
최소자승법과 전 처리를 이용한 원호 검출의 간단한 접근

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A simple approach for circular Arc detection using a least squares fitting and preprocessing

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요 약

원호는 산업 환경에서 객체의 검출 및 인식에 매우 유용한 특성이다. 본 논문에서는 새로운 원호 검색 방법을 제안한다. 원호 검출은 중점과 원호의 반지름, 두 개의 호 끝점이 필요하다. 제안하는 새로운 검출 방법은 호를 따라 지정한 세 점을 이용하여 가장 좋은 부분을 결정한다. 최소자승법을 적용하여 원호의 최적점과 중점 그리고 반지름을 얻는다. 남은 모서리 점들의 거리와 반지름은 원호의 두 끝점을 찾는 데 이용된다.

ABSTRACT

The circular arc is a very useful feature for object detection and recognition in industrial environments. In this paper, a new method to detect circular arcs is proposed. The detection of the circular arc includes the estimation of the center, the radius and the two ending points of the arc. This new method is based on determining the best part of the circular arc (part which does not contains outliers points) using 3 points designated along the arc. A least square method is applied to the best part of the arc and the center and the radius of the arc are obtained. The distance between the remaining edge's points (points which are not lying on the best part of the arc) and the radius is used to the two ending points of the arc.

키워드

arc detection, feature extraction, circular arcs, least squares fitting

I . INTRODUCTION

Circular arcs are important features on the image of industrial parts or tools [1, 2, 3], in the field of computer vision and pattern recognition [4], etc.

Many approaches have been proposed to estimate the arc parameters and most of them are still sensitive to noise and to outlier points.

The new approach for circular arc detection proposed in this paper, focus on selecting the best part of the arc in order to find the circular arc parameters (center and radius) by removing

the noise and ignoring the outlier points or the additional points which vary from the circular arc. The two ending points of the arc will be also detected. The algorithm for determining the best part of the arc is applied after some pre-processing operations on the image like the smoothing, binarization and the edge detection. With this new algorithm, the whole process of the arc detection can be divided as follows: A color image is converted in gray-scale image, we extract in a new image, the region of interest (ROI) containing the circular shape, the median filtering [5] is applied to the new image containing the circular shape

in order to remove noises but a small window (3*3) is used in order to keep the original size of the circular shape. After binarization of the image, the canny edge detection algorithm is applied to have a clear boundary of the circular shape which is very important to accurately analyze the arc shape. At that time we determine the best part of the arc which will be applied to the least square method in order to find the parameter (center and the radius) of the circle which fits the circular arc. The two ending points are then found by comparing the radius and each point of the circular arc.

The next sections describe in details our algorithm. The section II makes a review of the related work, section III explains in details the algorithm of the arc detection by selecting first the best part. Section VI describes the experimental results and section V gives the conclusion.

II. RELATED WORK

The Hough Transform method is considered to be the basic method for the arcs and circles detection even though important improvements have been made to it in the current methods.

II.1. Hough Transform

The Hough transform is a method for extracting features and often used in images analysis and computer vision. The original Hough transform was a line transform and was a quick method for searching a binary image for straight lines. Later, the transform has been extended in 1972 by Richard Duda and Peter Hart to identify positions of arbitrary shapes, most commonly circles and ellipses

The Circle Hough transform method has as purpose to find circles in imperfect image inputs. The circle candidates are produced by voting in the Hough parameter space and select the local maxima in the accumulator matrix. For each edge point on the image plane, the curves passing through the point are computed, and the accumulators corresponding to these curves are incremented by 1. The accumulator with a peak value demonstrates the presence of a curve, and is specified by the accumulator's coordinates, on the image plane [5].

In a two dimensional space, a circle can be

described by

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

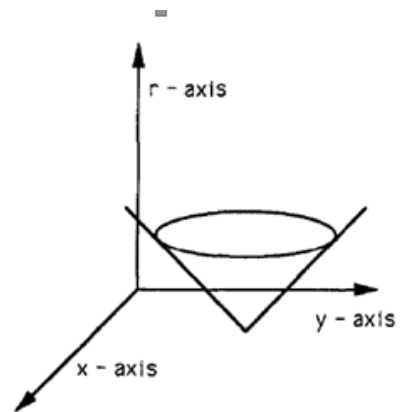


Figure 1. Circular Hough transform voted by an edge point

where (a, b) are the coordinates of the center of the circle and r is the radius of the circle. The HT using this equation finds all the points of the image satisfying (x, y). Those points are then lying on the surface of an inverted right-angle cone whose apex is at (x, y, 0).

For the 3D space, it is the intersection of many conic that helps to identify the circle parameters.

First the radius can be fixed and then find the optimal center of circles in 2D parameter space or finding the optimal radius in one dimensional parameter space. [3].

III. PROPOSED METHOD

The new method of detecting arc is based on the selection of the best part of the arc after some preprocessing operations on the image like smoothing, binarization, and the edge detection. This task is performed using 3 points designated along the circular arc curve, which will determine a circle ROI external to the circular arc.

After the selection of the best part of the arc, the least squares method is applied to it in order to find the best circle which can fit the arc. The radius and the center point are then obtained. The distance between the radius and the points of the arc which are out of the best part is used to determine the two ending points of the arc.

III.1. Selection of the best Part of an arc using 3 points

The best part of the arc means the part in which all the points are lying on the circular shape. It excludes the points which vary from the circular shape.

The best part of the arc is obtained using 3 points designated by the user along the arc. The 3 points must be designated in a such a way that they show automatically the orientation of the arc.

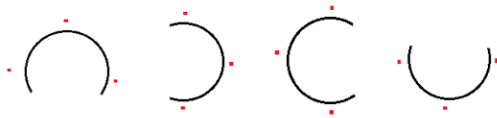


Figure 2. Illustration of how the 3 points indicate the orientation of the arc

From the 3 points, we made an algorithm for calculating a circle ROI passing through them. The circle ROI and its center we can have the space containing the best part of the arc

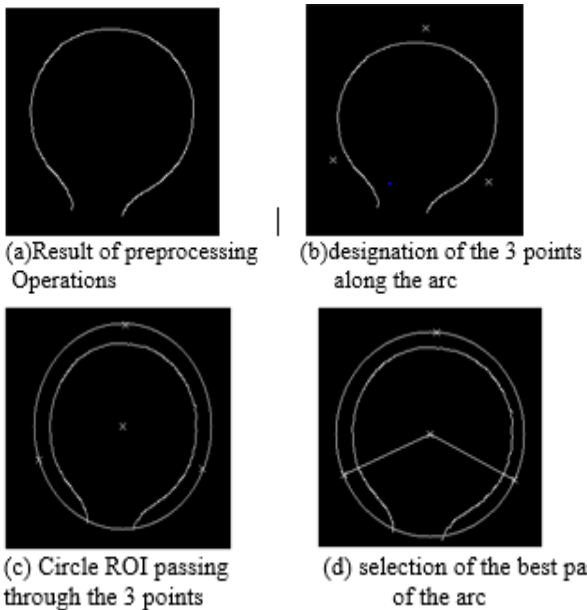


Figure 3. Examples of the selection of the best part of the arc

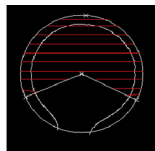


Figure 4. The space containing the best part of the arc (red)

From this example, the space containing the best part of the arc can be shown in the following image

III.2. Detection of the two ending points of the arc

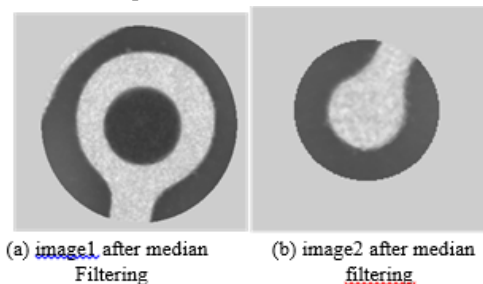
The 2 ending points of the arc are calculated by the difference between the radius of the circle fitting the arc and all the points of the arc which are not in the best part of it. If the difference is equal to a certain value fixed by the user, then the ending points are detected

IV. Experimental results

The analysis are performed on a core(TM) i7 2.80GHZ computer with Windows 7 as Operating system using Visual studio 2013 and c++ as language.

The results of each step of the process of arc detection can be explain as follow:

1. A color image is converted in a grayscale image
2. A median filter is used to remove some noises on the circular arc. In the filtering we used a small window(3*3) in order to remain with the real size of the circular arc
3. A binarization of the result of the filtered image is proceeded.
4. The new method for selecting the best part of the arc is applied
5. A simple least squares is applied to the best part of the arc to find the best circle to fit the arc. The radius and center are obtained.
6. The two ending are detect by comparing the radius and the others points of the arc out of the best part.



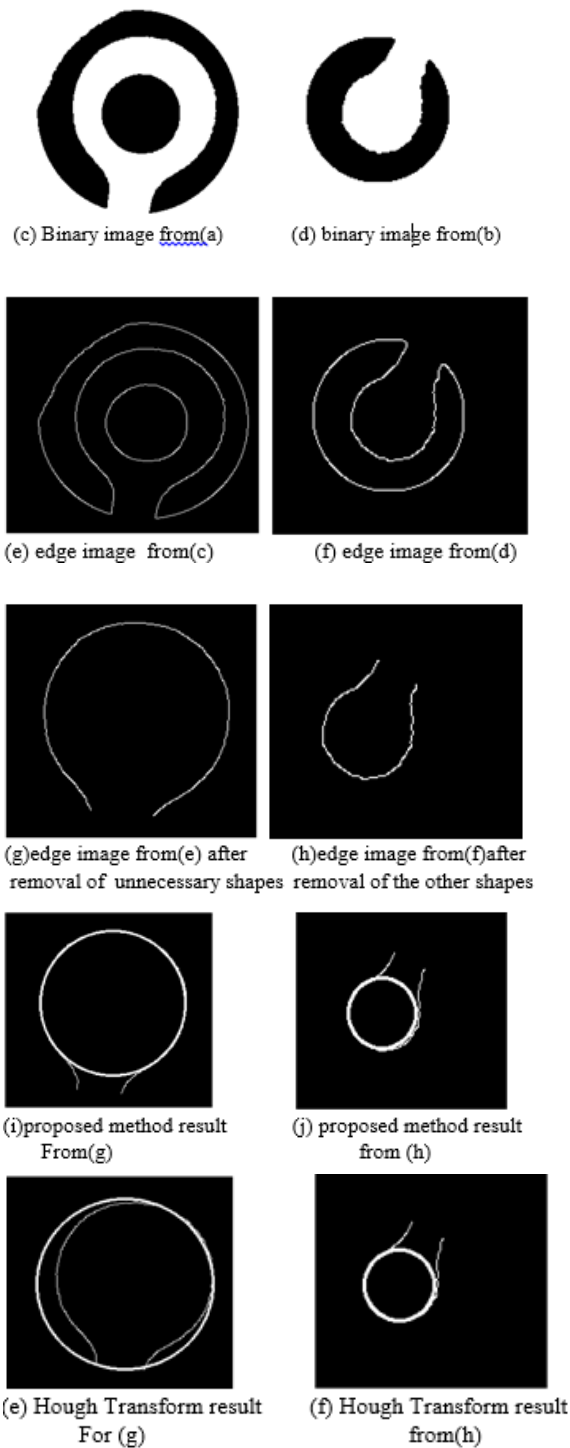


Figure 5. preprocessed images and results of arc detection by the proposed method and by hough transform method.

Table 1: Center position and radius in the different images by 2 ways

	Proposed Method		Hough Transform	
	Radius	Center point	Radius	Center point
Image1	86	(506,167)	75	(495,175)
Image2	29	(318,37)	31	(321,39)

This method of detecting arcs will allow to find in accurately way the circle parameters which fits the best the arc.

V. Conclusions

In this paper, a new approach of detecting arc in images is presented. This method improves the arcs detection in images by selecting the best part of the arc using 3 points designated along the arc and ignoring all the others data points which tend to vary from the circular shape.

The best part of the arc is then applied to the least squares method. The experimental results demonstrate that the proposed method can assure the high accuracy in finding the circle to fit the best the arc comparatively to the Hough transform method. The two ending points are also detected by the proposed method

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