used to illustrate the methodology (the photo was obtained with a digital camera Nikon Coolpix 885), for the use in a computer application developed in Interactive Data Language (IDL® 6.0 - Research Systems Inc.). The IDL System allows the work with different forms of data, through computational mathematics. One of the causes of the choice of the IDL was his characteristic multi-platform, facilitating its use in many operating systems. To compile the computer application is necessary only the installation of an IDL Virtual Machine (Virtual IDL Machine), don't depending of the full installation or acquisition of software. The application interface was presented in the figure 01.

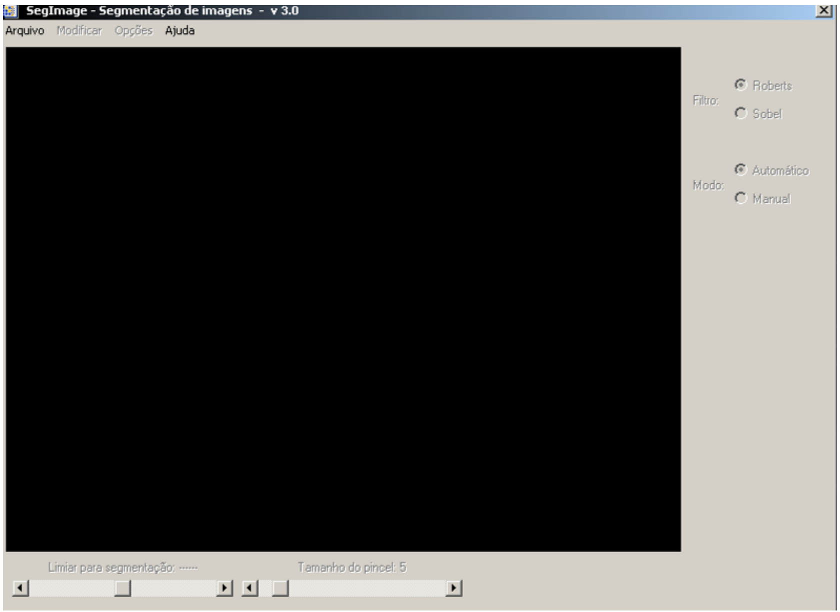


Figure 01: Interface of the application developed.

The information take by image processing were used on the second step of the methodology, which involved the development of an application CAD system. After those two steps, the CNC program was generated and ready to be executed automatically by the machine.

3. Results and discussion

For the development of propose methodology, initially was necessary develop of a computer application to get the information of the part (based in a single photo, the contour is detected and extracted for a text file with the x and y coordinates). The application developed produce text files with the information about the segmentation (filter used), profile (x,y coordinates) and individual pixels characteristics observed in the part analyzed (gray scale).

The application makes the segmentation with the digital filter selected by the user (filter options available for this version was *Roberts* and *Sobel*), to identify the contour and profile of interest in the image of the part. The initial interface of the application with the photo loaded is presented in the figure 02.

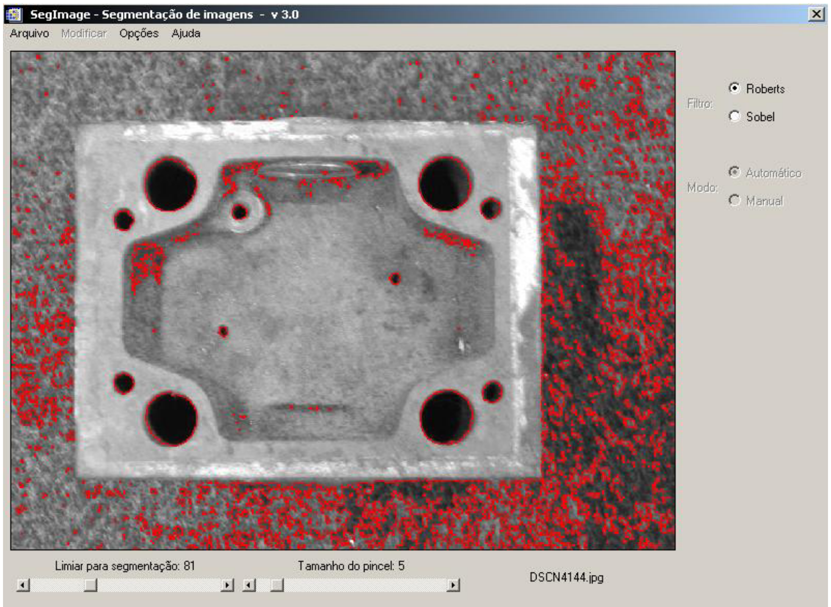


Figure 02: Example of the segmentation in the part used in this study.

In the active window are available options for the filter and segmentation threshold. Thus, with the selection of the filter and of the segmentation threshold, the image processing is made until that it is obtained the desirable result, as proposed by Gonzales and Woods (2000). The segmentation and the identification of the holes (indicated by arrows) are presented in the figure 03.

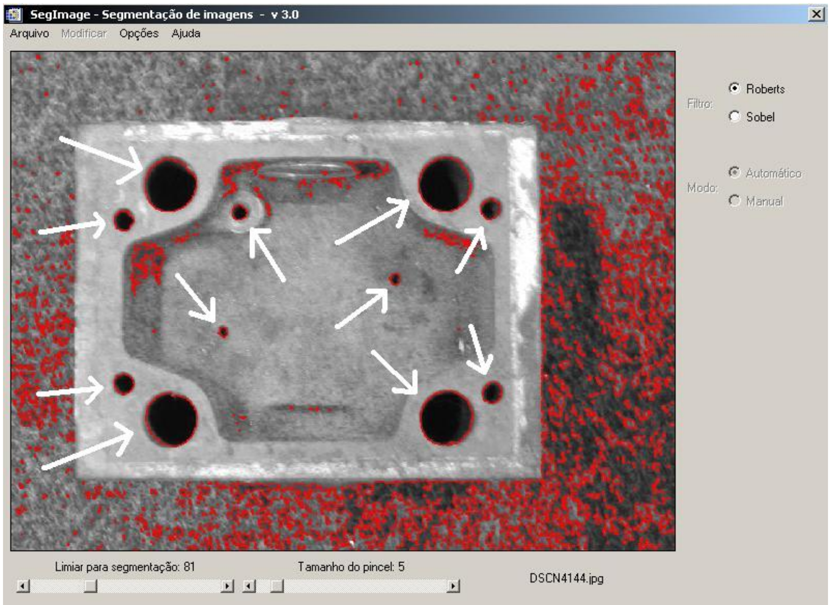


Figure 03: Holes identification.

The user concludes the image processing with a specific option in the menu that records a text file with the coordinates (position x, y) of each pixel in the contour of the part. In the sequence, with this file, the pixels of the part were analyzed in the CAD system being considered only the contour of the part (figure 04).

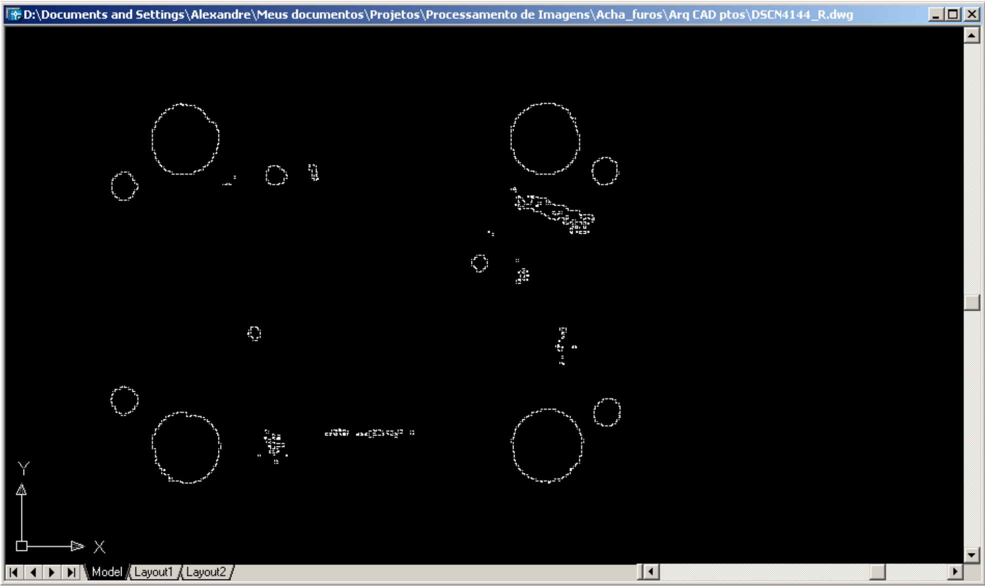
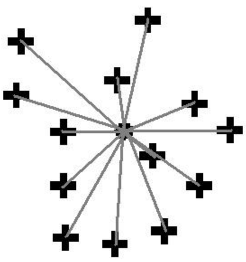


Figure 04: Internal contour of the part – CAD system.

The text file with the coordinates of each pixel in the contour is used to create a list (interpreted in the CAD system). This list indicates the holes showed in the figure 03, reconstructed in the CAD system (figure 04). With an application developed in the CAD system the geometry of the part was evaluated in agreement with configurations selected by user (related to the minimum and maximum diameter of the holes) to select the holes wanted. Each hole will be identified in the system CAD (according to the diameter) and later sent for the CNC machine, in the form of CNC programming.

For the identification of the holes, each pixel has your distance in relation to the close pixels analyzed in agreement with the configuration indicated by the user. In this phase, the CAD application search for similar distances (e.g. with similar ray) organized around the each pixels evaluated. The proximity of the pixels and your disposition will indicate the existence of a hole. The example of distribution of pixels in the figure 05(a) presents great dispersion among the pixels, while in the figure 05(b) is observed a less dispersion among the pixels in relation to the pixel tested (in the center), and this situation result in a small standard deviation, consequently, the hole was recognized only in the figure 05(b). The pixels don't recognized with hole is deleted of the file and of the drawing.


(a)

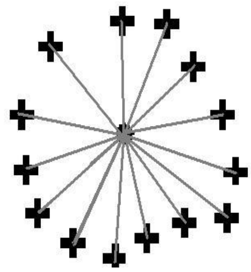

(b)

Figure 05: Hole recognition. (a) Profile don't recognized as a hole and (b) recognition of a hole.

With the coordinates of the pixels of the contour of the hole is defined the center and diameter of the hole, according to a standard deviation selected by the user. This information is compared with the configuration defined by the user.

The part is plotted in the CAD system and the holes of the part, according to the configurations select by the user are available for the CNC program. The figure 06 presents a reconstruction of the part in the CAD system. The arrows indicate the holes recognized according to the user preferences. The user preference excluded one hole (see the figure 03), because your diameter was smaller than the user wanted.

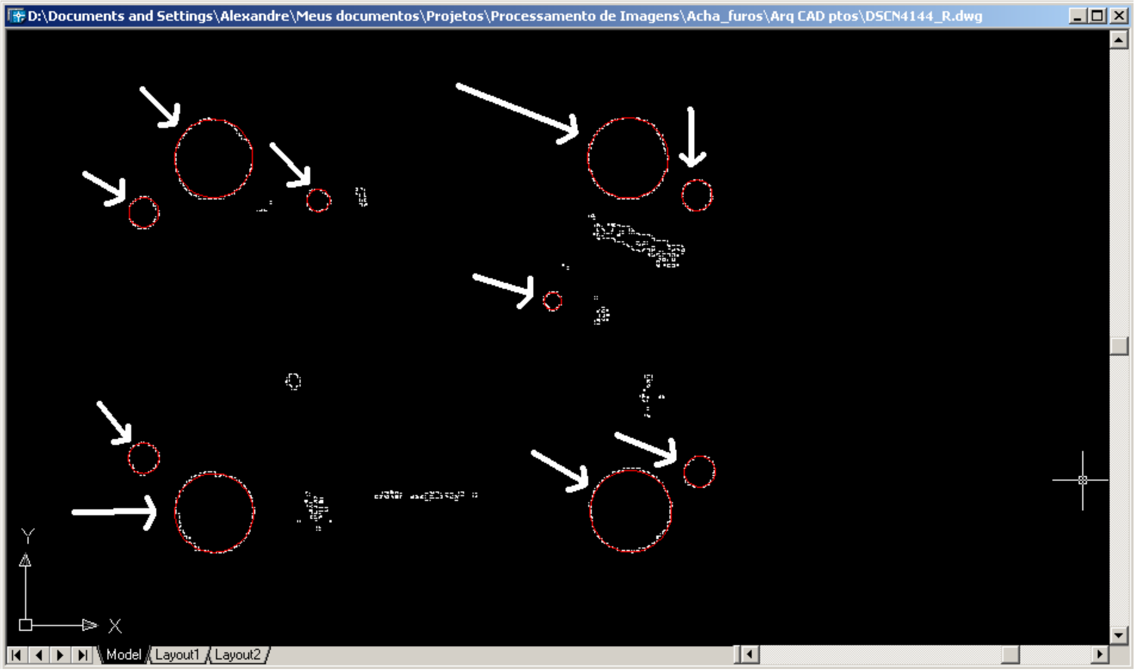


Figure 06: Part plotted in the CAD system – the holes selected (red) was indicated by white arrows.

After the identification of the holes in the drawing of the part, the 2D drawing of the part (figure 07) is generated for next step of the methodology.

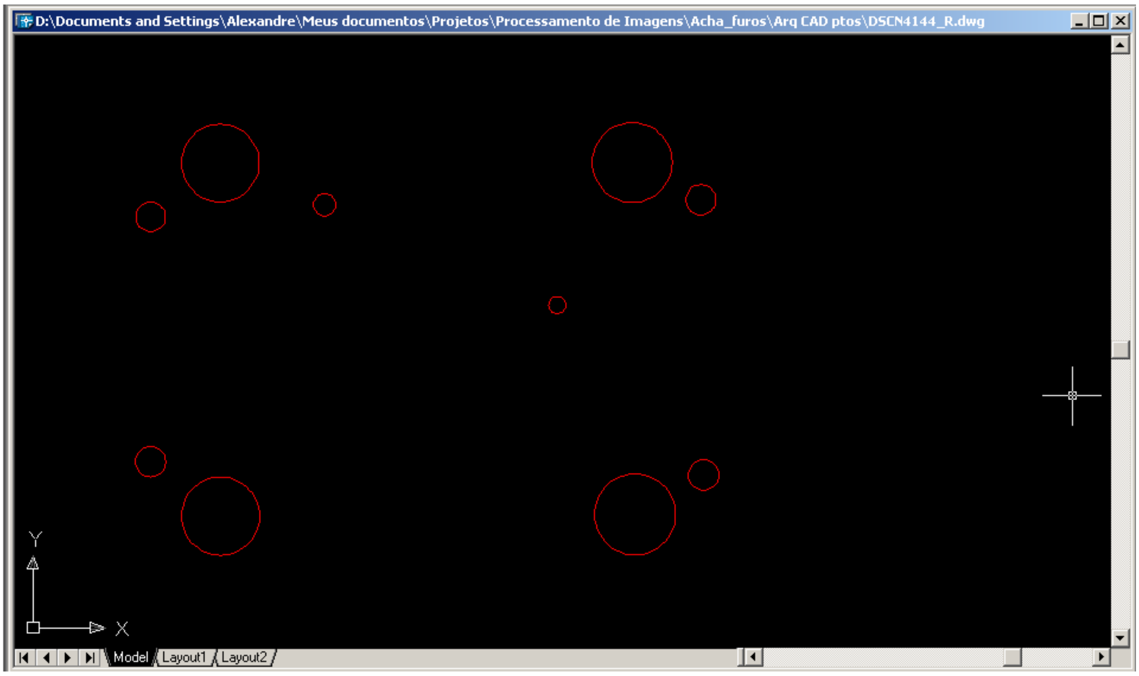


Figure 07: Holes identified in the image of the part.

The generation of the parameterized CNC program is made with the objective of realize the drilling process independent of the existence of the drawing of the part in a CAD system, only information obtained by the image processing of the part being used (Bradley, 2001). The holes identified were organized in groups in agreement with the dimensions of the diameter, and the sequence of use of the tools was determined. The example of CNC program generated for a CNC machine Discovery 308 is presented in the figure 08.

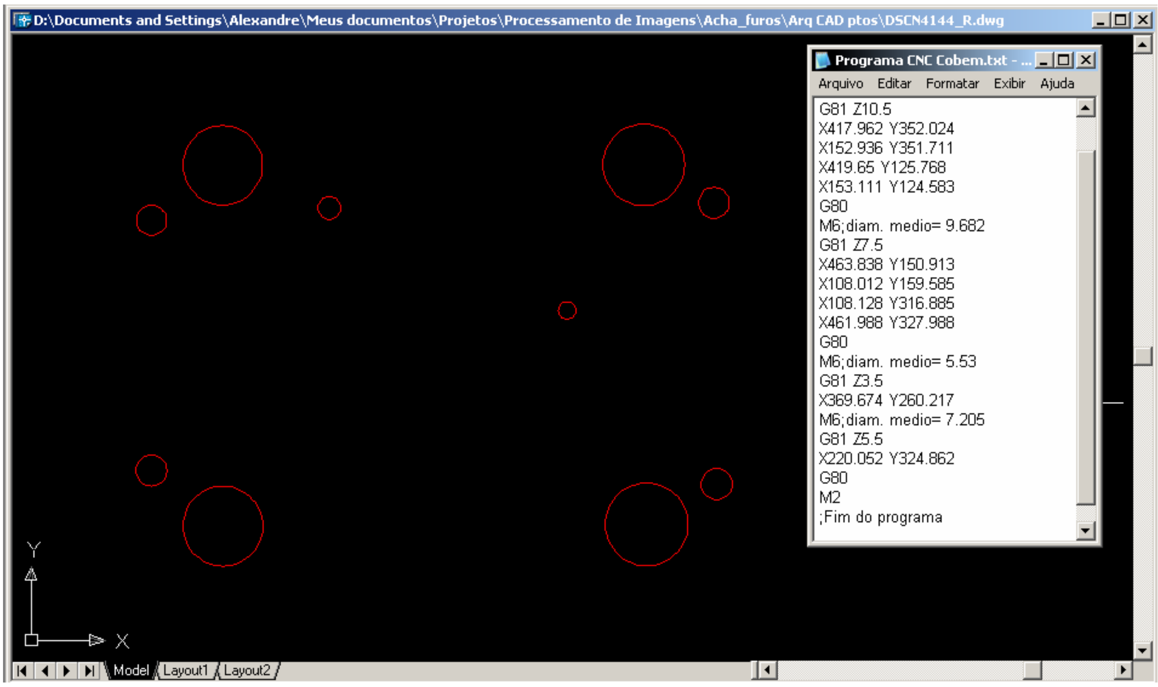


Figure 08: CNC program generated.

The CNC program generated for the part presented in this study is commented in the sequence. The CNC commands and coordinates obtained for each hole identified with the IDL application and the CAD application were used.

M6; average diameter= 25.468 *; first group of bore*
G81 Z10.5 *; drill cycle invoked*
X417.962 Y352.024 *; first bore coordinates of first group of bore*
X152.936 Y351.711 *; second bore coordinates of first group of bore*
X419.65 Y125.768 *; third bore coordinates of first group of bore*
X153.111 Y124.583 ; fourth bore coordinates of first group of bore
G80 *; drilling finish of the first group of bore*
M6; average diameter= 9.682 *; second group of bore*
G81 Z7.5 *; drill cycle invoked*
X463.838 Y150.913 *; first bore coordinates of second group of bore*
X108.012 Y159.585 ; *second bore coordinates of second group of bore*
X108.128 Y316.885 ; *third bore coordinates of second group of bore*
X461.988 Y327.988 ; *fourth bore coordinates of second group of bore*
G80 ; *drilling finish of the second group of bore*
M6; average diameter= 5.53 ; *third group of bore*
G81 Z3.5 ; *drill cycle invoked*
X369.674 Y260.217 ; *bore coordinates of third group of bore*
M6; average diameter= 7.205 ; *fourth group of bore*
G81 Z5.5 ; *drill cycle invoked for the fourth group of bore*
X220.052 Y324.862 ; *bore coordinates of fourth group of bore*
G80 ; *drilling finish of the second group of bore*
M2 ; *finish of the CNC program.*

3. Conclusion

This study presented a methodology of image processing with easy application and advantages to the production processes, and in relation to technique of reverse engineering, because had success to make the process of generation of the CNC program automatically.

The methodology presented tools of easy use, making the manufacture process faster, contributing to resolution of situations where the drawing of the part in the CAD system doesn't exist, and providing larger flexibility, velocity and, consequently, productivity in the production processes. The system continues in development with the purpose of present solutions for parts evaluated in three-dimensions.

4. References

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5. Responsibility notice

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