

Extract Circular Object by tracing Region Boundary and using Circularity Measure

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Abstract - Circularity measurement is defined as to explain how close an object should be a true circle. It is called roundness. Circularity measurement is a 2-Dimensional tolerance that it controls the overall form of a circle ensures it is not too oblong, square, or out of round. Circularity measurement essentially make a cross section of a cylindrical or round feature, and it also determines if the circle formed in that cross section is round object. Circularity measurement specifies the form of the surface in a specific area it needs to be considered when it calculates a statistical tolerance stack. It will skew the statistical tolerance slightly deeper, and it should be considered since parts are rarely perfectly circular. It focuses on the design of effective method that computes measurement of circularity of a part of a digital boundary. An existing circularity measurement of a set of discrete points, which was used in computational methodology, was extended to the case of part of digital boundary. From a single digital boundary, two set of points is extracted so that the measurement of circularity computed from these sets is representative of the circularity of digital boundary. So, the computation consists of two steps. First step is defined as the inner and outer sets of points are extracted from the input part of a digital boundary using digital geometry tools. Next step is defined as the measurement of circularity of these sets is computed by using classical tools from computational geometry. In this paper It find a circular object to trace region boundary using circularity.

Key Words: Object detection, Identifying round object, Detect circular object, Region boundary, Trace boundary.

1. INTRODUCTION

Shape is a powerful visual cue for recognizing objects in images, segmenting images into regions corresponding to individual objects. To exploit circularity information, so detect boundary information for image. In image processing a digital binary image can consist of only two types of pixels, first pixel is the region pixels and the second pixel is background pixels. The region pixels will essentially capture the information about object. The boundary pixels are the region pixels; it is defined by their connectivity with the background pixels. In a digital binary image the number of boundary pixels is far less as compared to the region pixels. However, the boundary pixels capture the information about extent and geometry of the region concisely. It is more efficient to manipulate region information using boundary. These

properties will make boundaries an attractive and economical representative of objects in shape analysis.

2. BOUNDARY TRACING

Boundary-based techniques and thus Boundary descriptors are used in wide range of applications. The boundary descriptors require an ordered set of connected pixels (in clockwise or anticlockwise sense) which define the boundary of the object. The process of obtaining an ordered set of boundary pixels is known as boundary tracing or following. We will restrict ourselves to boundary tracing in binary images. It explicitly states the ambiguity in boundary tracing depending on starting pixel and the direction chosen for first step.

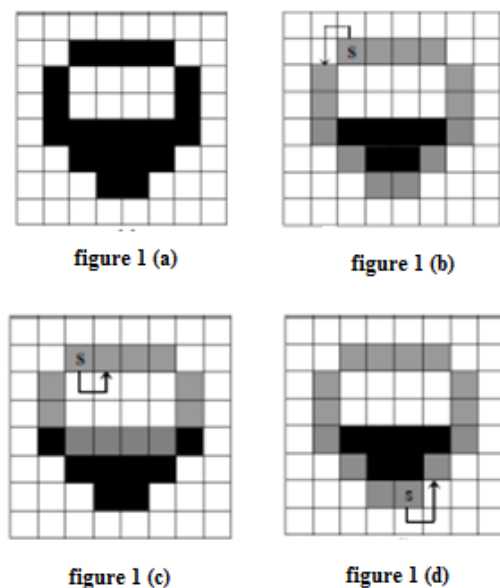


Figure 1: Boundary tracing

Consider Figure 1 (a). This figure is input to boundary tracing algorithm. Let the input "direction of tracing" be anticlockwise. The starting pixel for the tracing is indicated in Figures 1 (b) and (c), by "s". For both Figures, 3 (b) and 3 (c) the starting pixels are identical. However, direction chosen for the first step is "North" for Figure 1 (b) and it is "South" for Figure 1 (c). The traced boundaries are indicated using a grey shade. It can be observed that in Figure 1 (b) external boundary is traced, whereas in Figure 1 (c) internal boundary is traced. Also actual direction of tracing the boundary is

different in these figures (although the direction of search in the neighborhood is same, anticlockwise). In Figure 1 (d) the starting pixel as indicated by “s”, is different from that in Figure 1 (c). However, direction chosen for first step is same and is “South”. It is observed that in Figure 1 (d) external boundary is traced as against the internal in Figure 1 (c). Also the actual direction of tracing is different in these two figures.

2.1 The Traced boundary

For identical inputs the traced boundary should be same in terms of contents (pixel locations) and direction (order in which the pixels are traced). This condition enables the next step which is shape description.

2.2 Starting pixel

There is a requirement for identifying a starting pixel which satisfies a certain specific condition. The specific condition satisfied by the starting pixel should be useful to initiate the boundary tracing. There may be multiple pixels on the same boundary that satisfy the condition. If only the starting pixel is changed, the traced output boundary will change. However, the change should be limited to shift in locations by a constant number considering wrap around.

2.3 Locating starting pixel

There should be a method to locate a starting pixel. There should be adequate justification that the method indeed locates the starting pixel.

2.4 Open boundaries

There may be only open boundaries like in thinned ‘X’ or they may be connected to a closed boundary, like in thinned ‘P’. The algorithm should be able to handle these situations.

2.5 Terminating condition

Certain segments of the connected object may get repeated although in reverse order. However, the algorithm should terminate only when the whole sequence is going to be repeated.

3. BOUNDARY CONNECTIVITY

Boundary connectivity is defined as connectivity between pixel present work uses two types of connectivity; 4-way connectivity and 8-way connectivity. In order to avoid connectivity paradox, the boundary pixels are assumed to be 8-way connected (or simply 8-connected) and the background pixels are 4-way connected (or simply 4-connected). This assumption implies that in a binary image, the boundary pixels are those region pixels which are 4-connected with the background. To trace a boundary is to locate an 8-

connected path of boundary pixels in a particular order (direction of tracing). A boundary in general can be considered as comprising open and closed subsections. An open boundary is an 8-connected (open) path of region pixels which are 4-connected with the background. A closed boundary is an 8-connected closed path of region pixels which are 4-connected with the background.

4. INTERNAL AND EXTERNAL BOUNDARY

There are going to be binary images with internal and external boundaries. When the boundary thins to single pixel width, there are common pixels between both these boundaries (Figure 1 (a)). It is also possible that a starting pixel is one of these common pixels. In such a case one can trace both the boundaries from the same starting pixel. Hence it should be possible to specify which of these boundaries is to be traced.

4.1 External boundary

An external boundary is an 8-connected path (open or closed) of region pixels which are 4-connected with the external background pixels. For closed external boundary of a convex region, the “order” or “sense” or “direction” of tracing can be described as clockwise or anticlockwise. We note that when the region is not convex the sense may differ in different segments. For an isolated open boundary we may have to describe the sense by “forward” and “reverse”. It is possible that the external boundary may coincide with an edge of the image at certain locations. Secondly, if the image has multiple unconnected objects, the processing can be done considering one object at a time.

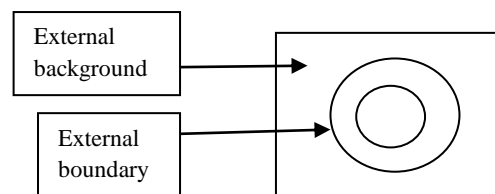


Figure 2: External boundary

4.2 External boundary tracing

Tracing external boundary when starting pixel is a convex corner. Let the scanning be initiated from a corner of a rectangular image. The pixels adjoining the edges of the image are 4-connected with the edges. The scanning visits the pixels in a 4-connected manner. Therefore, all the background pixels visited till the first region pixel is encountered, are external background pixels. Let the first encountered region pixel be the starting pixel. It is 4-connected with the external background pixel(s) and hence, is a pixel on the external boundary of the object. Therefore, the external boundary can be traced from the located starting pixel. While

initiating the tracing it is not known whether the boundary is “open” or “closed”. This information can be derived only after the boundary is traced. However the located starting pixel is either a convex corner or an end of an open boundary.

4.3 Internal boundary

The internal background pixels are 4-connected among themselves and they cannot be connected to any edge of the given image, using a 4-connected path of background pixels. An internal boundary is an 8-connected path (open or closed) of region pixels which are 4-connected with the internal background pixels.

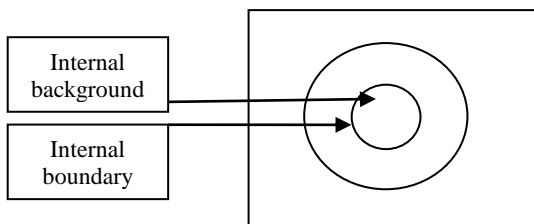


Figure 3: Internal boundary

5. CIRCULAR OBJECT

Circular shapes consist of a curved line that completely encloses with a space and is the same distance from the center at every point. The shape of circle is circular. Following figure is the example of circular object.



Figure 4: Circular object

6. CIRCULARITY MEASURE

Circularity measure is to define the degree to which a shape differs from a perfect circle. The new measure is easy to compute and, being area based, is robust-e.g., with respect to noise or narrow intrusions. Also, it satisfies the following desirable properties: it ranges over (0, 1) and gives the measured circularity equal to 1 if and only if the measured shape is a circle. For perfect circle circularity measure will be 1 and everything that deviates from that is rather not a circle.

6.1 Area and perimeter

Area – The total number of pixels that an object occupies. This pixel count can be calibrated to real world dimensions.

Perimeter – The distance around the outside edge of the object. Diagonal measurements are weighted accordingly. This can also be calibrated.

7. STEPS IN CIRCULARITY MEASUREMENT:

Circularity measurement is used to explain how close an object should be to a true circle. It is called roundness. Circularity measurement is a 2-Dimensional tolerance that it controls the overall form of a circle ensures it is not too oblong, square, or out of round. Circularity measurement essentially make a cross section of a cylindrical or round feature and it determines if the circle formed in that cross section is round object. Circularity measurement defines the degree to which a shape differs from a perfect circle. Circularity measurement can have two values (0, 1). Where 0 is the value, which refer an object in an image is not been a circular While 1 is the value, which refer an object in an image is a circle. Circular object detection can have two steps such as step 1 and step 2. Step 1 contain four methods such as Get image, Threshold the image, find boundaries for an image and Fill boundary that have gap. Second step in circularity measurement contain four methods such as Calculate circularity measurement, Get metric value for each object, Find object value that equal to 1 and Display resultant image. Circularity measurement can have the following steps are shown in the following diagram:

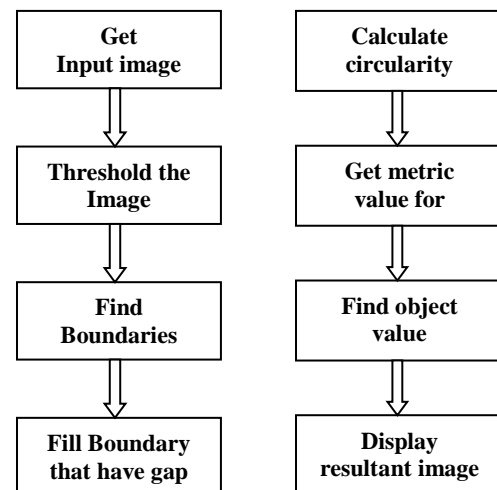


Figure 5: Circular object detection step 1 and step 2

7.2 Threshold the image

1. First RGB image is converted to grayscale image using function `rgb2gray ()` function.
2. Convert RGB color image to binary image in order to prepare for boundary tracing.
3. Convert this grayscale image to binary image (Black and white). This is done by using function `im2bw (I, level)`.
4. The Resultant output image will replace all pixels in the input image with luminaries greater than level with the value 1(white) and it also replaces all other pixels with the value 0(black).

7.3 Find Boundaries for an image

1. Trace region boundaries in binary image using boundary tracing function.
2. This function traces the exterior boundaries of objects, as well as boundaries of holes inside these objects, in the binary image.
3. Boundary tracing function also descends into the outermost objects (parents) and traces their children (objects completely enclosed by the parents).
4. Image must be a binary image where nonzero pixels belong to an object and 0 pixels constitute the background.

7.4 Fill Boundary Gap

1. Fill boundary gap is the next step after boundary finding. In this method we will fill holes in them circle.
2. Next step is to remove all objects containing fewer than 30 pixels. Fill any holes, so that region property can be used to estimate the area enclosed by each of the boundaries.

7.5 Calculate circularity measure

1. Estimate each object's area and perimeter. Use these results to form a simple metric indicating the roundness of an object:

$$\text{Metric} = 4 * \pi * \text{area} / \text{perimeter}^2 \quad \dots (1)$$

2. This metric is equal to one only for a circle and it is less than one for any other shape. The discrimination process can be controlled by setting an appropriate threshold.

7.6 Get metric value

Get metric value is used to get circularity measure for each object. All objects in images can have circularity measure metric. We can get this metric for all objects in an image to detect circle.

7.7 Find object value equal to 1

Find object that can have circularity measure equal to 1 is declared as circular object.

7.8 Display the Resultant image

Finally display the resultant image.

8. REVIEW OF CIRCULARITY MEASURE

A circularity measure recommended by the American Society for Testing and Materials (ASTM) is to compute circularity measure is ASTM circularity. Although this circularity measure has been applied using different names, in this work it will be called roundness factor. This circularity measure is based on the area of a circumscribed circle with the same maximum diameter of an object and is defined as

$$RF = 4\text{Area} / \pi F^2_{max} \quad \dots (2)$$

Where F^2_{max} is the maximum Ferret's diameter, the longest distance between two points along the boundary of an object in the image. The main disadvantage in using this parameter consists in small variations in shape, sometimes seen as fine peaks, which strongly affect the results of roundness measure, even when the object being evaluated has a well-defined circular shape in an image. In such cases, the Ferret's maximum diameter is larger than the diameter of the inscribed circle. It was demonstrated in these parameters such as Ferret's diameter differ up to 30 percent within the image analysis tests of various image processing systems.

The radius ratio measurement is based on the definition of a circle. It computes proportion of minimum and maximum radii of the object, as follows:

$$RR = r_{bmin} / r_{bmax} \quad \dots (3)$$

Where r_{bmin} is the minimum radius from a border point to the center of the border, and is the maximum radius. The main disadvantage of this circularity measure is that proportions of shortest and longest radii don't provide sufficient information to characterize the roundness and it can affect by pixel aberrations as well.

The mean roundness measurement is based on the theory of mean deviation. It will calculate the sum of the absolute differences between radius of each border pixel and average radius. This measure is defined as

$$MR = \frac{1}{n} \sum \frac{\bar{r}_b}{|r_j - \bar{r}_b| + \bar{r}_b} \dots (4)$$

Where r_b is the average radius from the border points to the center of the object and R_j is the radius of border point to the center of the border. The center of an object is usually expressed as expected point from all border points. This expression is valid only if the expected value is equal to mean. Therefore, average is highly correlated for closed to circular objects. Consequently, this circularity measure is not reliable to assess the roundness of irregular and partial shapes, and asymmetrical distributions.

9. REVIEW OF RESULT ANALYSIS

Circularity measurement is used to identify a circular object in an image. Circularity measurement can have the following result analysis in practical experience. Review of result analysis for circularity measurement is shown in below tabular column.

Table 1. Review of Result analysis

Training image	Testing Image	output
50	50	43

10. CONCLUSION

In this paper, new quantitative methods to estimate the circularity of digital objects were introduced. The proposed measure takes into consideration the dominant geometry of the objects and avoids the use of parameters such as area, perimeter and diameter. In this experimental analysis, we showed the robustness of the proposed circularity measure in different scenarios including artificial controlled scenarios and a real application; in particular, an analysis of circularity measure of a specimen of graphite was carried out. From the results of the present study, we concluded that the proposed circularity measure represents a good measure to quantify the circularity because it satisfies the following conditions: (1) circularity measure ranges within [0,1], where 1 is scored only by a perfect circle, (2) it is invariant with respect to resolution, so the circularity measure becomes independent of the equipment, (3) it is tolerant to circularity shape variations, (4) It is tolerant with respect to noise or to narrow intrusions on image, (5) it can be easily compared to human perception, and (6) it is easy to compute. In this paper, a circularity measure has been defined for open or closed digital curves. Because an existing circularity measure of a set of discrete points, which is some-times used in computational

methodology. It is extended to the case of digital data. Once the minimum area annulus, such that the outer disk contains all the points of the digital curve and the inner disk does not contain any background point is computed, the circularity measure is defined as the squared ratio between the inner and outer radii. Because we consider two sets of points, the problem we deal with is more general than the usual problem of finding a minimum area annulus enclosing one set of points. The geometric interpretation of this computation, an algorithm in $O(n \log n)$ that only uses classical tools of computational geometry is derived. Moreover, an optimization using only local rules is proposed so that the worst-case complexity reaches $O(n)$ in the case of convex digital curves. This work proposed for robust circular object detection. Circularity measure is robust to occlusion, noise, and small shape deformations and it can detect multiple circular objects in a single image. With the motivation of obtaining accurate measurement of circular objects, it presented a new method of automatically detecting a circular object in images: we detect a circle using circularity measurement, iterative improve the fit, remove outlier pixels and search for boundary. Using real images, we demonstrated that our method can detect partially occluded circular objects within a reasonable time.

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