APP PHY 157 WFY-FX-2

LAB REPORT 6

Morphological Operations

Source code here!

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https://github.com/lovelyandeo/AP157-Computational-Analysis-and-Modeling-in-Physics

Background

Morphological operations in image processing utilize mathematical operations to manipulate the shape and structures of objects in an image, or its *morphology.* A structuring element is used to alter the pixel values of an image based on the interaction or relationship between them.

Objectives

In this activity, we aimed to:

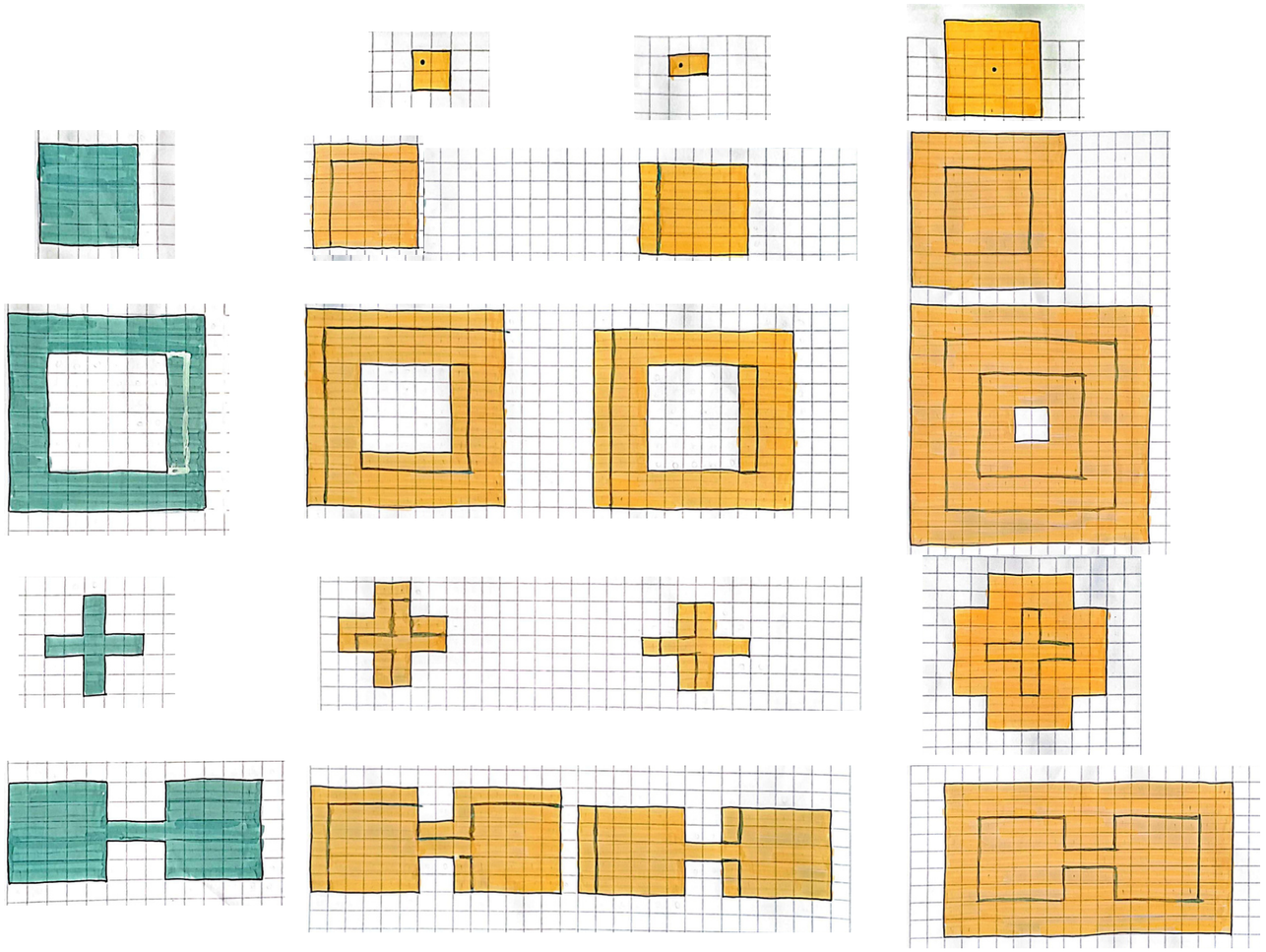
1. Demonstrate the different morphological operations such as erosion and dilation
2. Explore how the combination of these operations (opening and closing) can be utilized in cleaning up binary images

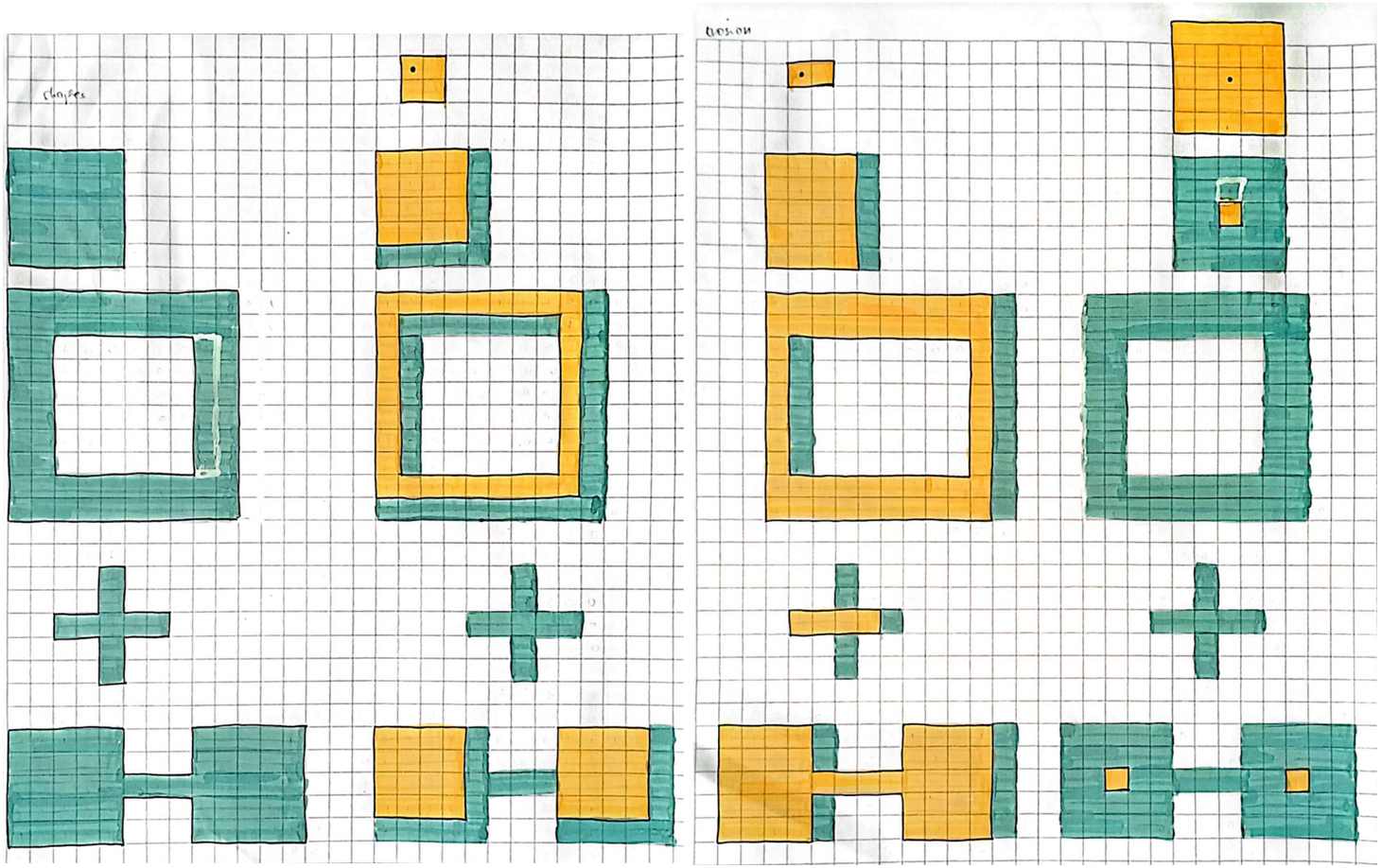
Results and Analysis

For this part of the activity. The goal is to develop a deeper understanding of set theory and the morphological operations which are dilation and erosion. The first column of images is the shapes that were dilated/eroded using the first row of shapes as the structuring elements. The way it works is that the element is slid through every pixel of the shapes to find similarities, and then alter the image accordingly based on the element's origin. On the right is the hand-drawn predicted result of the dilation operation.

The blue outline indicates the original size of the shape, and from there, we can see a significant increase in their sizes brought upon by the structuring elements. This happens because in general, the dilation operation causes the 1s pixels of the image to increase and the blacks or 0s to decrease, following the location of the origin. It is also evident that different structuring elements enlarged the shapes differently.

Dilation





Opposite of dilation, the erosion operation causes the 1s pixels of the image to decrease and the 0s or black ones to increase. On the left is the hand-drawn expected result of applying erosion to the same shapes with the same structuring elements.

The blue color indicates the original size of the shape and the yellow corresponds to the size of the shape after the erosion. Upon visual inspection, shapes definitely decreased in size and lost some of their defining pixels like that of the cross.

Again, different structuring elements shrank the shapes differently. And the choice of the origin shows to plays an important part in these morphological operations.

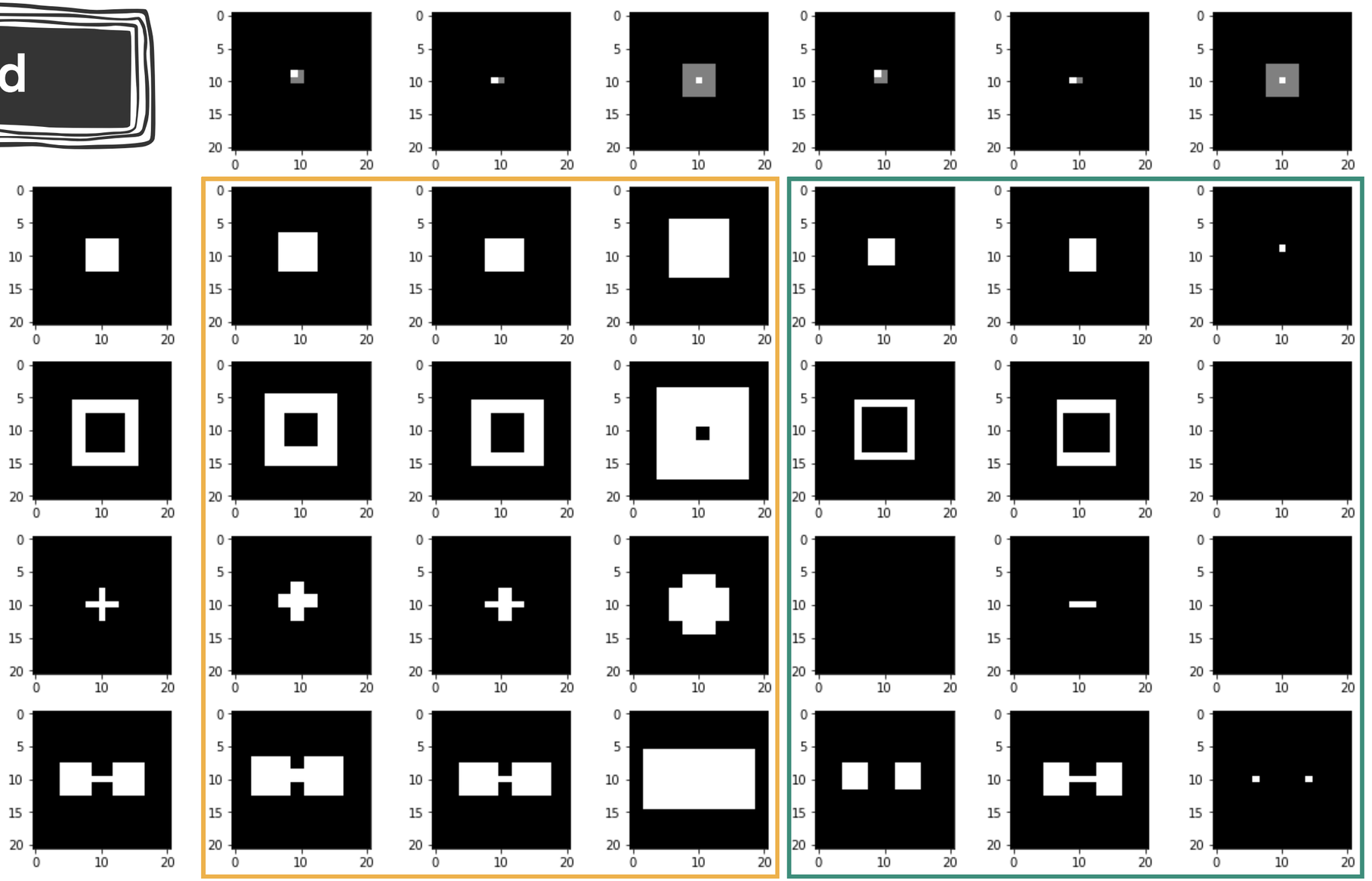
Erosion

Automated

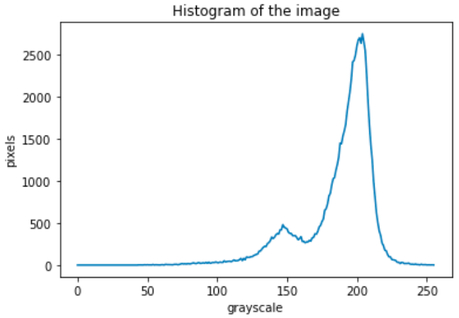
The shapes and structuring elements were then made in Python whereas the morphological operations were applied using the cv2 library. The results validate the previous predictions of what the operations do to the shapes given the structuring elements.

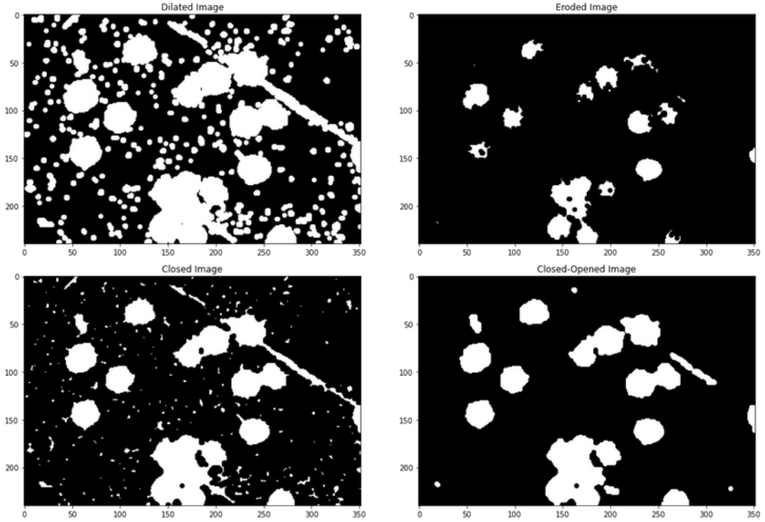
Dilation

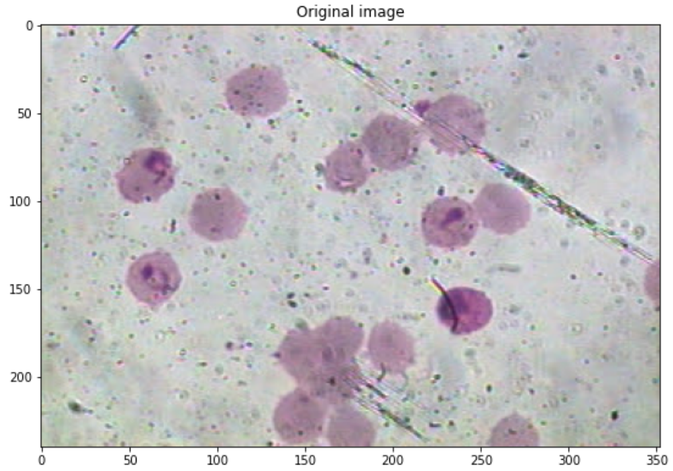
Erosion

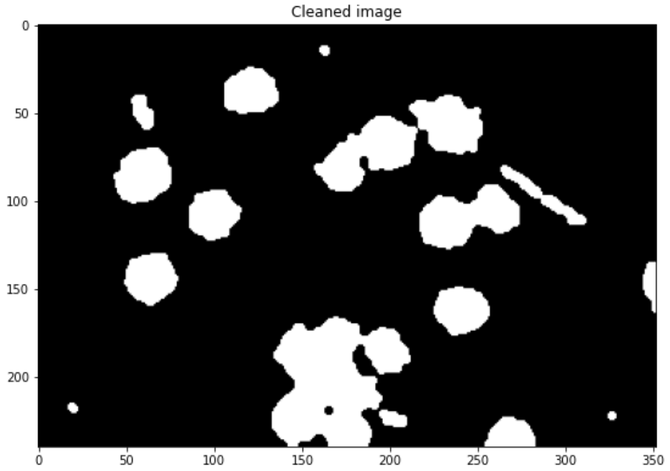


Applications





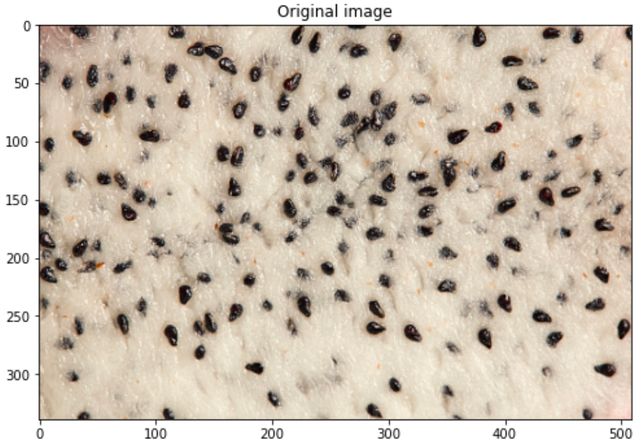




Morphological operations such as erosion and dilation are used a lot in cleaning up binary images, in preparation for feature extraction. For this part of the activity, we explored the effects of combining these operations in removing unnecessary details in images. Particularly, we used the closing (dilation followed by erosion) and opening (erosion followed by dilation) operations.

The first example here is the malaria-infected cells above, taken under a microscope. Extracting the features of this is essential to scientists and medical professionals for accurate diagnosis, monitoring disease progression, drug discovery, and advancing our understanding of the disease.

As noticed, our specimen has a lot of tiny particles in its surrounding that are not really that relevant in feature extraction. Upon applying a threshold, some of the blobs had some hollow parts, and some trivial details were also included. Hence, operations were applied and a circle structuring element was used. The combination of closing (filled in the holes in the blobs) and opening (reduced the foreground noise) operations lessened the inclusion of unnecessary details the most.



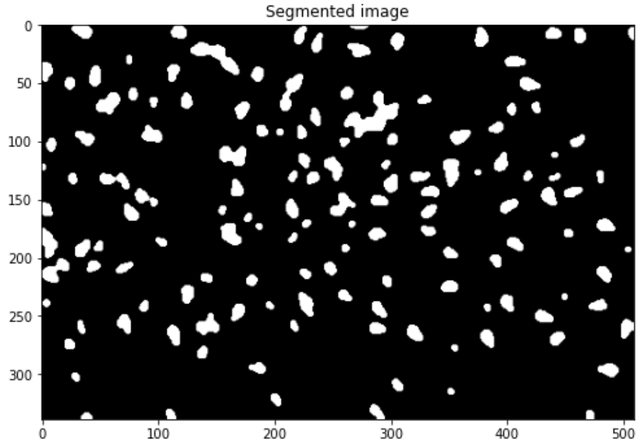


Image source: 123rf.com

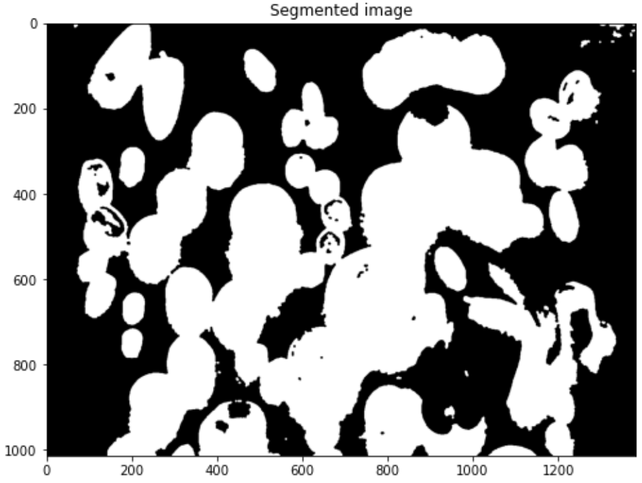


Image source: iStock.com

Moreover, the same techniques and operations were applied to different images. First here was with the dragon fruit seeds. I wanted to check how well the operations would do with small-sized same-colored ROIs. Using the same structuring element for the malaria one, the combination of closing and opening operations was also applied to get the final segmented or cleaned binary image. It is understandable to have retained some of the small details corresponding to the seeds of the fruit covered with its flesh.

In the next example, I wanted to see how the operations would perform if the ROIs are clumped together and had different shapes. The same closing and opening operations were applied, also using the same circle structuring element. The segmented image looked clean although it wasn't able to include some inner parts of some fruits, which is also understandable since they had the same colors as the background.

Applications

Since I have also been working with satellite data for my research, I was curious as to how I can segment these satellite images using morphological operations. Image segmentation plays a huge part in extracting features from satellite images, which are then used for different research applications. It is important to clean these images beforehand as it can mess with the accuracy and add complexity to the feature extraction process. This often translates to the outliers in the dataset extracted.

Now, on the examples on the right, I was able to get a relatively clean output of the first image by applying the closing operation followed by dilation and using a 3x3 square structuring element. This allowed me to fill in the holes in the square, reduce the foreground noise, and increase the pixels of the houses more. Although some irrelevant pixels still remained.

The second image below is quite different because the colors of the houses are different and sort of blend with their surrounding, making it extra challenging to segment. By applying the closing and then opening operations (using the same 3x3 square structuring element), I would say the houses were still poorly segmented and even the roads were also included. Further processing could definitely improve this result!

Image source: gcatholic.org

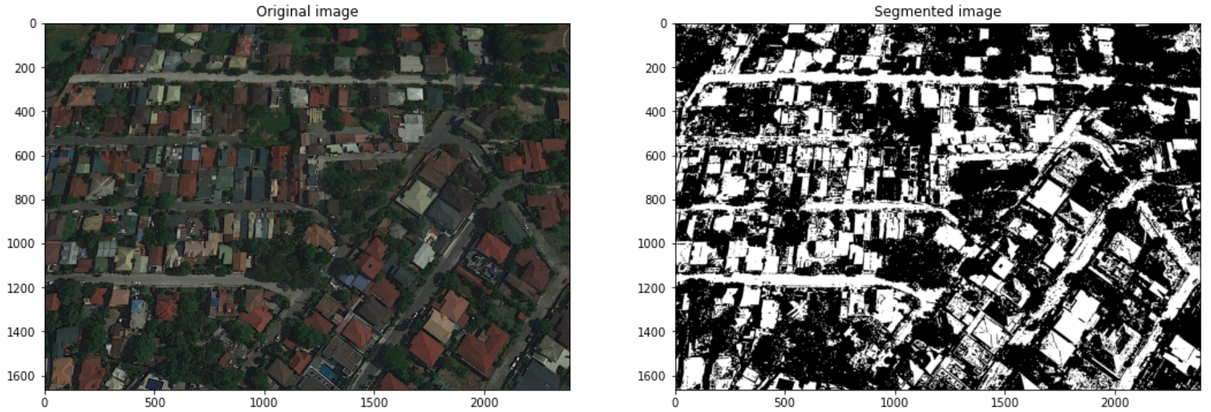
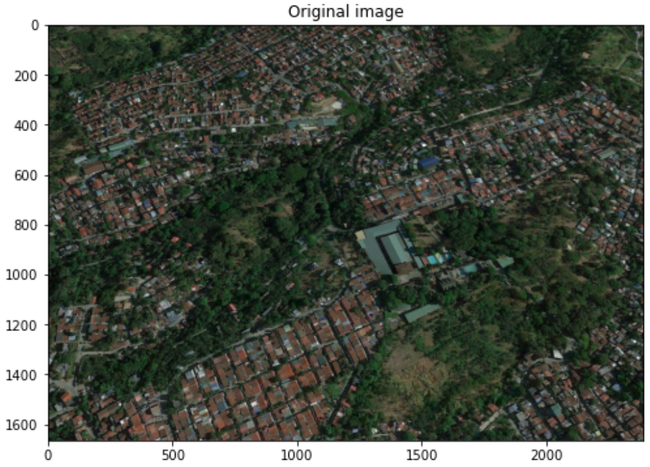


Image source: Google Earth Pro

Applications



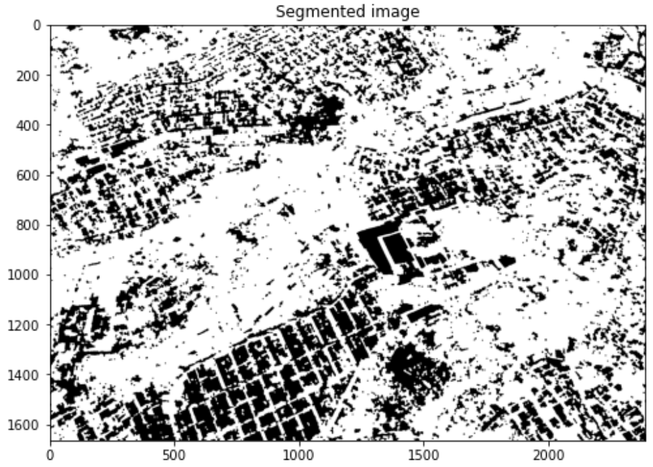
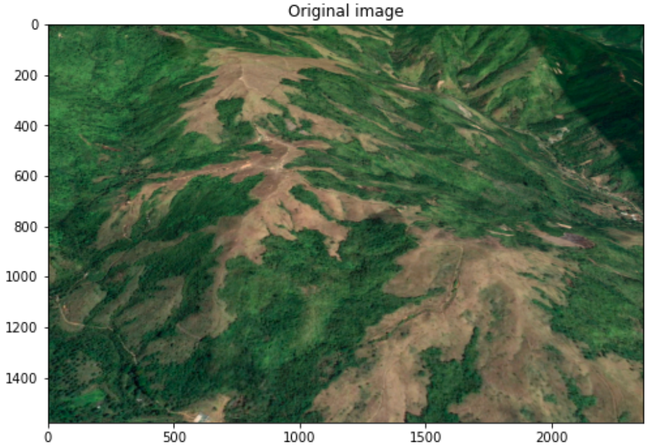


Image source: Google Earth Pro

Now here, I wanted to see how morphological operations apply in cleaning up images with irregularly-shaped ROI. In the image on the left, I wanted to record the vegetation within an area in Quezon City and so I tried extracting the pixels corresponding to the trees and other greeneries. The best-resulting image shown beside the original image, came from applying the closing and opening operations using a circle structuring element. Note that the image itself is quite complex hence it wasn't that well segmented.



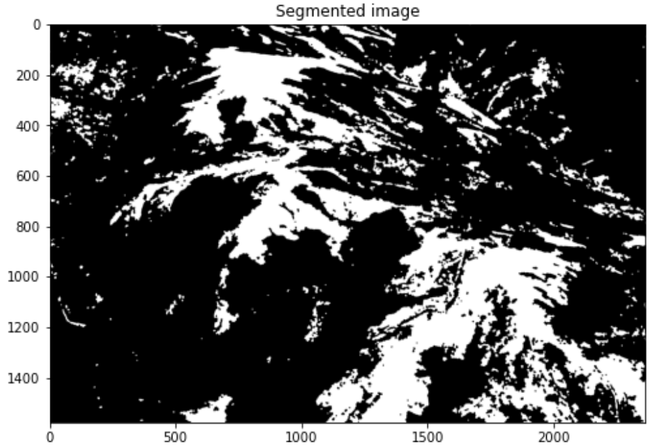


Image source: Google Earth Pro

The image below is a place in Rizal which was badly affected by various environmentally abusive and illegal activities before. I wanted to highlight that by extracting the pixels of the parts with bare land cover. After applying the closing and opening operations using a circle structuring element, I was able to show a somehow representation of the state of the area due to deforestation. Again, further process could definitely improve this even more!

Applications

Key takeaways

- Morphological operations can be combined however you like to clean images and get the desired results you want.
- The complexity of the image you have and the structuring element you choose matter A LOT. These may define the limitations of the morphological operations for that particular image.

Reflection

I always say I enjoy every activity, but I really do! Like this one, it was fun being able to manipulate and play around with the shapes and images using different morphological operations. In the first part, I enjoyed manually drawing the results of the erosion and dilation operations. And quite frankly, I also missed coloring and being artistic in that way :') On the applications part, it was also cool to be able to experience the first few steps of satellite imagery featurization, since I've only really dealt with processing satellite data/features that were already extracted by a third party or some API. Hopefully, I can apply these to my future ventures with my research interest!

Self-evaluation

100/100

+ 10 bonus points

I believe I was able to deliver what was required for this lab report. And I also went above and beyond by demonstrating the different possible applications of morphological operations.

References

Here are the materials I used as guide to accomplish this activity:

Soriano, M. (2023). A6 - MORPHOLOGICAL OPERATIONS. https://uvle.upd.edu.ph/pluginfile.php/872182/mod_resource/content/1/Activity%205%20-%20Feature%20Extraction%20%20Image%20Segmentation%20%20%28Part%201%20of%203%29.pdf

Manansala, J. (2021). Image Processing with Python: Morphological Operations. https://uvle.upd.edu.ph/pluginfile.php/872182/mod_resource/content/1/Activity%205%20-%20Feature%20Extraction%20%20Image%20Segmentation%20%20%28Part%201%20of%203%29.pdf