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Circular Hough Transform For Detecting And Measuring Circles of Object

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Abstract- This article presents a robust method for detecting and measuring the circles of industrial object like water pump pulley(WPP-44), images based on circular Hough transform. The software of the application is based on detecting and measuring the circles surrounding of that object. The objective of this application is the recognition of circular shapes in an image. This paper presents efficient implementation of Image Processing technique for measurement of dimension of the object used in Turbine system. The proposed work makes use of the Matlab software for the said work..At First an segmentation or edge detection technique is used for finding the edges in the input image, then the characteristic points of circles are determined, after this process the pattern of the circles is extracted, and then with the help of other extraction parameter of the diameter of object(WPP-44).

Keywords- *Hough Transform, Circle Hough Transform, Detection, Measurement, Edges, Water Pump Pulley.*

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I. INTRODUCTION

Nowadays, in industry various methods are used for quality assessment of final product. For measuring various circles in any product different producer are used. Likely for Water Pump Pulley - 44 (WPP-44) there are many circles present at top side of an object.

Therefore, industry has to balance the demand of high quality production and low prices may ways, such as to increase the capacity and production technology. The process of quality assessment production is complex. Due to its complexity, there are failures object to occur in each production process. The failure object is found from the defect of object which cannot be repaired and thus wastes the production cost. The Failure Analysis (FA) is to identify the failure of defect on media and classify the pattern of defect. The FA helps technicians to access problems rapidly, which decreases the waste and the production cost. Consequently, this study is to introduce a method of Detection and measurement of these circles present in WPP-44 based on the Circular Hough Transform and Image .

II. HOUGH TRASFORM

A commonly faced problem in computer vision is determining the location, number or orientation of a particular object in an image. One problem could, for instance, be to determine the straight roads on an aerial photo, this problem can be solved using Hough transform for lines. Often the objects of interest have other shapes than lines, it could be parables, circles or ellipses or any other arbitrary shape. The general Hough transform can be used on any kind of shape, although the complexity of the transformation increases with the number of parameters needed to describing the shape. In the following we will look at the Circular Hough Transform (CHT)[5].The Hough transform can be described as a transformation of a point in the x,y-plane to the parameter space. The parameter space is defined according to the shape of the object of interest. A straight line passing through the points (x_1, y_1) and (x_2,y_2) can be in the x,y-plan to be described by:

$$y = ax + b \qquad (1)$$

This is the equation for a straight line in the Cartesian coordinate system, where a and b represent the parameters of the line. The Hough transform for lines does not use this representation of lines, since lines perpendicular to the x-axis will have an a-value of infinity[9]. This will force the parameter space a,b to have infinite size. Instead a line is represented by its normal which can be represented by an angel θ and a length ρ .

$$\rho = x\cos(\theta) + y\sin(\theta) \qquad (2)$$

The parameter space can now spanned by θ and ρ , where θ will have a finite size, depending on the resolution used for θ . The distance to the line ρ will have a maximum size of two times the diagonal length of the image.

III. CIRCULAR HOUGH TRASFORM

The circle is actually simpler to represent in parameter space, compared to the line, since the parameters of the circle can be directly transfer to the parameter space. The equation of a circle is

$$r^2 = (x - a)^2 + (y - b)^2 \qquad (3)$$

As it can be seen the circle got three parameters, *r*, *a* and b. Where a and b are the center of the circle in the *x* and *y* direction respectively and where *r* is the radius. The parametric representation of the circle is

$$x = a + r\cos(\theta)$$
$$y = b + r\sin(\theta) \quad (4)$$

Thus the parameter space for a circle will belong to R^3 where as the line only belonged to R^2 . As the number of parameters needed to describe the shape increases, as well as the dimension of the parameter space R increases, so do the complexity of the Hough transform[1].

Therefore, the Hough transform in general is only considered for simple shapes with parameters belonging to R^2 or at most R^3. In order to simplify the parametric representation of the circle, the radius can be held as a constant or limited to number of known radii.

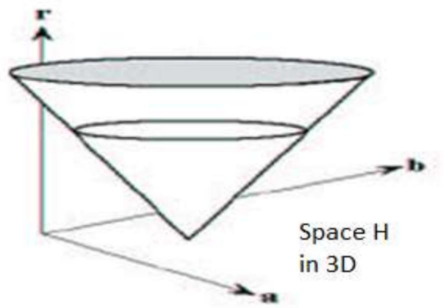

Fig. 1 The parameter space used for CHT

The process of finding circles in an image using CHT is:First we find all edges in the image. This step has nothing to do with Hough Transform and any edge detection technique of your desire can be used. It could be Canny, Sobel or Morphological operations[3][2].

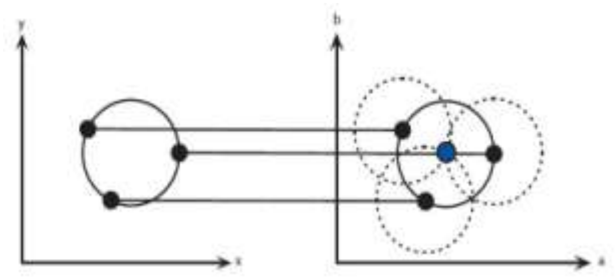

Fig. 2 Circular HT from the x,y-space (left) to the parameter space (right), for a constant radius[2]

At each edge point we draw a circle with center in the point with the desired radius. This circle is drawn in the parameter space, such that our x axis is the a-value and the y axis is the b value while the z axis is the radii. 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, we sweep over every edge point in the input image drawing circles with the desired radii and incrementing the values in our accumulator. When every edge point and every desired radius is used, we can turn our attention to the accumulator[9]. The accumulator will now contain numbers corresponding to the number of circles passing through the individual coordinates. Thus the highest numbers (selected in an intelligent way, in relation to the radius) correspond to the center of the circles in the image[4][6].

Multiple circles with the same radius can be found with the same technique. The center points are represented as red cells in the parameter space drawing. Overlap of circles can cause spurious centers to be found, such as at the blue cell[7]. The circles can be removed by matching to circles in the original image.

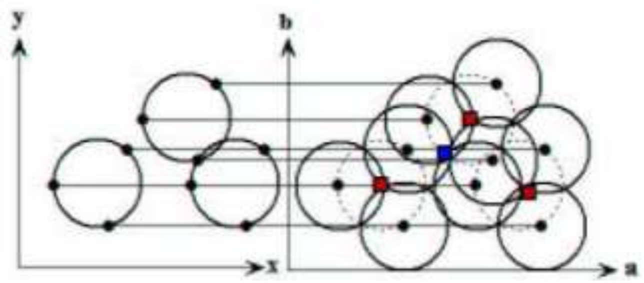

Fig. 3 Each point in geometric space (left) generates a circle in parameter space (right). The circles in parameter space intersect at the (a, b) that is the center in geometric space[10]

IV. CIRCLE DETECTION ALGORITHM

Circular Hough Transform function detects multiple circles in an image. The image contains holes or circles or disks whose centers can be in or out of the image.

Syntax:

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

Inputs:

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<1, default:0.3)
delta: the maximal difference between two circles for them to be considered as the same one (default: 12); e.g., circle1=[x1 y1 R1],circle2=[x2 y2 R2], delta = |x1-x2|+|y1-y2|+|R1-R2|.

Output:

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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'

- Turn the colour image into gray image.
- Create a 3D Hough array. The first two dimensions specify the coordinates of the circle centers (x,y), and the third specifies the radii(r).
- Detect edge pixels using Sobel edge detector. Reset the lower and/or upper thresholds to balance between the performance and detection quality.
- For an edge pixel (px,py), the locations of its corresponding possible circle centers are within the area (px-maxR:px+maxR, py-maxR:py+maxR).

- Create the grid [0:maxR2, 0:maxR2], and then compute the distances between the center and all the grid points to form a radius map (Rmap), followed by clearing out-of-range radii . Where : maxR2= 2 * max R.
- For each edge pixel, increment the corresponding elements in the Hough array.
- Collect circles
  Format: [cx cy R c]
  Clear pixel count < 2*pi*R*ratio
- Delete similar circles.
- Draw circles on the original image.
- After drawing circle on image than using circular hough transform(CHT) , the radius of circles is find out.

V. EXPERIMENTAL RESULTS

The following Figure 4 is used as a sample image which is taken from camera, that image act as a real time image which is stored in a temporary image. This image will detect and measure parameter of WPP-44 by applying circular hough transform technique..The sample images then were resized to 365x352 pixels for a fast image processing response.

Figure 4: Input Image

A threshold value was defined to represent the boundary of the circle pattern by applying edge detection technique. Then, the maximum values from the layer were compared with the threshold to identify for the circle pattern.

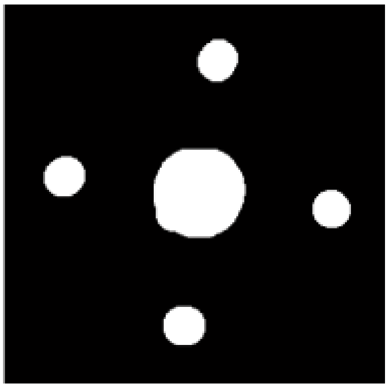

Figure 5: Shows the segment of top view detection

By using circular hough transform implantation the detection of cirles are done. Figure 6 demonstrated circle pattern depicting the peak value voted from the accumulator array, that the defect was the circle pattern.

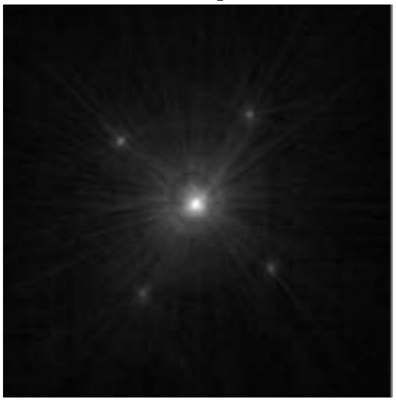

Fig.6 : The implementation of Circular Hough Transform Technique and detection of circles (bore)

Using circular hough transform the circles are detected of water pump pulley and also the centre point of circle is determined.

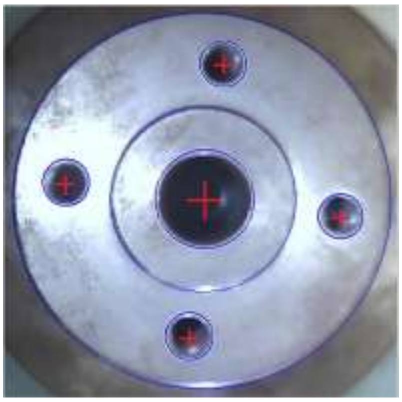

Figure7: Final Output

To get clear image of circles and to calculate diameter of object, histogram is applied to Figure7. By using histogram accuracy of parameter measurement is increased.

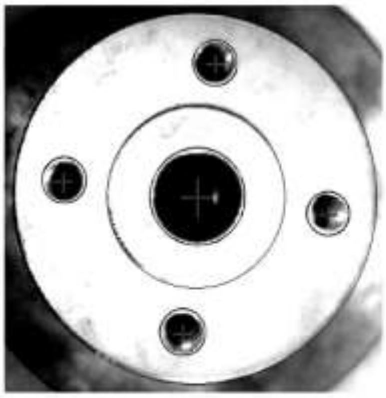

Figure8: Histogram of Final OutPut

The experiment showed that the developed circle detection algorithm was able to correctly detect and measure the circles of sample with maximum accuracy.

TABLE I. EXPERIMENTAL RESULTS

Sr. No.	Name	Standard Readings	Calculated Readings	Accuracy in %
1	Total Diameter	69.85mm	67.74mm	96.979
2	Outer Diameter of bore	33.15mm	32.55 mm	98.19
3	Centre bore	15.86mm	14.88 mm	93.82
4	Thread Holes			
	I Hole1	7.98mm	7.1 mm	87.88
	II Hole2	7.98mm	7.8 mm	97.74
	III Hole3	7.98mm	7.85 mm	98.37
	IV Hole4	7.98mm	7.7 mm	97.5

VI. CONCLUSION

This study was to introduce an algorithm for circle pattern detection and measurement of WPP-44 object based on the Hough Transform method. The experiment demonstrated ous a satisfying result. The developed algorithm was advantage for the parameter measurement and the failure analysis of WPP-44 production process, such as help to access problems rapidly, decrease waste, and reduce the production cost of WPP-44 industry.

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