International Journal of Scientific Research and Engineering Development-– Volume 2 Issue 5, Sep – Oct 2019
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

A Case Study: Circle Detection Using Circular Hough Transform

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***Abstract* – Circle detection is an important aspect of image processing. The Hough transform is one of the methods to find circles in an object especially the objects used in various industrial applications. This paper presents a modified method based on the basic CHT algorithm and using relatively less calculations in order to improve the computational performance for a good accuracy of circle detection in a binary image. The purpose of the technique is to find circles in imperfect image inputs. As the results of the experiments, the object detection rate of the proposed system was 95% in accuracy.**

***Keywords* – Circular Hough Transform, edge detection, circular shape recognition, Computation Time.**

I. Introduction

Paul Hough suggested an efficient method for detecting lines and edges in binary images in 1962 [1]. In everyday experience circular features are commonly sought in digital image processing. The problem of detecting circular features is very important for image analysis, in particular for industrial applications such as automatic inspection of manufactured products and components, aided vectorisation of drawings, target detection, mechanical parts[2], and particle trajectories[3,4] etc.

Object detection and recognition in noisy and cluttered images is challenging problem in computer vision. The goal of this research is to identify objects in an image (here we consider coins). There are several problems in detecting and recognizing the coins in the image. First, the target object is obscured due to the presence of the other object which can interfere with recognition process. Second, some of the objects are overlapping between each other that make the recognition process challenging. Third, the various object positions and finally, the images itself contain noise that make the recognition process difficult without proper preprocessing and segmentation process. This paper gives basic introduction to circular hough transform with giving some experimental results. Edge detection Algorithm is also introduced.

The paper is organized as follows. Section 2 introduced related works performed by researchers in this domain. Section 3 includes the concept of the proposed method. In section 4 proposed the algorithm. Section 5 shown the results and section 6 conclude the paper.

II. Related Work

The detection of circular and elliptic shapes is a common task in computer vision and image recognition. Some methods rely on converting gray-scale images to binary ones using edge detection techniques and calculating numerical shape descriptors. Simple shape descriptors are sorted out in [8]. One of them, known as elliptic variance, is especially useful for detecting ellipses. Rosin proposed other descriptors (moment invariants, Euclidean distances) that can be adapted to measure the ellipticity of shapes [5].

The first to present a direct method for fitting ellipses to a set of points in the least-squares sense. Their method is exploited in the segmentation algorithm presented in this work. Previous methods used a generic conic fitting or an iterative approach to recover elliptic solutions. A variety of 'fit-to-data' functions were discussed [6]. Low level edge detection operators do not guarantee continuous boundaries of objects. This makes many image analysis tasks difficult, especially for noisy images. The aim of contour grouping algorithms is to connect edges that are supposed to be sub-parts of the same object. Contour grouping techniques were concentrated mainly on detecting salient curves [7].

Their basic idea is to reshape an initial curve provided by any rough segmentation technique, subject to constraints from a given image. Initially, the current curve is set to the initial one. [2] Showed that active contours can also be employed for tracking moving objects. The energy function calculates the difference between object features and background features, so it is useful for stained smears.

III. CIRCULAR HOUGH TRANSFORM

The construction of real circle detection algorithm is one of the most challenging tasks because images are sensitive to noise and other complexities involved in processing. Various algorithms were proposed in this domain but Circular Hough Transform (CHT) has long been recognized as robust techniques for circle detection. The circle is actually simpler to represent in parameter space. The circle equation is

n 2 2

$$r = (x-a)^2 + (y-b)^2 \quad (1)$$

As it can be seen the circle got three parameters a, b and r. Centre of the circle in x and y direction is given by a and b, r is the radius. Circle parametric representation is given by

$$x = a + r\cos(\theta) \quad (2)$$

$$y = b + r\sin(\theta) \quad (3)$$

Thus the parametric space for a circle will belong to R. As the number of parameters needed to describe the shape increases as well as the dimensions of the parameter space R increases so do the complexity of the Hough Transform. So with the Circle Hough Transform, we expect to find triplets of (x, y, R) that are highly probably circles in the image. First find out the edges using Canny edge detection algorithm. For each edge point, draw a circle assuming that edge point as centre with the desired radius. The circle is drawn in the parameter space (fig 1).

The 'a' value is the x-axis, 'b' value is the y-axis while the z-axis is the radii in the parameter space of the circle drawn. At the coordinates which belong to the perimeter of the drawn circle we increment the value in our accumulator matrix which essentially has the same size as the parameter space. In this way for each edge point in the input image drawing circles with the desired radii and incrementing the values in our accumulator. When completed with every edge point and every desired radius, turn attention to the accumulator. The numbers in the accumulator will represent the number of circles passing through the individual coordinates. Thus the highest numbers are taken into consideration.

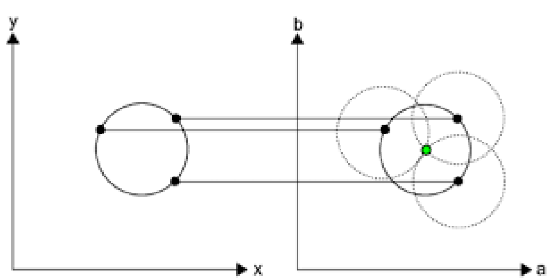

Fig. Circular Hough Transform concept

Implementation :

Implementing Circular Hough Transformation on coins. We get the following results:

Firstly the original image is taken into consideration. Various coins are placed alongside as shown in Fig2.

The image is now inserted as input for cicular hough transformation. Circular Hough transformation will use Sobel or Canny edge algorithm to detect edges in the image.

The coins in the image are detected by Sobel detecting Algorithm in Circular Hough Transform as shown in Fig3.

Fig2 .Original image of coins

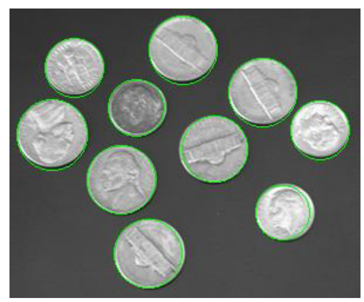

Fig3.Circles detected using Edge Detection

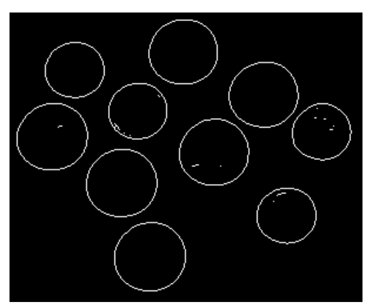

Fig4. Parametric Space Representation of Circle

IV. CIRCLE EDGE DETECTION

Syntax:

circles = houghcircle(im, minR, maxR);

or

circles = houghcircle(im, minR, maxR, ratio);

or

circles = houghcircle(im, minR, maxR, ratio, delta);

Input:
im: input image (gray or color)
minR: minimal radius (unit: pixels)
maxR: maximal radius (unit: pixels)
ratio: minimal number of detected edge pixels of a circle to the circle perimeter (0<ratio)

Output:
circles:
n-by-4 array of n circles;
each circle is represented by [cx cy R c],
where (cx cy), R, and c are the center coordinate, radius, and pixel count, respectively.

Steps:
1.First of all we check the input parameter.
2. If the number of input is '4', in that case , delta=12, because Each element in [cx cy R] may deviate 4 pixels approx.
3. If the number of input is '3', then ratio=0.3 ,which is the 1/3 of the perimeter and delta=12.
4. If the number of input is not '5',at that time program will show a message that" Require at least 3 input arguments"
5. If minR<0 or maxR<0 or minR>maxR or ratio<0 or ratio>1 or delta<0, the it will show this message
'Required: 0<minR, 0<maxR, minR<=maxR, 0<ratio<1, and 0<delta'

The shape recognition of an object is possible through sobel edge detection algorithm that gives accuracy to find edges of the object in given image.
The computation time is dependent upon the factors such as the type of Edge Detection Algorithm and the Dimension of input image.

V. EXPERIMENTAL RESULTS

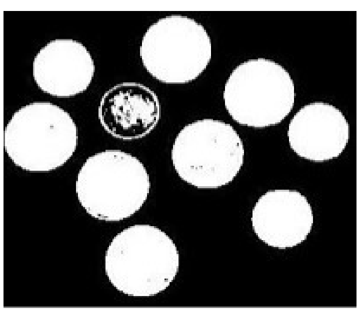

Fig5.Final result given by Circular Hough transform

The highest success rate of the proposed system to detect the object was 95%.

Experiment number	Image dimension	True Circles	Results of Edge Detection	CHT Results
1	250 x 180	10	14	10

From fig.4 The edge detection algorithm detected around 14 circles. Then after passing these parameters the circular Hough transform gives the result as 10.

VI. CONCLUSION

In this paper we have proposed Circular Hough Transform and Edge Detection methodology. Circular Hough Transformation algorithm can be used along with the existing algorithms or concept can be applied in developing new algorithm. The experimental results indicated that our algorithm can be effectively applied to detect the objects. Future research domain include the areas such as algorithm optimization, reduction in complexity of algorithm, accurate circle detection etc.

VII. REFERENCES

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