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Classification of Image Corner Point Detection Systems to Identify a Shape

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abstract

Study This contains about the detection of circular object images. The circular object tested is the moon image object, the moon image was chosen because the moon image has various moon shapes, namely the full moon, half moon and crescent moon. To detect the shape of the circular object image, several stages are carried out by starting the image segmentation process. (1) The segmentation process using the bi-level thresholding method makes the image black and white, (2) after that the image is repaired with the morphological process of the opening and closing methods. (3) For training data, the shape extraction process is carried out, namely the circular nature of the object (circularity) to determine the roundness of an object. For the testing process, the same process is also carried out as the process of obtaining circular image detection.

abstract

Kajian ini berisi tentang pendeteksian citra objek melingkar. Objek melingkar yang diujikan adalah objek citra bulan, citra bulan dipilih karena citra bulan memiliki berbagai macam bentuk bulan yaitu bulan purnama, bulan sabit dan bulan sabit. Untuk mendeteksi bentuk citra objek melingkar dilakukan beberapa tahapan dengan memulai proses segmentasi citra. (1) Proses segmentasi menggunakan metode bi-level thresholding menjadikan citra menjadi hitam putih, (2) setelah itu citra diperbaiki dengan proses morfologi metode opening dan closing. (3) Untuk data latih dilakukan proses ekstraksi bentuk yaitu sifat lingkaran dari objek (circularity) untuk mengetahui kebulatan suatu objek. Untuk proses pengujian juga dilakukan proses yang sama seperti proses perolehan deteksi citra melingkar.

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ACM Computing Classification System (CCS)

EBSCOhost

Communication and Mass Media Complete (CMMC)

1. Introduction

The detection of circular objects is applied to moon images, which exhibit various phases, including the full moon (a perfect circle), half moon, and crescent moon. This study explores the process of detecting these circular shapes through a series of steps aimed at improving detection accuracy. Previous studies have utilized shape extraction techniques, particularly the circularity method, to analyze images of rice for the identification of good rice varieties. The circularity descriptor defines a perfect circle with a value of 1, while more elongated shapes approach values closer to 0 (Adnan et al., 2019). Similarly, leaf shape analysis employs shape extraction techniques that include descriptors such as rectangularity, circularity, sphericity, eccentricity, axis ratio, diameter, complexity, and perimeter. Additionally, the incorporation of color and texture features in feature selection has proven effective in enhancing the accuracy of shape detection, as these features are often correlated (Valimmal et al., 2022).

Building on the findings from these studies, this research aims to conduct a series of experiments combining shape feature extraction with segmentation techniques, as well as morphological opening and closing operations, to optimize the performance of circular object detection in image analysis. Bi-level thresholding segmentation is used to separate circular image objects from their background by applying intensity values. In this technique, pixels with intensity values smaller than a predefined threshold are classified as one area, while those with values greater than or equal to the threshold are grouped into another area (Abdul Kadir, 2019). The calculation for bi-level thresholding segmentation is defined by Equation 1, where 'TTT' represents the intensity threshold, resulting in a binary image where pixels are either black (intensity value 0) or white (intensity value 1). This segmentation method facilitates the distinction of objects within an image, as illustrated in Figure 1.

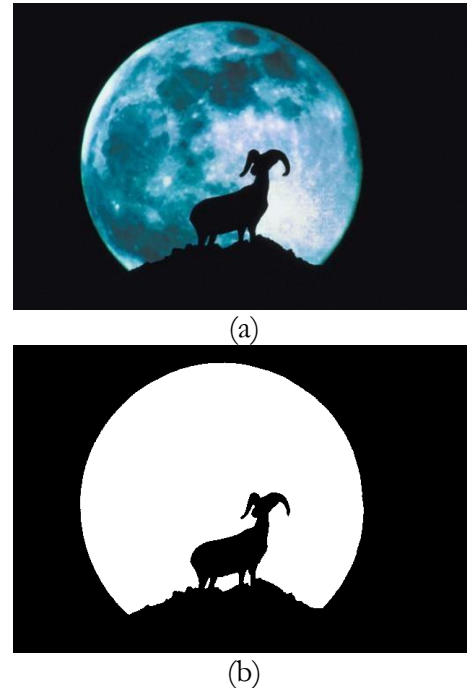


Figure 1. (a) Input image, (b) bi-level thresholding segmentation results.

The morphological process is applied to binary (black-and-white) images to alter the structure of an object's shape. This process relies on two fundamental operations: dilation and erosion. Additionally, two important operations derived from these basic operations—closing and opening—are widely used in image processing (Abdul Kadir, 2019). The opening operation involves an erosion step followed by dilation using the same mask element. This technique is beneficial for smoothing the contours of an object and removing small pixels that do not fit within the mask element (Abdul Kadir, 2019). The opening operation maintains the relative size of the object, although it may eliminate small objects and smooth the edges. On the other hand, the closing operation, which is performed by first applying dilation and then erosion, is useful for smoothing object contours and filling small holes (Abdul Kadir, 2019). Moving on to shape extraction, it involves determining the geometric features of an object. Shape descriptors are sets of parameters that define specific characteristics of an object, which are used to express its features. These features are represented by numerical values that help identify the object (Abdul Kadir, 2023). In circularity shape feature extraction, the process compares the average Euclidean distance from the centroid to the object's edge, normalized by the

standard deviation. This comparison is mathematically expressed in the formulas for the (μR) mean and standard deviation (σR) which are fundamental to extracting the circularity feature, as illustrated in Equations (Abdul Kadir, 2023).

2. Reserch Methode

The system diagram is described to determine the steps of the circular object detection process that will be carried out.

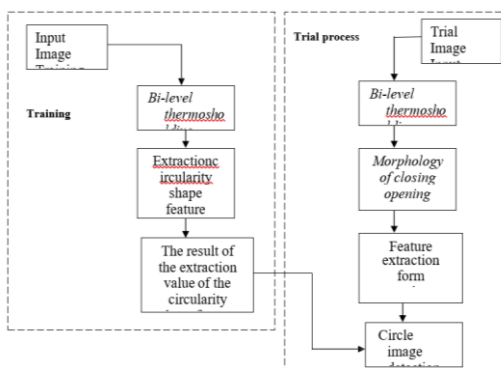


Figure 2. Diagram of the circle image detection system

There are two input images, namely training images and trial images. For training images, they are black and white (binary) circle images and semicircle images which can be seen in Figure 3.



(a)



(b)



(c)

Figure 3. (a) circle testing image, (b) left half circle testing image, (c) top half circle testing image

For the test image, the RGB color image of the moon object is used, while the data for the test is three images of the moon object taken from the internet.



(a)



(b)



(c)

Figure 4. (a) input trial image with code a1, (b) input trial image with code a2, (c) input trial image with code a3

The training image and the reading test image are subjected to a bi-level thresholding process to obtain a binary image so that it can facilitate the process of extracting shape features. For the lower threshold

value of 40 and the upper threshold of 100 using equation 1.



Figure 5. Bi-level Thresholding image results

The morphological process is used for the image testing process to improve image quality. For the morphological process, the first process used is the closing process with the equation 3. After the closing process is carried out with the opening process using equation 2. For each closing and opening process using the mask value 7.



(a)



(b)

Figure 6. (a) segmented image, (b) image after morphological closing and opening process

The circularity shape feature extraction is used to determine the value of the shape feature extraction on a circular image object, so this method was tested on training data, the results can be seen in table 1.

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Table 1. Results of feature extraction of circularity shape Citra Training

Image Name	Circularity Value Results
Circle image	0.9003213
Half image left circle	0.6701525
Half image top circle	0.681084

The results obtained using equation 4, equation 5, and equation 6 produce values that are close to 1, while for image a2 and image a3 where the circle is half-shaped, the values obtained are greater than 0.5. The same thing is done for the test image, but it is possible that the test image has more than one object, so for the object to be detected, the white object is selected and compared with the training object.

3. Results and Discussion

Results

In testing the detection of circular objects on moon images using shape feature extraction, this was carried out on three test images which produced the results in Figure 7.



Figure 7. Results of roundness detection on the moon image (image name a1)

From figure 7, the results of 3 detections on the moon image are obtained which have one perfect circle shape and two images which have a semicircle shape. The results of the Circle object detection image can be seen in table 2.

Table 2. Circle Object Detection Results

Test Image Name	Detection Results
Image a1	3
Image a2	2
Image a3	0

For image a2, the detection result of 2 is due to the imperfect morphological results, which should only detect 1 circular object, the same as image a3 which is caused by another object in the middle of the circular object, so that during the morphological process the circular object is not perfect.



Figure 8. Results of the morphology of the a3 image object

Figure 8 shows the results of a circle that was subjected to the morphological process so that when the circularity feature extraction process was carried out, it obtained a value of 0.3880317, which is far from the training data value.

Discussion

The results of this study on circular object detection in moon images indicate that the extraction of circularity features works effectively for detecting objects with clear circular shapes, such as the full moon. In the test with image a1, three objects were detected, two of which were semi-circular and one perfectly circular, which shows that the method can handle nearly perfect shapes well. This aligns with Stegmann and Gomez (2002), who suggested that statistical shape analysis using geometric descriptors like circularity is highly effective in identifying symmetric objects. However, the detection accuracy decreased for images a2 and a3. In image a2, the morphological process failed to completely remove

noise, resulting in the detection of two objects instead of one. This highlights the limitations of morphological operations in removing unwanted small objects or noise, as noted by Abdul Kadir (2019). In image a3, no circular objects were detected due to interference from other objects that disrupted the circularity extraction process, which supports the findings of Valiammal and Gethalaksmi (2019), who emphasized the challenges of feature extraction when objects overlap or are affected by external disturbances. While the morphological operations, such as opening and closing, were helpful in refining the image, their effectiveness was limited when objects overlapped or were obscured. Furthermore, despite the change in position, the circularity values for semi-circular shapes remained consistent, indicating that the position of the object does not significantly impact the circularity extraction, in line with Adnan et al. (2022), who found that object orientation had minimal effect on feature extraction results.

However, when multiple objects were present, as in image a3, the results were less accurate, highlighting the need for better noise reduction and object separation techniques. The circularity extraction produced values close to 1 for perfect circles and values near 0.5 for half-circles, which is consistent with the theoretical understanding that perfect circles should yield a higher circularity score (Adnan et al., 2022). Nevertheless, when objects overlap, as shown in image a3, the circularity score dropped significantly, demonstrating the impact of object interference on detection accuracy. To improve detection accuracy, future work could incorporate advanced image processing techniques such as smoothing filters or alternative methods like Hough Circle Transform or convex hull methods, which could better handle overlapping objects and reduce detection errors (Stegmann & Gomez, 2002). These methods would enhance the robustness of circularity extraction, particularly in the presence of noise and overlapping objects.

4. Conclusion

Based on the research conducted and the trials carried out, several conclusions can be drawn. First, the

morphological process significantly influences the results of circularity feature extraction. The application of morphological operations, such as opening and closing, helps refine the image and enhances the detection of circular shapes. However, the effectiveness of these operations can be impacted by the presence of noise or overlapping objects. Second, the position of the image does not significantly affect the value of the circularity feature extraction. For example, the left semicircle image produced a feature extraction value of 0.6701525, while the upper semicircle image yielded a value of 0.681084, showing that the circularity extraction method remains relatively consistent regardless of the object's orientation.

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