ACTIVITY 7

FEATURE EXTRACTION

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APPLIED PHYSICS 157

Contents

TABLE OF CONTENTS

1 OBJECTIVES

2 INTRODUCTION

3 DIFFERENT COINS

18 RICE GRAINS

27 DIFFERENT DICE SHAPES

34 REFLECTION + REPORT GRADE

OBJECTIVES

Objective 1

Use image segmentation and morphological operations to obtain a clean image for feature extraction.

Objective 2

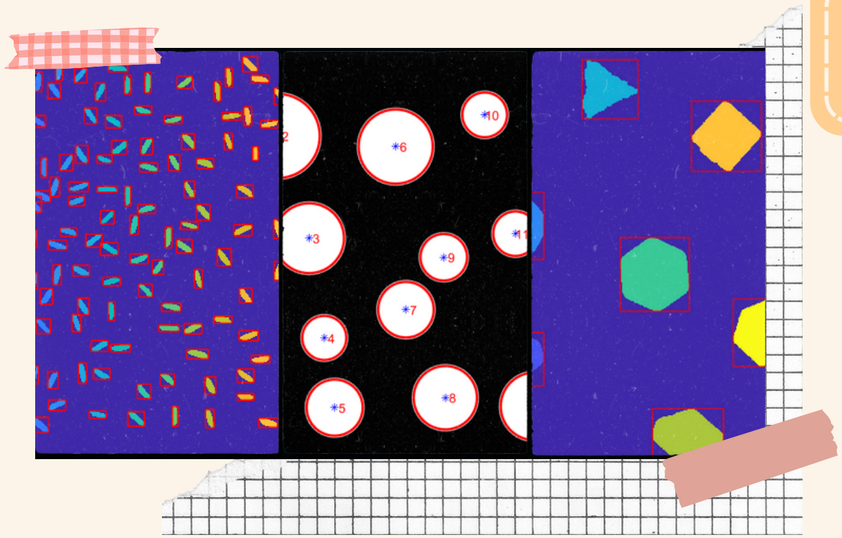
Extract the features of the regions of interest using regionprops.

Objective 3

Analyze the features extracted and compare them with the actual values, if necessary.

INTRODUCTION

The past two activities (image segmentation and morphological operations) have equipped us with skills that lead us to this last activity: feature extraction. In image processing, feature extraction captures the important properties or features from an image such as color, size, shapes, etc. In this activity, we'll use our past knowledge to segment the image, use morphological operations to clean it, and extract some useful features.



INTRO

01

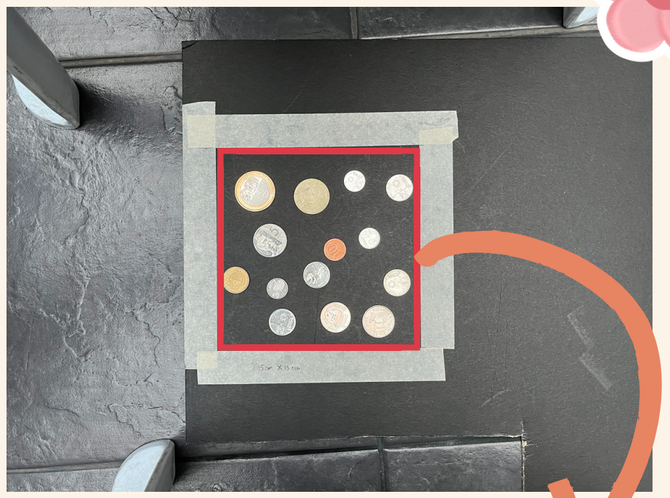
DIFFERENT COINS

Let's try to extract the features of different coins and see if they match the actual values.

COINS

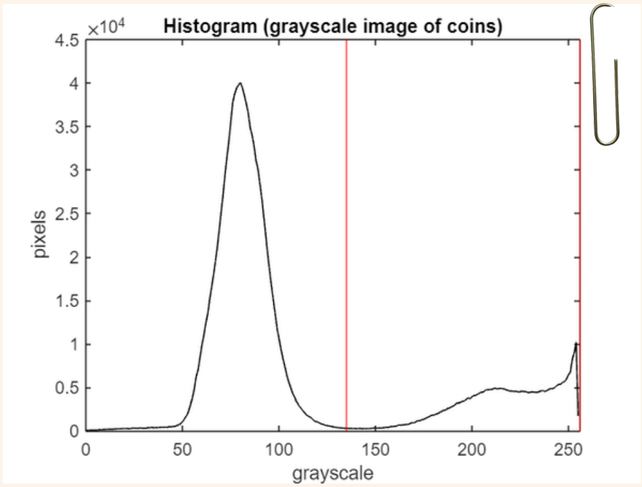
ORIGINAL IMAGE

With the assistance of my labmates, we captured images of different coins for use in this activity. To maintain a scale, we placed the coins inside a 15cm by 15cm square. Furthermore, to prevent distortion of the coins' shape and size, we positioned the square at the center tile of the 9x9 camera grid. After capturing the image, I cropped only the central portion, which will be utilized for feature extraction in MATLAB.

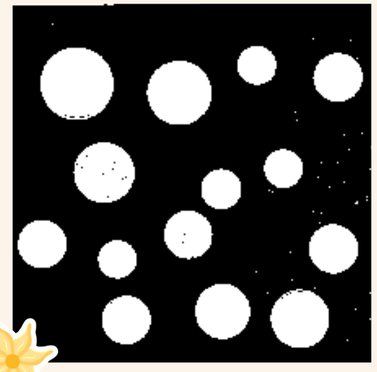


THRESHOLDING

original image



histogram

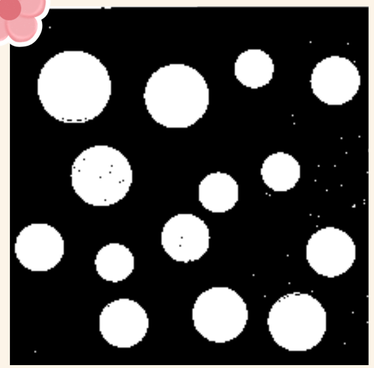


thresholded

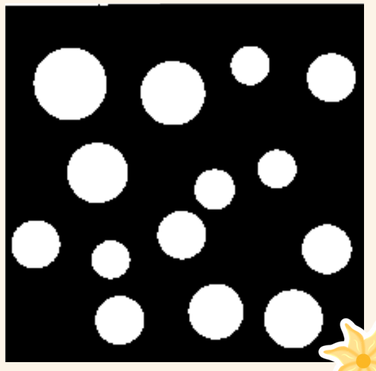
I performed image segmentation using thresholding since the coins were placed on a black background, resulting in a high contrast between the regions of interest and the background. After converting the image to grayscale, I generated a histogram to assist in selecting the appropriate threshold values. For thresholding, I utilized the range of 135–256. It's important to note that the thresholded image still contains some white dots (noise). Therefore, the next step involves employing morphological operations to remove these artifacts.

CLEANING THE IMAGE

```
BW1 = imopen(threshold(image,130,256), strel("disk", 2));
BW2 = imclose(BW1, strel("disk",2));
BW3 = imopen(BW2, strel("disk",3));
BW4 = imclose(BW3, strel("disk",3));
BW5 = bwmorph(BW4, "fill");
```



thresholded

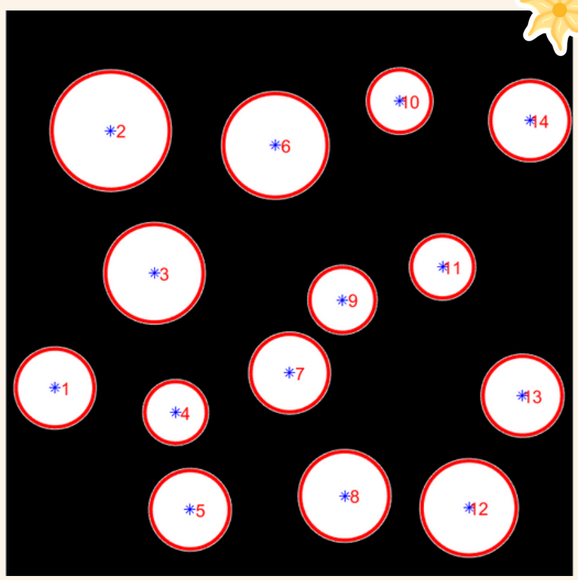


cleaned

To clean the image, I employed a combination of opening and closing operations using a disk structuring element with radii 2 and 3. Next, I utilized the fill operation to remove black dots within the region of interest. This resulted in a clean image without affecting the size and shape of the coins. With this, we are now prepared to extract some features!

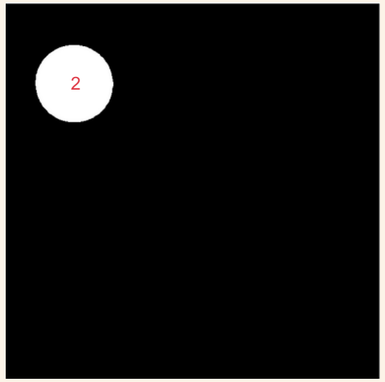
FEATURE EXTRACTION

The image comprises both old and new peso coins. For the feature extraction, I will focus on obtaining the area and diameter of the coins. The Bangko Sentral ng Pilipinas Website provides theoretical values for these, allowing us to compare and determine if the applied process distorted the coins' size. Using regionprops, I extracted the area, centroid, as well as the major and minor axis lengths. By calculating the mean of the major and minor axis lengths, I obtained the diameter. In the following slides, we will examine each type of coin individually.



	Area	Centroid		MajorAxisLength	MinorAxisLength
1	22110	106.1061	814.3064	168.4535	167.1277
2	50048	225.8262	260.7799	253.7160	251.1687
3	34582	319.9448	567.6158	210.7850	208.9010
4	13802	365.6856	866.9378	133.4076	131.7401
5	22347	396.7794	1.0762e+03	169.5638	167.8124
6	38991	580.2629	292.5869	222.9791	222.6515
7	21935	610.9735	782.1614	167.7260	166.5275
8	28479	729.3852	1.0464e+03	190.9957	189.8633
9	15415	724.6536	624.7766	140.2826	139.9227
10	14202	847.7243	197.3449	134.6432	134.3135
11	14040	940.0476	554.0088	134.3775	133.0468
12	32294	997.1763	1.0723e+03	203.7737	201.7929
13	22629	1.1122e+03	830.9278	170.5960	168.9019
14	22361	1.1282e+03	239.1073	169.9162	167.5719

20 PESO COIN



scale: 1mm : 81.33333pixel

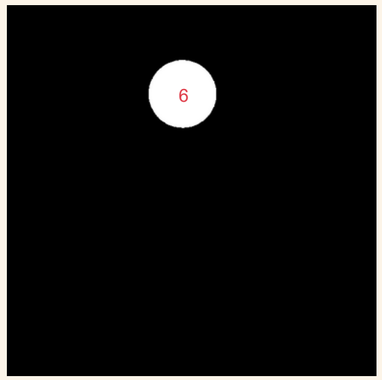
diameter: 30mm

area: 706.86 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	31.04	3.46
Area (mm^2)	756.62	7.04

For the new 20 peso coin, the percent errors for the diameter and area are acceptable.

5 PESO COIN (OLD)



scale: 1mm : 81.33333pixel

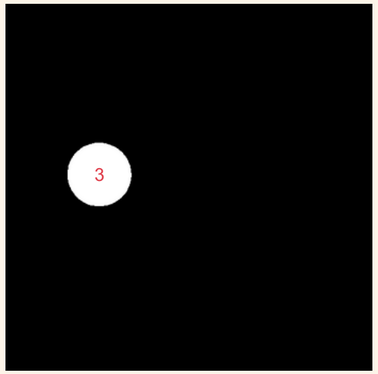
diameter: 27 mm

area: 572.56 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	27.40	1.46
Area (mm^2)	589.44	2.95

For the old 5 peso coin, the percent errors for the diameter and area are acceptable.

5 PESO COIN (NEW)



scale: 1mm : 81.33333pixel

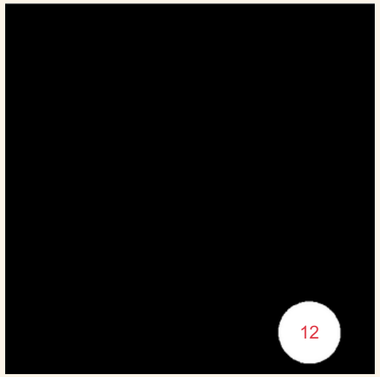
diameter: 25 mm

area: 490.87 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	25.8	3.20
Area (mm^2)	522.81	6.51

The new 5 peso coin is 2 mm smaller than the old one. Still, the percent errors are acceptable.

1 PESO COIN (OLD)



scale: 1mm : 81.33333pixel

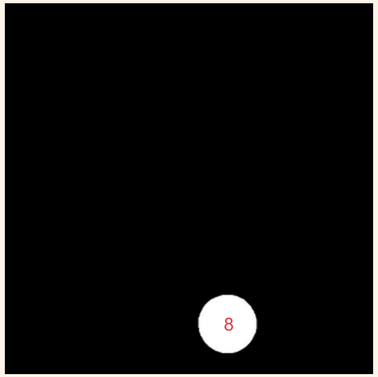
diameter: 24 mm

area: 452.39 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	24.93	3.88
Area (mm^2)	488.22	7.92

The percent errors are acceptable for the old one peso coin.

1 PESO COIN (NEW)



scale: 1mm : 81.33333pixel

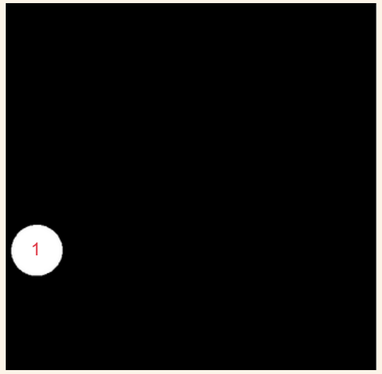
diameter: 23 mm

area: 415.48 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	23.41	1.80
Area (mm^2)	430.55	3.63

The new one peso coin is 1mm smaller than the old one. The percent errors are also acceptable.

25 CENTS (OLD)



scale: 1mm : 81.33333pixel

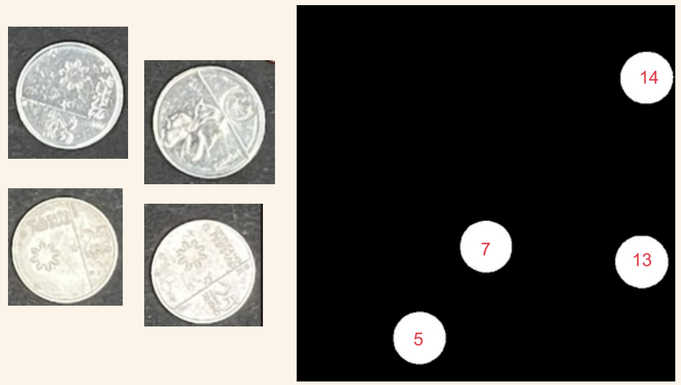
diameter: 20 mm

area: 314.16 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	20.63	3.15
Area (mm^2)	334.26	6.40

The percent errors for the 25 centavo coin are acceptable.

25 CENTS (NEW)



scale: 1mm : 81.33333pixel

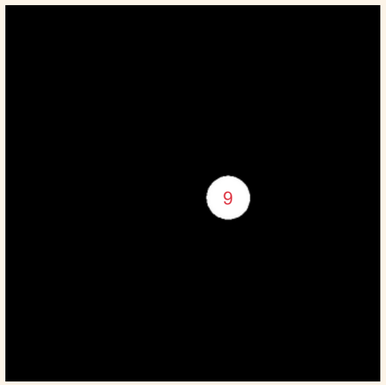
diameter: 20 mm

area: 314.16 mm^2

Blob No.	Diameter (mm)	Percent Error (%)	Area (mm^2)	Percent Error (%)
5	20.74	3.70	337.85	7.54
7	20.55	2.74	331.62	5.56
13	20.87	4.35	342.11	8.90
14	20.75	3.74	338.07	7.61

The blob near the center has the lowest percent errors compared to the blobs near the edge.

10 CENTS (OLD)



scale: 1mm : 81.33333pixel

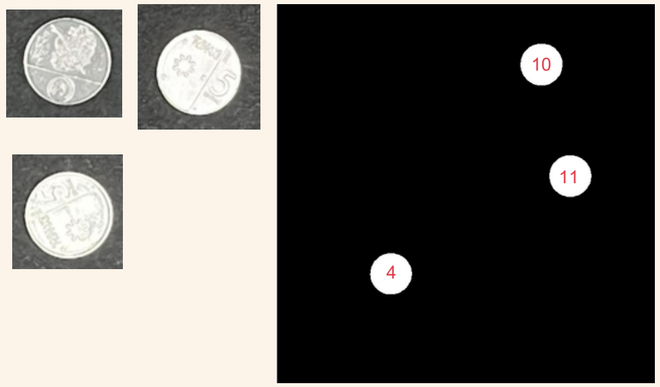
diameter: 17 mm

area: 226.98 mm^2

Feature	Value from extraction	Percent Error (%)
Diameter (mm)	17.23	1.33
Area (mm^2)	223.05	2.67

The percent errors of this coin are the lowest compared to all the coins in the image. This is since it is nearest to the center of the image. Hence, it is the least distorted.

5 CENTS (NEW)



scale: 1mm : 81.33333pixel

diameter: 16 mm

area: 201.06 mm^2

Blob No.	Diameter (mm)	Percent Error (%)	Area (mm^2)	Percent Error (%)
4	16.30	1.88	208.67	3.79
10	16.53	3.34	214.71	6.79
11	16.44	2.75	212.27	5.58

The blob near the center has the lowest percent errors compared to the blobs near the edge.

CONCLUSION

- All the percent errors are acceptable. Hence, the feature extraction is successful.
- The blob with the lowest percent error is the ten centavo coin since it is nearest to the center of the image. Hence, I conclude that the center of the image is the least distorted. And as it moves away from the center, the blob becomes more distorted.
- The sources of error are the technique used in capturing the image, the lighting, and the not-so-accurate scale used.

02

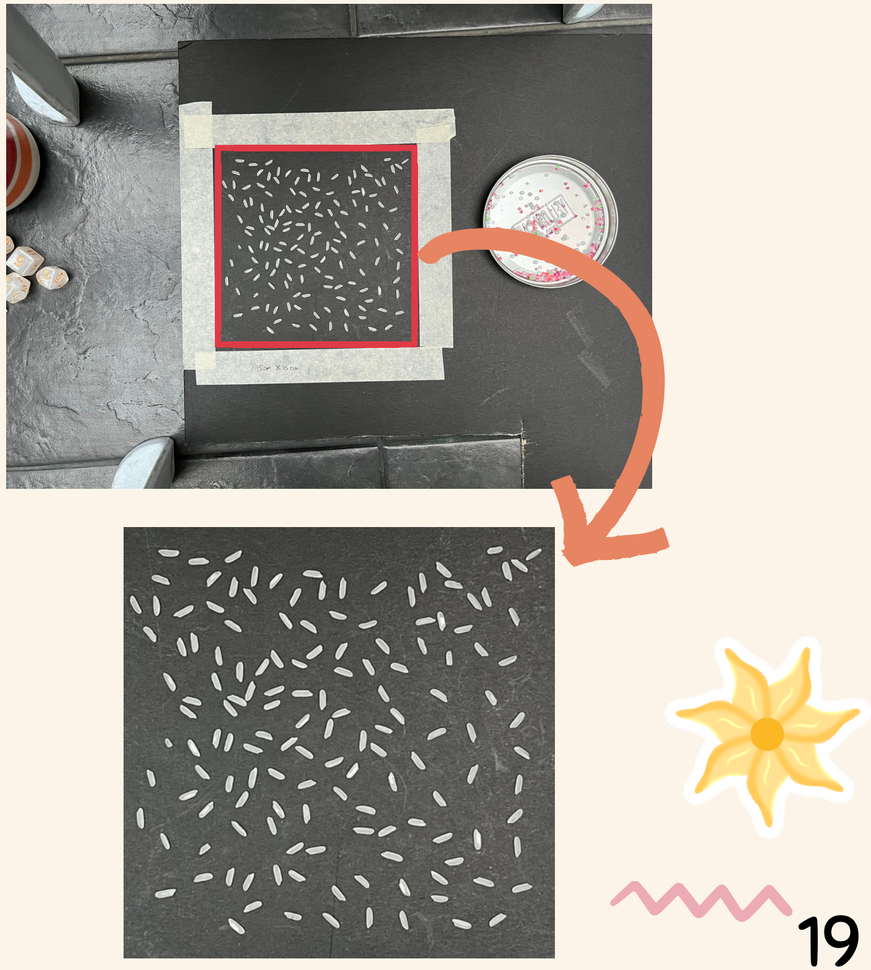
RICE GRAINS

Now let's try extracting the features of smaller objects – rice grains!

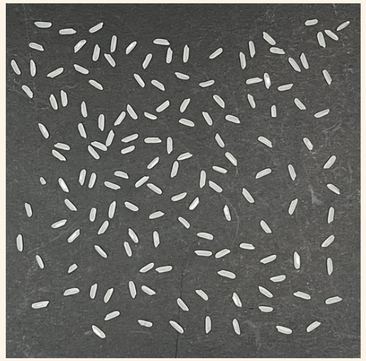
RICE GRAINS

ORIGINAL IMAGE

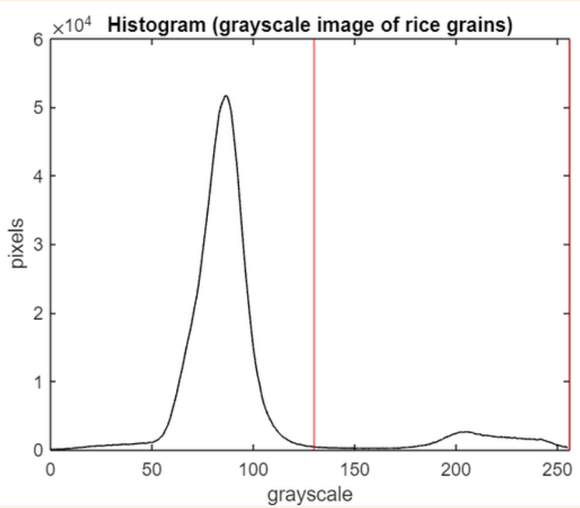
Similar to our approach with the image containing different coins, we also captured an image of the rice grains, ensuring that the square fits the center tile of the 9x9 camera grid. Here, I have already cropped the square image that will be used for feature extraction. The image size is 1220-by-1220 pixels, resulting in a scale of 1mm:81.33333 pixels.



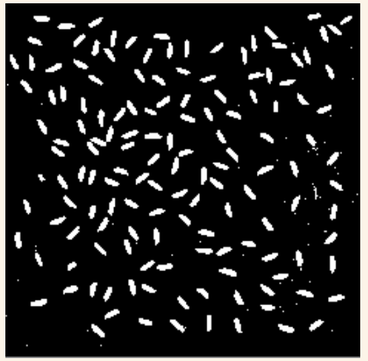
THRESHOLDING



original image



histogram

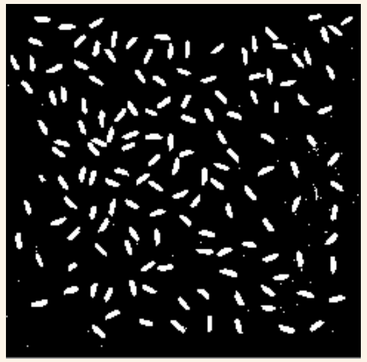


thresholded

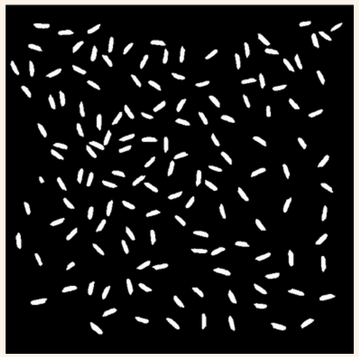
Due to the high contrast between the region of interest (ROI) and the background, I applied thresholding for segmentation. The threshold value used was 130–256. However, the resulting thresholded image requires some additional cleaning. Now, let's proceed with the application of morphological operations.

CLEANING

```
BW1 = imclose(threshold(image, 160, 256), strel("disk",1));
BW2 = bwmorph(BW1, 'thin');
BW3 = bwmorph(BW2, 'fill');
BW4 = imopen(BW3, strel("disk",1));
```



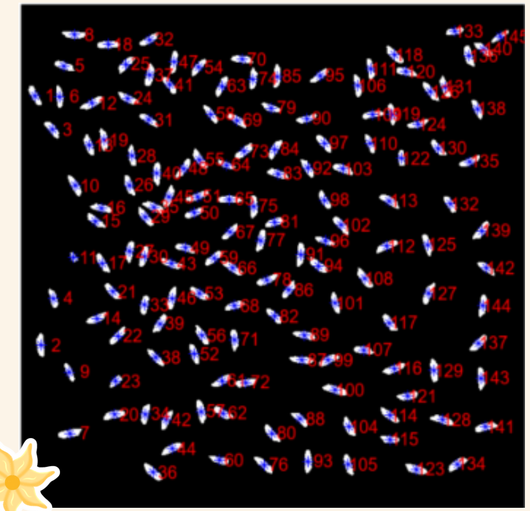
thresholded

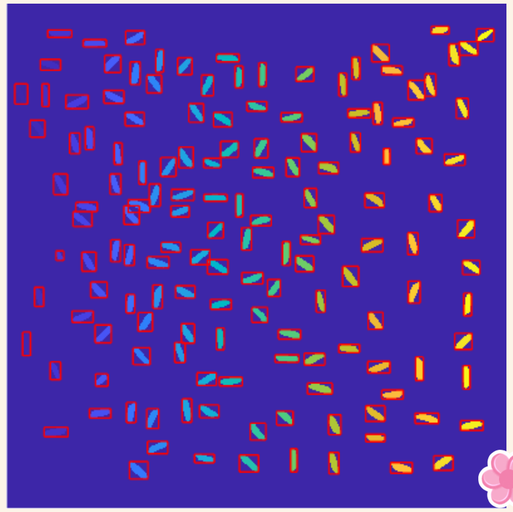


cleaned

To clean the image, I employed the closing operation with a disk-shaped structuring element of radius 1. Next, I applied the thinning and filling operations. Finally, I used the opening operation with the same structuring element. This resulted in the clean image displayed above. As observed, the shape and size of the rice grains were not significantly affected by the applied operations. We are now prepared to proceed with feature extraction!

FEATURE EXTRACTION

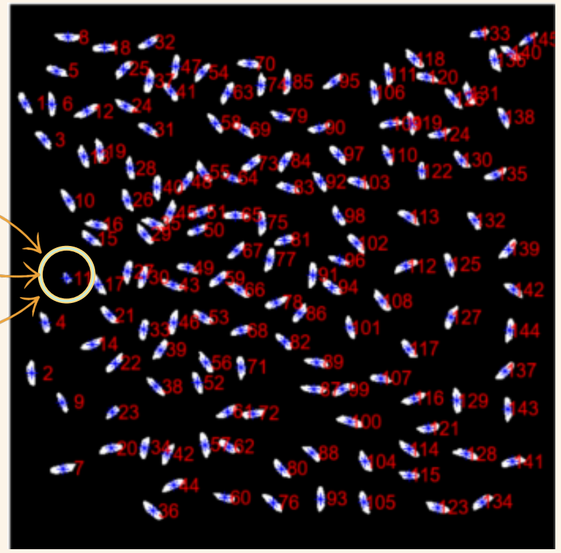


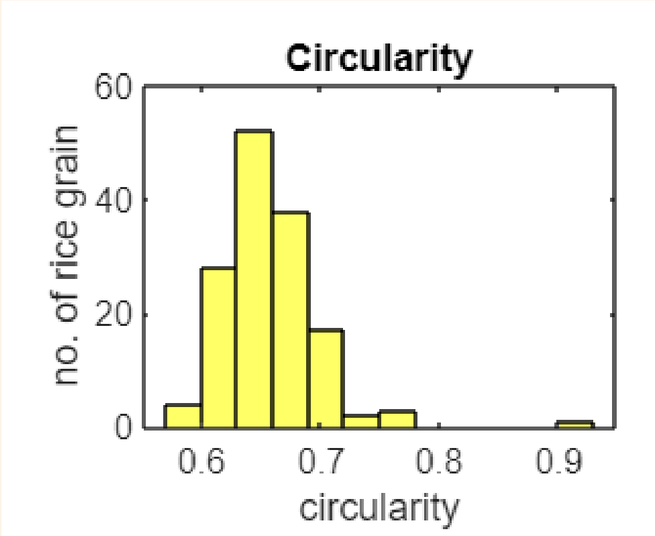


The image contains a total of 145 rice grains. The features that I extracted include the centroid, bounding box, perimeter, circularity, as well as the major and minor axis lengths. I utilized the centroid to label each grain with corresponding numbers, and the bounding box feature was used to create the image on the right. The diameter, which is the mean of the axis lengths, will be further explored in the following slides. Additionally, the perimeter and circularity will also be investigated.

CIRCULARITY

scale: 1mm : 81.33333pixel

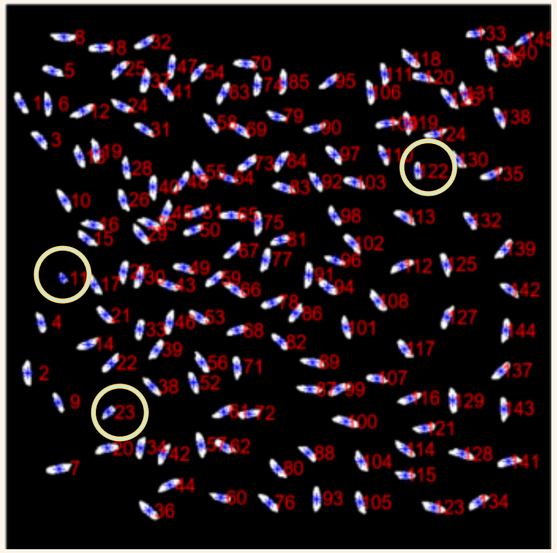


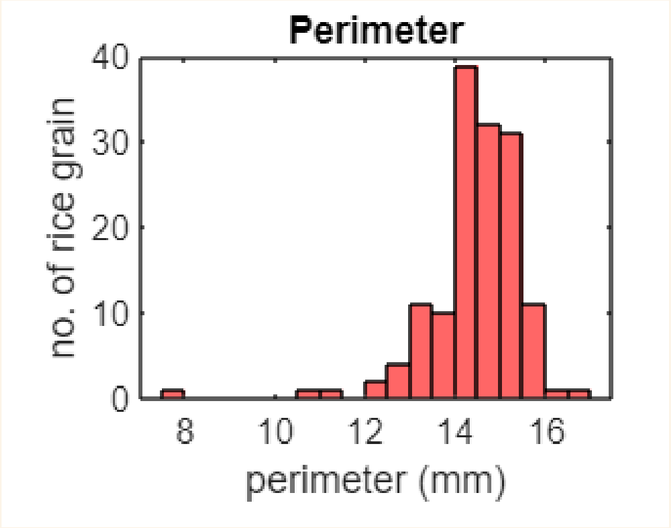


Circularity serves as a measure of the roundness of objects and is calculated as (4 * Area * π) / (Perimeter^2). Perfect circles have a circularity value of 1. Since rice grains are not perfect circles, we can expect to observe low circularity values. For the image utilized in this analysis, the average circularity is 0.659. The histogram above indicates the presence of an outlier with a circularity of 0.921. This outlier corresponds to the smallest grain in the group, which appears to be cut in half compared to the other rice grains.

PERIMETER

scale: 1mm : 81.33333pixel

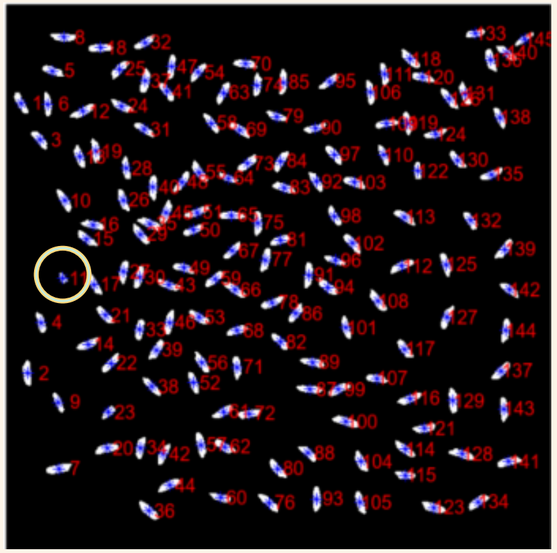


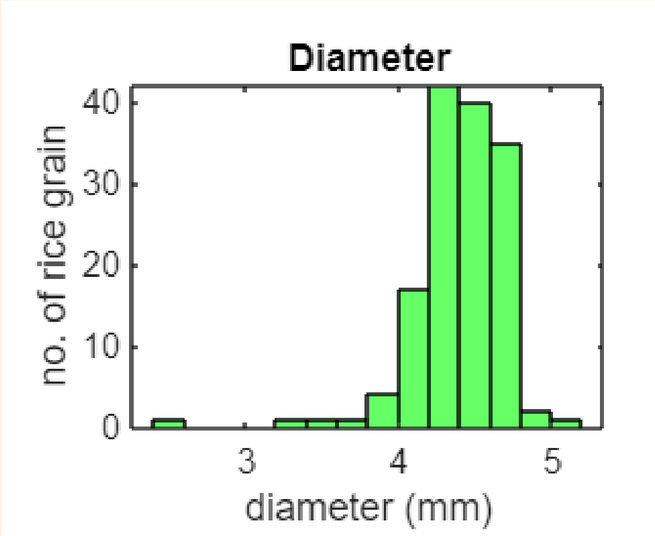


The average perimeter of the rice grains in the image is 14.43mm. The smallest grain, identified as grain #11, has a perimeter of 7.56mm, making it an outlier within the group. Additionally, grain #23 and #122 are also outliers, measuring 10.58mm and 11.35mm in diameter, respectively.

DIAMETER

scale: 1mm : 81.33333pixel





I calculated the diameter by taking the mean of the major and minor axis lengths. The average diameter of the rice grains in the image is 4.40mm. The smallest grain, identified as grain #11, has a diameter of 2.45mm, making it an outlier within the group. Based on the average diameter of the grains, they can be classified as short-grain rice, with an average diameter of less than 5.5mm.

CONCLUSION

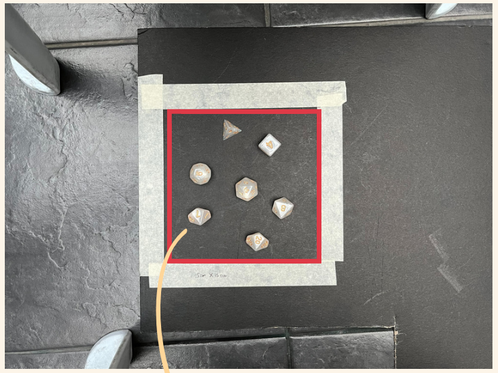
- There are several features of rice that we can extract such as circularity, perimeter, and diameter.
- The average circularity is 0.659 while the average perimeter is 14.43mm. There are also outliers that are present in the group.
- Since the average diameter of the grains is 4.40mm, it can be classified as short-grain rice.

03

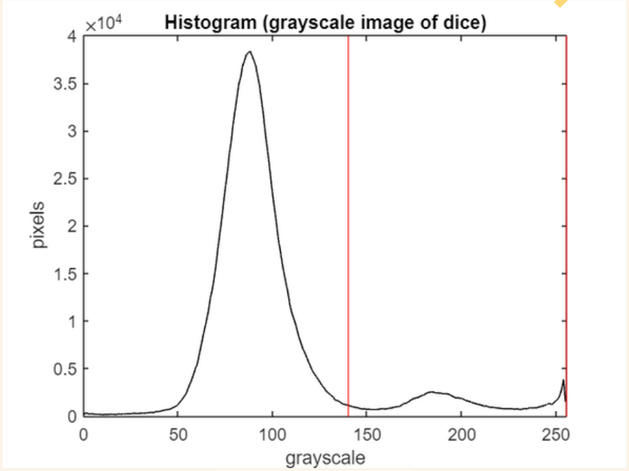
DIFFERENT SHAPES OF DICE

Let's now use an image containing different shapes of dice. What features can we extract?

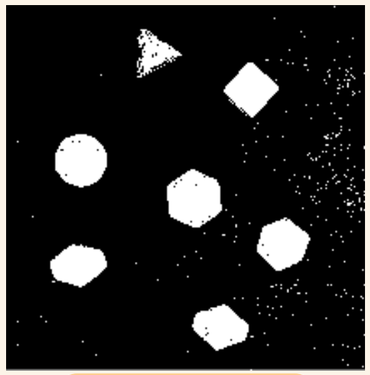
THRESHOLDING



original



histogram

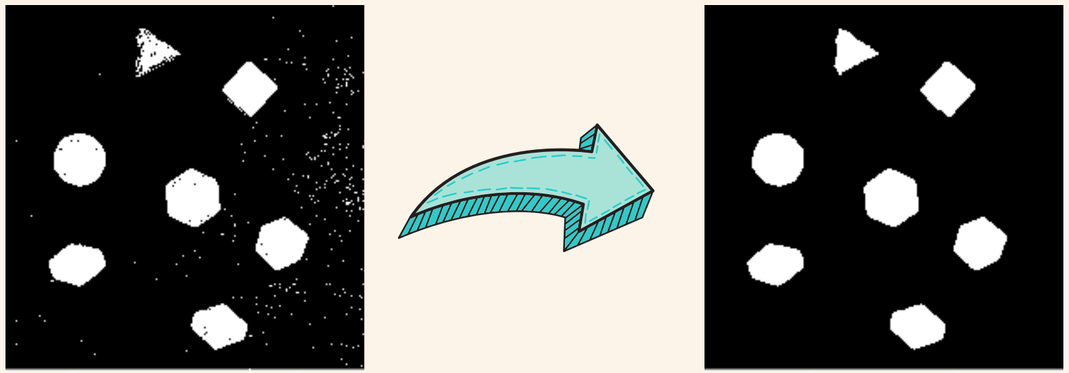


thresholded

Here, I also used thresholding (140–256). The resulting image has noise included in the background so it's time to clean it !

MORPHOLOGICAL OPERATIONS

```
BW1 = imopen(threshold(image,125,256), strel("disk", 2));
BW2 = imclose(BW1, strel("disk",2));
BW3 = bwmorph(BW2, "fill");
BW4 = imopen(BW3, strel("disk",6));
BW5 = imclose(BW4, strel("disk",6));
```



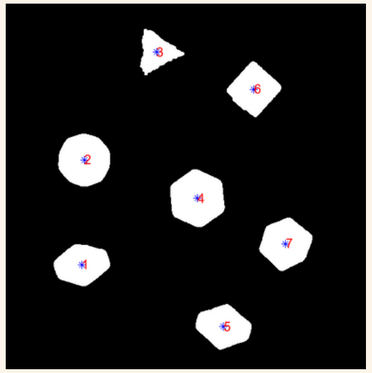
thresholded

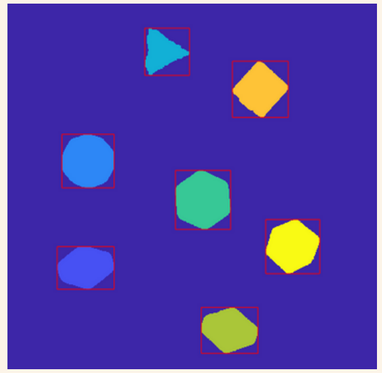
cleaned

To clean the image, I employed several operations. First, I utilized a combination of opening and closing operations with a disk-shaped structuring element of radius 2. This was followed by the fill operation to fill in the gaps within the regions. Finally, I performed another combination of opening and closing operations, this time using a disk structuring element with a radius of 6. Notice that the "triangular" blob's edges are not that clean. This is due to the reflection of the dice that affected the image and the thresholding process.

FEATURE EXTRACTION

cleaned

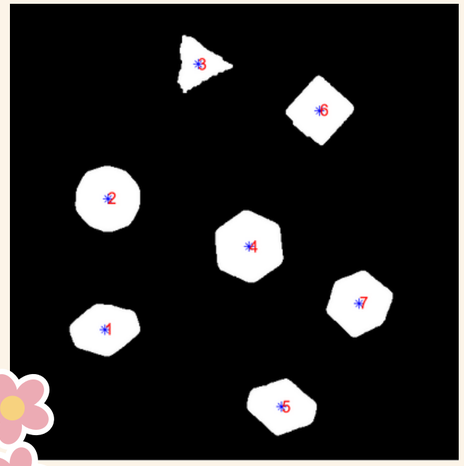




extraction

I extracted the following features: centroid, bounding box, circularity, as well as the major and minor axis lengths. The centroid feature was used to label the regions with numbers, while the bounding box was utilized to create the image on the right. Additionally, I calculated the diameter by averaging the major and minor axis lengths. The diameter and circularity features will be further explored in the upcoming slides.

FEATURES: DIAMETER & CIRCULARITY



	Circularity	Diameter
1	0.9243	19.6947
2	1.0026	21.6995
3	0.6156	16.7444
4	0.9642	22.9571
5	0.9079	19.8100
6	0.8594	19.8387
7	0.9427	20.6778

The dice with the highest circularity is dice #2 (1.00) which is the dodecahedron dice with 12 sides. The lowest circularity is dice #3 (0.62) which is the tetrahedron dice. The biggest dice based on diameter is dice #4 (22.96mm) which is the D17 sphere dice.

CONCLUSION

- The reflective property of the dice affected the thresholding process and resulted in crooked edges of the tetrahedron dice.
- Both circularity and diameter features describe the differences between the dice used.
- Feature extraction's accuracy depends on the quality of the image and the segmentation technique used.

REFERENCES

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3. https://www.mygreatlearning.com/blog/feature-extraction-in-image-processing/#:~:text=Feature%20extraction%20is%20a%20part,a%20large%20number%20of%20variables.
4. https://www.bsp.gov.ph/Coins%20and%20Notes/Coins/NGCCS/NGCCoins.pdf
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REFLECTION

This activity is truly enjoyable, involving various stages from image segmentation and the application of morphological operations to the analysis of extracted features through feature extraction. Moreover, I have discovered the extensive possibilities offered by feature extraction. In this activity alone, I was able to validate the sizes of the peso coins and identify the type of rice grains used. One particular aspect that I found delightful was calculating the percent errors in the diameter and area of the coins. Witnessing small and acceptable percent errors indicated the success of the entire process, leaving me with a great sense of satisfaction. The only challenge encountered involved cleaning the image using morphological operations, as it required multiple attempts and various combinations of operations to find the optimal formula. However, overall, this has become one of my favorite activities.

REPORT GRADE

Criteria	Score
Technical Correctness	35
Quality of Presentation	35
Self Reflection	30
Initiative	10
TOTAL	100 (+10)

EVALUATION

Overall, I know that I have accomplished all the tasks included in this activity. Moreover, I did some extra experiments and analyzed each of the features extracted from the images. I also put a lot of effort in creating this presentation and cited a lot of sources for additional information in the report.