On the Detection of Generic Conic Form Parameters Using Hough Transform

Maysa Malfiza Garcia de Macedo, Aura Conci
IC- Computing Institute-UFF- Fluminense Federal University
Passo da Pátria, 156, Niterói, RJ, Brazil
mmacedo@ic.uff.br, aconci@ic.uff.br

Abstract

Hough Transform (HT) is a method for shape extraction from images based on accumulator array of the most voted form. This paper introduces a unique methodology to detect any conic equation parameters using HT idea. Based on the analysis of generic conic equation it is observed that is possible to unify its identification on images if some aspects are considered. The bases of the formulation here presented are the use of polar coordinates on the match of open or closed form and the parameters search sequence. In this way we can identify complex forms through of the union of several conic detections.

1. Introduction

Detecting the equations that describe objects on an image is very useful in many applications [1]. The Hough transform is one way of doing this. Its idea is transform an image edge on the space (x,y) to represent it in a space of parameters (ρ, β, x_0, y_0, ...). Each point of the images produces an increment of n cells of the accumulator array, so all points in the same curve are mapped in an intersection cell at the parameter space. The biggest value will define the aimed curve. This method was first proposed for line detection, and then improved to circles and ellipses detection [2] [3]. The generalized HT considers arbitrary set of points. However, in such generalization the main objective is related to the pattern recognition than to equation detection because no more a equation are searched [4]. This paper extends the initial study of detection of lines, circle or ellipses form separately to a generic detection of any conic equations, so this algorithm is able to detect all open or closed equation parameters.

2. Generic Conic Detection

The developed integrated formulation approach is based on the use of polar coordinates on the description of all curve equations and parameters; the order of search for these parameters; and its respective level of approximation and range. It was observed that the search sequence is fundamental on the successes of the unified formulation. It is better start the search for the polar coordinates (polar radius, polar angle) of each image pixel, given value intervals of the angle. Other simple but relevant consideration is that more important than the number of parameters is the definition of its range in limits and also in number of bins. The accuracy in a conic detection depends on the chosen size of cell, it means, the smaller size of cell is, the more accuracy and slower it is. Considering the common aspects of all conics to establish a unified approach, the parameters of a curve are represented as a set $P = (p_1, p_2, p_{3,\ldots})$. Then, each element of P should have a value in the adequate range as $L = (l_1, l_2, l_3,\ldots)$ and $U=(u_1, u_2, u_3,\ldots)$, where L is the lower limit and U is the upper limit according to the image domain. The accumulator matrix has a dimension given by:

$$D = \begin{cases} length(P)+1 & \textit{if the conic has rotation} \\ length(P) & \textit{otherwise} \end{cases}$$

For each element in P, its polar equation is computed. If there is center or focus, these are calculated as following:

$$x_0 = x - \rho\cos\beta\cos\omega + \rho\sin\beta\sin\omega,$$

$$y_0 = y - \rho\cos\beta\sin\omega - \rho\sin\beta\cos\omega,$$

where ρ is the polar form of curve point, (x,y) is an image point, β is the slope between the curve center or focus and a curve edge point, and ω is the curve rotation angle. Afterwards, the cell that corresponds to the wanted parameters is incremented by 1, but the accumulation array has to respect the limits L and U. This algorithm allows detecting conics shapes also in very noisy images. It is also possible to detect approximated conic forms from drawing. When all parameters of curve are detected its easier compute their geometric features like slopes, curvatures, focuses, centers and others, which can be useful in pattern recognition or shape analysis [1]. Only circles and ellipses are closed curves. Considering the other conic forms, it is not possible to define the initial and final points only through the space of parameters. So it is necessary to create a limit point identification mechanism. In this work is proposed as a mechanism a simple comparison between the pixels in the original image and in the detected image to elect the border points. However, if such pixels do not match, the Euclidian distance with a tolerance will be used. In case of lacking points along the curve this distance is also considered. Moreover, if the matching does not occur, the final point will be the last pixel matched successfully with the original image. When a conic form is closed, both initial and final points receive as default the value zero. Furthermore, arcs of circles or ellipses can be determined by the same mechanism as shown in next section. Another possible resource about the final point identification is detecting more than one conic at the same image. The basic idea about that is detecting a conic, then this form is erased and then the next conic could be detected at the same image [2].

3. Experimental Results and Conclusion

In this section, the efficiency of the generic detection is shown. Figure 1 shows the original image, its edge detected by Canny method and the 4 main circles detected by unified approach commented on section 2.

This shows the possibility of detection conic forms in failed or lacking images. The detected radius are: 136, 35, 16, 16 pixels and center (142,131); (152, 107), (196, 66) and (223,148).

In this paper, an approach for the generic detection of conic forms based on the Hough transform is presented. Several tests illustrated the efficiency on detection of any conic form or any combination of conic shapes can be found in [2]. The conic form can be corrected detected in any quantity on the image; with any rotation; for closed or opened curves; with fails or noise; for circle or ellipses arcs; by hand drawings, or in a coarse manner when the form is drawn. Finally when several different kind of conics can appear and be detected in the same image. The features that define the curve equation can also be computed. The union of all conic detection on the same approach it is a new issue. It also detects any kind of conic when these are at the same image.

4. References

[1] Costa, L. and R., Cesar Junior. *Shape Analysis and Classification: Theory and Practice*. CRC Press , 2000.

[2] Macedo, M. M. G., *Uso da Transformada de Hough na Vetorização de Moldes e outras Aplicações*. M. Sc. Dissertation, Computer Science Department - Universidade Federal Fluminense, 2005.

[3] M. Blanco, M. G. Penedo, N. Barreira, M. Penas, M. J. Carreira: "Localization and Extraction of the Optic Disc Using the Fuzzy Circular Hough Transform". ICAISC 2006: 712-721.

[4] O. Ecabert, and J. Thiran. "Adaptive Hough Transform for the Detection of Natural Shapes under Weak Affine Transformations". Pattern Recognition, Vol. 25, pp. 1411-1419, 2004.

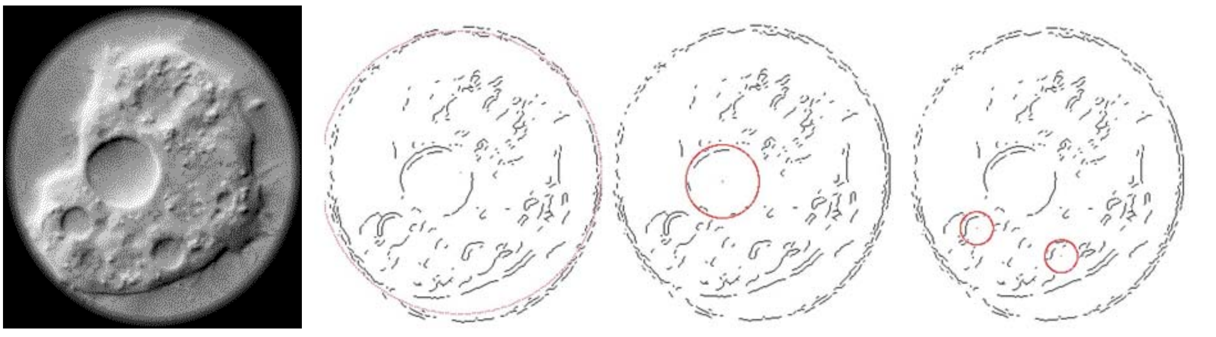

Figure 1 – Original image and the 4 main circle detected (in red)