Canny and Morphological Approaches to Calculating Area and Perimeter of Two-Dimensional Geometry

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Abstract— **Calculating area and perimeter in real-world conditions has its challenges. The actual conditions include applications in the medical field to measure the presence of tumors or the condition of human organs and applications in geography to measure specific areas on a map; applications in architecture often calculate the area and perimeter of buildings, interior design, exterior design, and other uses. Technology makes it easier to perform automatic calculations by applying mathematical methods with computer vision techniques. The Canny method is usually used, which is good enough for detecting edges but not sufficient for measuring irregular geometric shapes. This paper aims to calculate the area and perimeter of a geometric shape using the Canny method and geometry and compares the results of the two types of methods. Data samples in various forms are used in this study. Calculating area and perimeter using the Canny method involves obtaining the length (X, Y) of the RGB image converted to HSV. Edge detection values are used to calculate the area and perimeter of objects. The morphological method uses binary image input as input data. Then proceed to the convolution process with structuring and calculating the area and perimeter of objects. Based on the research results, calculating the area and perimeter of objects is more effective using morphological methods than the Canny method, with an average comparison of more than 1.03%. However, the level of accuracy is affected by the selection of structuring elements (strels) which must be optimal and global.**

Keywords— **Canny, morphology, area, perimeter, geometry.**

I. INTRODUCTION

The development of information technology in this era makes many innovations that impact the daily activities of modern society. One of the many highlighted is Computer Vision technology in images. This technology is widely used to process digital images to identify a particular object, either 2D or 3D. Implementations regarding the area and perimeter of an object can also be used for actual conditions, such as: in the medical field to measure the presence of a tumor or the condition of human organs; in the field of geography, it is used to measure specific areas on a map, and also other uses, in the architecture field, similar uses can be found in interior and exterior design predictions. In the civil field, the actual measurement of building parts also needs to be done before the construction process takes place, as well as in other fields. An example that we can see is that we often find square, rectangular, round, or circular shapes. There is currently no tool to calculate the area of an object practically for Measuring the area of a shape, and most still use the manual method with a ruler. To determine the extent. Using Image Processing, you can process images as samples of objects whose area you want to know so that you can determine the length and width (size). The input object used can be an image in jpg or png format, which then image processing retrieves data for each object that needs to be examined according to the original area and then enters it in the program, and then performs the Image Processing process

One method that can measure an object's area and perimeter is edge detection [1]. The edge pixel connection of an object can answer the problem regarding the perimeter value of an object. Other things, such as calculating the area of an object, can be calculated using the total number of pixels within the object edges of a digital image.

One of the edge detection methods is the Canny method [2]. This method performs well on the edge detection of various types of objects. However, the Canny method does not show good results on edges with low ash scales [3]. The morphological approach solves the problems of the Canny edge detection method [4] to produce better edge detection for further processing in digital image information retrieval.

This paper proposes a system that automatically calculates the area and perimeter of various two-dimensional geometric shapes to test the reliability of the canny and morphology methods.

The system calculates area and perimeter using the Canny method, obtained in digital image processing starting from the conversion of RGB to HSV images, then detecting the edges of an object with the Canny method. After object detection, the following process measures the object's area and perimeter with a formula according to the object's shape. Calculating the area using the Morphology method uses the concept of image as a form of a set with elements in binary 1 or 0. Furthermore, binary elements are processed by a convolution process so that the results are used for edge detection to calculate the area and perimeter of objects.

For evaluation, we tested ten objects of various shapes to measure their area and perimeter using the Canny edge detection method. Meanwhile, for calculating the area and perimeter of objects using the morphological method, 12 objects with various shapes were also used

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A. Previous Research About Canny Method for Area or Perimeter Calculation

Fujimoto, et al [5] used Canny edge detection in combination with other methods for two-dimensional viscous/inviscid flows. The result is Canny edge detection also contributes to helping detect shocks even in viscous flows.

Ratsakou A, et al [6] conducted research with canny edge detection to reproduce a signal. The results of this research show that the reconstruction is entirely satisfactory compared to the original geometric drawings.

Huang, Meiling, et al [7] dan Gandhi, B.S et al [8] used the canny detection method to detect the edges of rock objects on the surface of explosion piles. The edge detection results [7] can eliminate noise from blast debris. The result of object detection with the help of the canny method [8] has increased compared to that without the canny edge detection method.

Chen, Dan, et al [9] used canny edge detection to segment focus on 3D images to predict the acute expansion of epidural hematoma. The detection results show good accuracy results.

The Canny edge detection method and other edge detection methods were used in a study conducted by Lu Ye, et al [10] to estimate the exterior design of buildings. The curvature condition of the building with all kinds of conditions was tested in this study. The result canny edge detection method produces the best results compared to other detection methods

Images with various complexities were processed using the Canny edge detection method combined with the circular Hough Transform modification method in a study conducted by Meng Y, et al [11]. The result is that various objects can be identified with efficient processing time.

Saha Tchinda B, et al [12] handle retinal image segmentation with several edge detection techniques such as the Canny method. The output of the edge detection method will be used as an attribute as part of the neural network input. The segmentation results show pretty good performance compared to the other segmentation methods discussed in this study.

Zhang Z, et al [13] and Hu T, et al [14] use the support of the Canny edge detection method to solve image processing problems such as the detection of asphalt pavement thickness[14] and also the detection of quality of cross-sectional fiber image [13].

B. Previous Research About Morphology Method for Area or Perimeter Calculation

Firoz R, et al [15] used morphological transformation to enhance the medical image. This research results in the level of image contrast automatically being set better to make it easier to read the patient's condition as represented by the medical photo images they have.

Li C, etl al [16] reduced the burden of manually inspecting trains by creating an automatic system for monitoring trains with image processing monitoring the railroad perimeter.

Forssen J, et al [17] performed calculations and morphological analysis of city layouts such as roof and facade vegetation. More specific forms of observed objects, such as grid maps of sidewalk areas, yards, and others, are observed in this study. The results of the research analysis showed quite good and careful results.

Wang X, et al [18] analyzed the morphological image of biofilm evolution. The prediction accuracy results are quite good and appropriate compared to real conditions.

Bhaskar D, et al [19] retrieved the morphological information of pathological objects to be included as input for unsupervised cell classification. The classification results obtained from this study were quite good.

Zhang J, et al [20] used digital image processing techniques to find information from microorganisms. The condition of these microorganisms can vary, even to the point where they break down into small parts that require more detailed observation. The intended image processing techniques are morphological methods, segmentation, and others. The results of this study show that the condition of microorganisms can be adequately observed.

Morphological surgery is also related to detecting brain tumors in a study conducted by Morad A, et al [21]. Combined with other techniques in digital image processing and also processed using machine learning so as to get good enough classification results for labeling low-, moderate-stage brain tumors or both.

Leyh J, et al [22] used data regarding a special condition of the human brain called Microglia. Morphology calculations also play a role in detecting existing sample images. The results obtained in this automatic detection are information about microglia that can be adequately extracted so that the medical team can determine the further steps for treating the patient.

Abdulazeez A, et al [23] also used morphology calculations to extract features as input and tested them on several classification methods. The results of morphological calculations show the leaf characteristics observed in this study with good results.

Sharma R, et al [24] Morphological techniques take geometric features from agricultural products. The execution of all methods in this study provides valuable information for follow-up steps for agricultural yields under certain conditions. Physical characteristics such as the weight and volume of agricultural wheat products are the main focus of this research.

C. Previous Research About Calculating the Area or Perimeter of Two-Dimensional Geometry

Kumar V, et al [25] created an automatic system to detect and recognize two-dimensional shape data in conditions that are not too noisy. Edge detection is used to calculate the distance and area of objects.

Santiago-Montero R, et al [26] performed shape analysis and computer vision processes in the medical field to detect size and compactness and determine whether or not there is a hole in an object. Sharma R, et al [27] used a similar technique to determine the size and shape of wheat grains. Li W et al. also calculated the compactness of two-dimensional shapes in a Geographic Information System with a similar technique [28]. The detection results of the earlier parts can be carried out well in this study.

Araujo G, et al [29] have identified representative sandy soil texture parameters. The identification uses digital image processing techniques. The results obtained were then analyzed, and it was found that the method was accurate and efficient for determining the morphological differences of soil particles.

Rabbani A, et al [30] estimated the surface for predicting the permeability of porous rocks. Several rock types are the object of research. The results show that the accuracy of the estimate is well-known.

Shen Y, et al [31] extracted information about geographic maps. Information in the form of lines drawn with specific points on the map. The results of this study are in the form of areas delimited by lines and key corners to help gather the required information.

The sections of the paper are organized as follows: Section I provides a brief introduction to the research. Part II describes the methods used in this study, namely the Canny Edge Detection Method, the Morphological approach, and information about the measurement area and object parameters. Section III describes the results and discussions regarding the implementation, evaluation, and discussion of an automatic area or perimeter calculation results. Finally, section IV describes the conclusions and concludes this paper with future works.

II. METHOD

This method section provides details about the research methods carried out, the materials, and the formulas used in calculating the area and perimeter of the objects in this study. In this study, the calculation of the area and perimeter of geometric figures uses the canny and morphological methods. In the morphological method, area and perimeter calculations use the concepts of gradient morphology and connected components.

A. Size of Geometry

The coordinate method is one of the numerous methods for calculating the area and perimeter of asymmetrical shapes [32]. The breaking up the irregular shape into numerous pieces in the shape of a regular shape, the area of the irregular shape can be determined as the sum of the areas of each component of the regular shape.

The following equations can be used to manually calculate the area and perimeter of a typical geometric shape:

1) Square

$$Perimeter = 4 \ x \ side \tag{1}$$

$$Area = side \ x \ side \tag{2}$$

2) Rectangular

$$Perimeter = 2 \ x \ (length + width) \tag{3}$$

$$Area = length \ x \ width \tag{4}$$

3) Circle

$$Perimeter = 2 \ x \ phi \ x \ radius \tag{5}$$

$$Area = phi \ x \ radius \ x \ radius \tag{6}$$

4) Triangle

$$Perimeter = 1^{st} \ side + 2^{nd} \ side + 3^{rd} \ side \tag{7}$$

$$Area \ x \ base \ x \ length \ 2 = 1 \tag{8}$$

5) Trapezoid

$$Perimeter = sum \ of \ all \ four \ sides \tag{9}$$

$$Area = \frac{Number \ of \ parallel \ sides \ x \ height \ from \ area}{2} \tag{10}$$

B. Canny

John F. Canny created the Canny edge detector in 1986. It uses a multi-step algorithm to identify different edges in images [5]. Even though this edge detection technique is relatively ancient, it is still employed in research since it has become the industry standard. This test measures input parameters or process inputs and outputs or outputs contained in the designed system. Additionally, the stages of image input, the RGB image conversion stage to HSV and canny edge detection stage, the area prediction calculation stage, and around are measured. Then, the results of these measurements are analyzed. When used to identify the edges of objects, the Canny method provides the best edge detection.

C. Morphology

A morphological method sees an image as a collection of (x, y) positions with either 1 or 0. The purpose of morphological procedures is to make a shape (structure) more recognizable [15]. Morphological image processing is done by passing a Structuring Element to an image in a way that is almost the same as convolution. A Structuring Element is typically passed to an image-like convolution when performing morphological image processing. Similar to masks in standard image processing, structuring elements (not morphologically). The morphological operations used in this study's filter operations are:

1) Dilation

Based on the structuring element S used, dilation combines background points (0) to become a part of an object (1). where B is the structural element, and A is the input image.

$$D\ (A, B) = A \oplus B \tag{11}$$

2) Erotion

According to the structuring element S, erosion removes object points (1), so they become a part of the background (0). Operations that can output pixels in images with reduced-object tendencies are thinned out. The original image, which was smaller than the structuring element, will be reduced by the erosion operation, as stated as follows:

$$E\ (A, B) = A \ \Theta \ B \tag{12}$$

D. Morphological Gradient

Dilation and erosion operations are frequently combined to maximize morphological operations in image processing. According to Soille (1999) [33], there are three primary categories of morphological gradients:dilated_image–eroded_image

- original_image – eroded_image
- dilated_image – original_image.

While the eroded image is an eroded image, the dilated image is a dilated image. The first type, dilated image-eroded image, is used in this essay. So that the following formulation of the morphological gradient:

$$MG = (A \oplus B) - (A \Theta B) \tag{13}$$

The internal gradient will make the object's interior boundary sharper, making it stand against the background. In contrast, the object boundary will be darker than the background on an internal gradient. The internal gradient will serve as the mask for the object's internal boundary in a binary image. Morphological gradients can be referred to as edge images because the resulting image emphasizes the object's edge. It happens because the non-edge areas of the object are lost when the thickening and thinning operations are reduced.

E. Proposed Method

The steps for calculating the area and perimeter of objects using the Canny method can be seen in Fig. 1. The calculation phase starts with the data input. This input data is in the form of an image that has extracted the fundamental color values: red, green, and blue (RGB). Then the process continues with RGB conversion to another color space, namely Hue Saturation Value (HSV). Based on the color channels in the HS, object shape detection is done by the Canny edge detection process. After the object edge detection process, the distance or perimeter and the area of the object are calculated. The perimeter or area is calculated by finding the height and width values of each form of the test data object.

Calculating the area using the morphological method as seen in Fig. 2., begins with reading the input data in the form of an RGB image. Then the image is converted into a binary image. The object that is the focus of the test is confirmed to be white. The binary pixel must be inverted first if the color is white. The next step is to search for a connected image component and label the connected component. The area of the object can be obtained by calculating the number of pixels in the connected component that was found earlier.

Figure 1. The stages of calculating the area and perimeter of objects using the Canny method

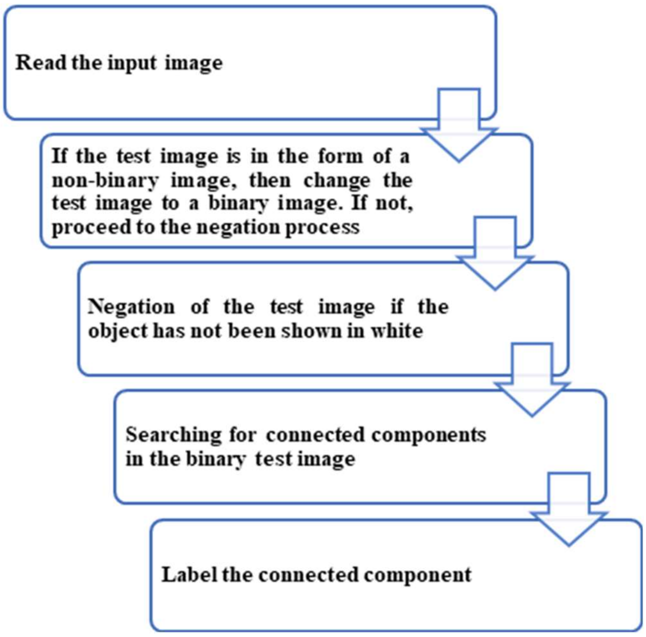


Figure 2. The stages of calculating the area of objects using the Morphology method

Fig. 3 shows the steps for calculating the perimeter of a geometric shape with the concept of gradient morphology using the formula in equation (13). The system will process the first step of image input. Then there is a filtering process to ensure the image is in the form of a binary image. If the color is still not white, then there must be a color image conversion process into a binary image. Inverse or inverting the binary image pixel values must be carried out if the shape object tested is still not white. Before the core calculation process is carried out, it must be confirmed that the strel is used. Later a dilation operation, or erosion operation, is appropriate. Next, the process continues with the search for connected components and labeling the connected components found. Perimeter measurements can be carried out at this stage by calculating the number of pixels that enter the connected component.

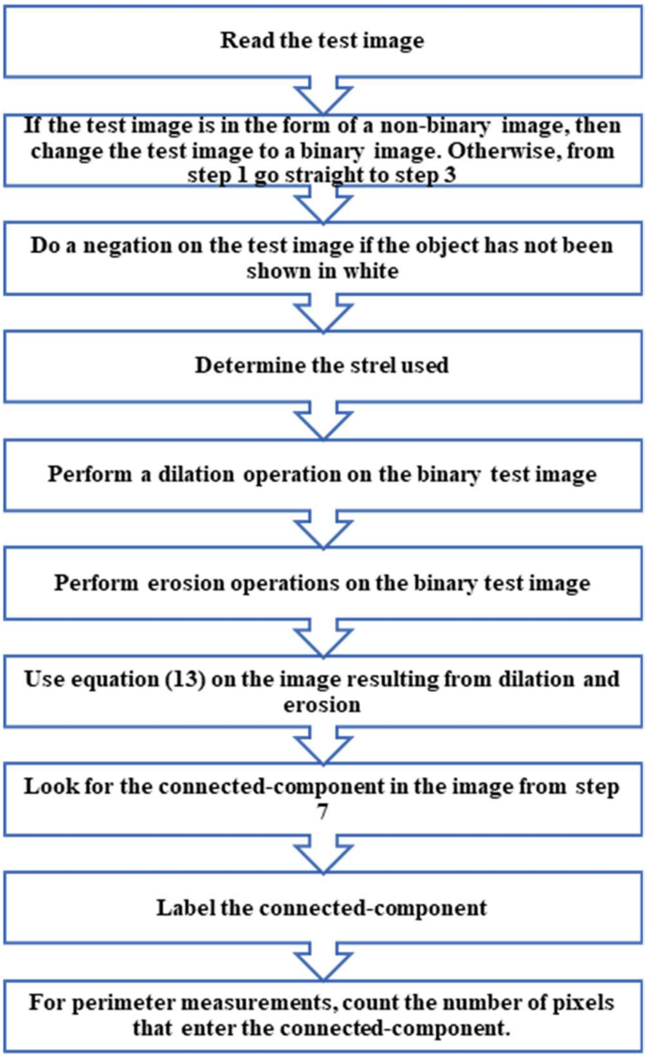


Figure 3. The stages of calculating the perimeter of objects using the Morphology method

III. RESULTS AND DISCUSSION

Section III discusses the results of testing the area and perimeter of geometric drawings. The Canny edge detection method and the morphological method were used in this study. The results of the two methods were compared, and the results were analyzed in this session

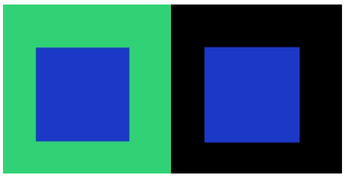
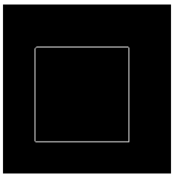
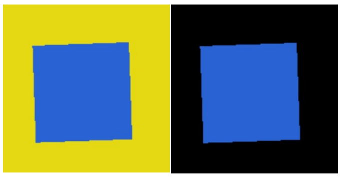
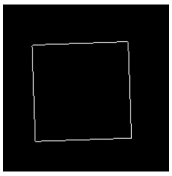
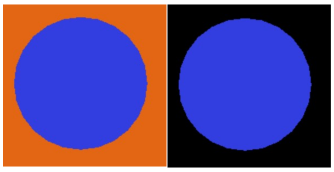
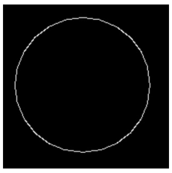
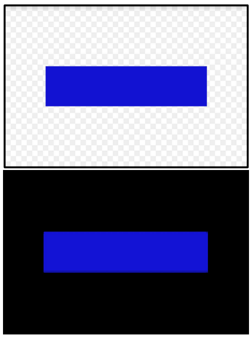
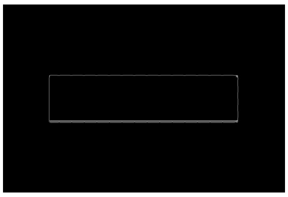
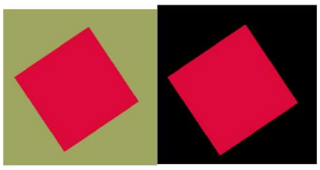
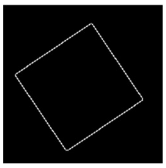
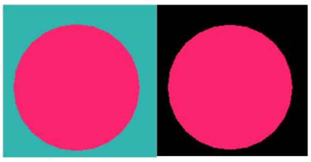
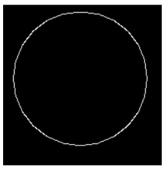
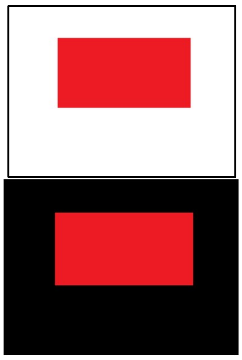
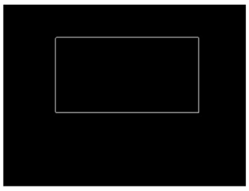
A. Canny Method Result

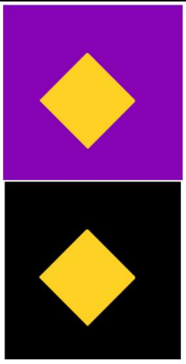
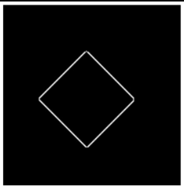
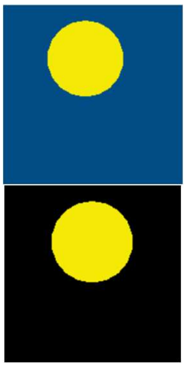
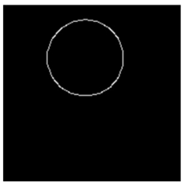
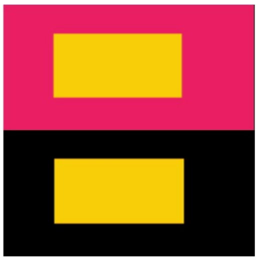
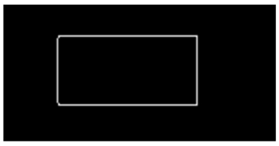
The test using the canny method includes measuring the input or process input parameters and the output or output contained in the designed system and the stages of image capture, the RGB to HSV image conversion stage, and canny edge detection up to the calculation stage. Area prediction is then followed by analyzing the results of these measurements.

Edge detection with the Canny method measures the area and perimeter of two-dimensional geometric objects. The measurement phase starts after the edge is detected. Edges are boundaries for calculating length and width. Later, the process is continued by combining the formula for the area of a two-dimensional shape to get the result.

The sizes of different objects can be known from the sample shapes and colors of different geometric shapes. The result shows that the program can determine the area and perimeter of different object shapes. Table I shows the following the results of testing with the canny method:

TABLE I
CANNY METHOD TEST RESULTS

No. Image	HSV Parameter	RGB and HSV Image	Result	Size of Area and Perimeter
1	**Lower_blue (90,100,145) Upper_blue (120,255,255)**			Area = 8,781 cm^2 Perimeter = 11,853 cm
2				Area = 10,080 cm^2 Perimeter = 12,699 cm
3				Area = 14,600 cm^2 Perimeter = 13,541 cm
4				Area = 63,633 cm^2 Perimeter = 39,845 cm
5	**Lower_red (136,87,111) Upper_red (180,255,255)**			Area = 17,254 cm^2 Perimeter = 16,615 cm
6				Area = 14,600 cm^2 Perimeter = 13,541 cm
7				Area = 20,398 cm^2 Perimeter = 18,996 cm

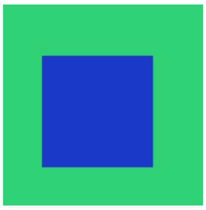
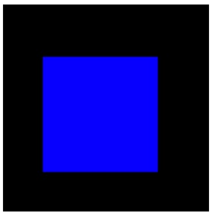
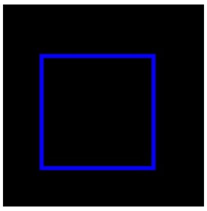
No. Image	HSV Parameter	RGB and HSV Image	Result	Size of Area and Perimeter
8	**Lower_yellow (22,60,200) Upper_yellow (60,255,255)**			Area = 7,791 cm^2 Perimeter = 11,165 cm
9				Area = 3,877 cm^2 Perimeter = 6,978 cm
10				Area = 3,641 cm^2 Perimeter = 8,096 cm

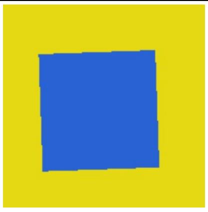
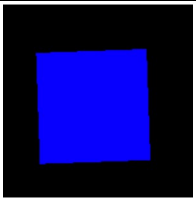
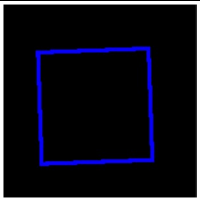
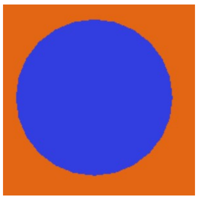
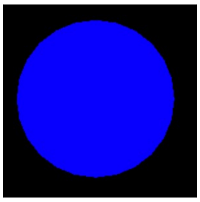
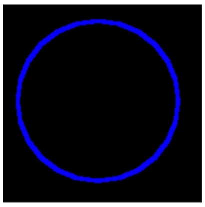
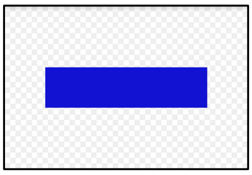
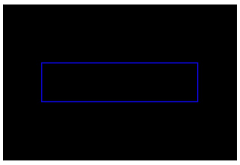
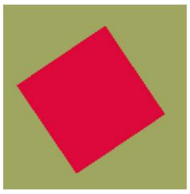
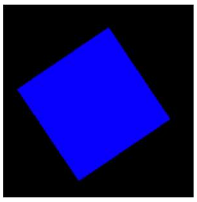
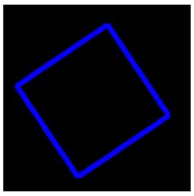
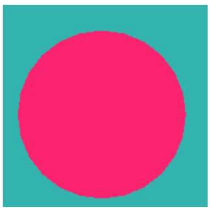
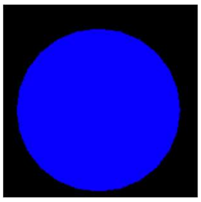
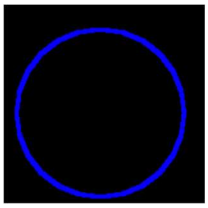
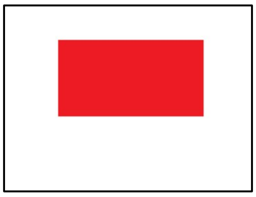
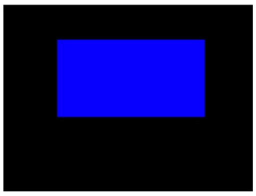
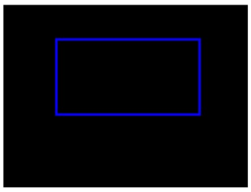
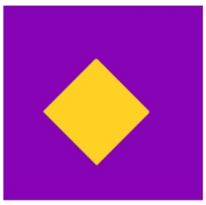
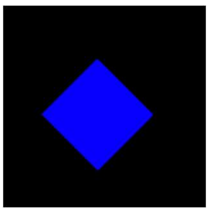
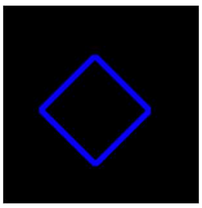
B. Morphology Method Result

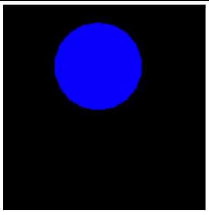
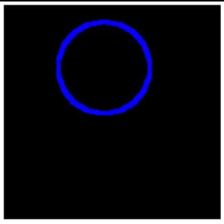
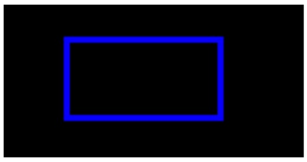
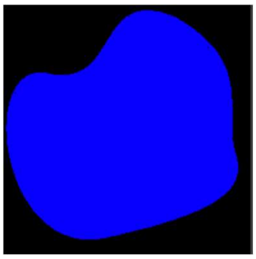
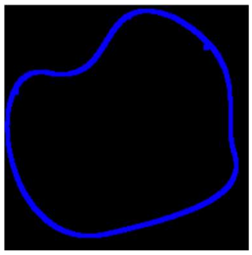
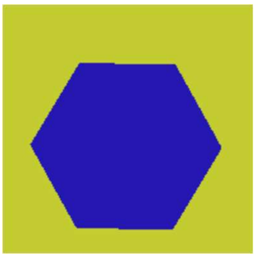
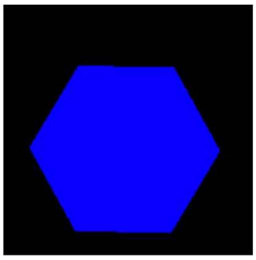
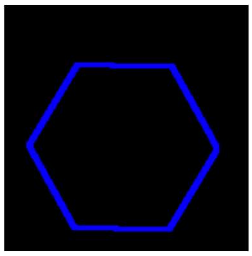
Testing with the morphological method is carried out using the image concept as a set with elements in the form of binary 1 or 0. Then passing a structuring element to an image in a way that is almost the same as convolution, and the results will be used for edge detection as information in calculations area and perimeter of the object. Canny and Morphology have differences in detection. Canny and Morphology have differences in detection. The morphological operation operated by strel makes the area included in the two-dimensional spatial structure visible. Then calculate the area and circumference using the reference number of pixels in that area

The morphological operation operated by strel makes the area included in the two-dimensional spatial structure visible. Then calculate the area and circumference using the reference number of pixels in that area Table II shows the results of testing with the morphological method:

TABLE II
MORPHOLOGY METHOD TEST RESULTS

No. Image	Image	Area	Perimeter
1		 Area: 12321 pixels Area: 8,556 cm^2	 Perimeter: 1776 pixels Perimeter: 11,684 cm

No. Image	Image	Area	Perimeter
2		 Area: 13174 pixels Area: 9,148 cm^2	 Perimeter: 1903 pixels Perimeter: 12,519 cm
3		 Area: 20421 pixels Area: 14,181 cm^2	 Perimeter: 2592 pixels Perimeter: 17,052 cm
4		 Area: 89400 pixels Area: 62,083 cm^2	 Perimeter: 5992 pixels Perimeter: 39,421 cm
5		 Area: 12904 pixels Area: 8,961 cm^2	 Perimeter: 2497 pixels Perimeter: 16,427 cm
6		 Area: 20418 pixels Area: 14,179 cm^2	 Perimeter: 2584 pixels Perimeter: 17 cm
7		 Area: 28782 pixels Area: 19,9875 cm^2	 Perimeter: 2856 pixels Perimeter: 18,789 cm
8		 Area: 5669 pixels Area: 3,936 cm^2	 Perimeter: 1674 pixels Perimeter: 11,013 cm

No. Image	Image	Area	Perimeter
9		 Area: 5424 pixels Area: 3,766 cm^2	 Perimeter: 1328 pixels Perimeter: 8,736 cm
10		 Area: 5151 pixels Area: 3,577 cm^2	 Perimeter: 1216 pixels Perimeter: 8 cm
11		 Area: 31569 pixels Area: 21,922 cm^2	 Perimeter: 3376 pixels Perimeter: 22,210 cm
12		 Area: 14892 pixels Area: 10,34 cm^2	 Perimeter: 2261 pixels Perimeter: 14,875 cm

C. Comparison of Canny and Morphology Method Results

Based on the results of testing the area and perimeter using the canny and morphological methods, there are similarities and differences in the results obtained. The difference in the results of the two methods can be known by comparing the results. Table III compares the Canny and Morphological methods' area and perimeter measurements results. The Canny method, also known as the morphology method, yields calculation values for the area and perimeter of objects that are not too dissimilar, with an average of around 1,134 cm.

TABLE III.
COMPARISON OF CANNY AND MORPHOLOGY METHOD RESULTS

No. Image	Canny		Morphology		Comparison
1	Area	8,781 cm^2	Area	8,556 cm^2	1,026
	Perimeter	11,853 cm	Perimeter	11,684 cm	1,014
2	Area	10,080 cm^2	Area	9,148 cm^2	1,102
	Perimeter	12,699 cm	Perimeter	12,519 cm	1,014
3	Area	14,600 cm^2	Area	14,181 cm^2	1,030
	Perimeter	13,541 cm	Perimeter	17,052 cm	0,794
4	Area	63,633 cm^2	Area	62,083 cm^2	1,025
	Perimeter	39,845 cm	Perimeter	39,421 cm	1,011
5	Area	17,254 cm^2	Area	8,961 cm^2	1,925
	Perimeter	16,615 cm	Perimeter	16,427 cm	1,011
6	Area	14,600 cm^2	Area	14,179 cm^2	1,030
	Perimeter	13,541 cm	Perimeter	17,0 cm	0,797
7	Area	20,398 cm^2	Area	19,9875 cm^2	1,021
	Perimeter	18,996 cm	Perimeter	18,789 cm	1,011

No. Image	Canny		Morphology		Comparison
8	Area	7,791 cm^2	Area	3,936 cm^2	1,979
	Perimeter	11,165 cm	Perimeter	11,013 cm	1,014
9	Area	3.877 cm^2	Area	3,766 cm^2	1,029
	Perimeter	6.978 cm	Perimeter	8,736 cm	0,799
10	Area	3.641 cm^2	Area	3,577 cm^2	1,018
	Perimeter	8.096 cm	Perimeter	8,0 cm	1,012

IV. CONCLUSION

The results of the study show several things, which can be concluded as follows: There is an average result of the comparison of area and circumference between the Canny method and Morphology of more than 1.03%. It occurs in the square area with the position rotated 90 degrees and the circle's perimeter. These results occur because the Canny method for sizes X and Y does not perpendicularly follow the object's position. The circle's perimeter difference is caused by calculating the perimeter in the Morphology method, which is influenced by the size of the strel (Structuring element), which is less than optimal with the object. The Canny method is not suitable for calculating the area of irregular shapes and the position of objects that are not perpendicular. The canny method is less effective because the area calculation still uses the manual geometric shape formula implemented in the program code. It won't be easy to calculate the area of shapes other than squares, rectangles, and circles. The morphological approach can be used as an alternative method for measuring the area and perimeter of a wildly irregular geometric shape. The precision of the calculation accuracy is relatively high, with it shown that the calculation results are the same as calculations using mathematical formulas. The selection of strel (Structuring element) can affect the measurement results' accuracy, especially the perimeter measurements using the morphological method.

Future research can be continued by selecting suitable strels automatically when using morphological methods. In addition, the Canny method can also be combined with other methods to calculate the area and perimeter of objects with irregular shapes.

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