MORPHOLOGICAL OPERATIONS

A presentation by **Hans Emmanuel Hernandez** (2020-11387)

OBJECTIVES

In this activity, we implement various morphological operations in image processing. Specifically, we have the following objectives:

- Relate the principles of Set Theory with morphological operations
- Predict and explain various morphological operations
- Simulate and validate various morphological operations
- Perform various morphological operations to clean an image
- Describe how the results vary for different structuring elements

01 RESULTS AND ANALYSIS

PREDICTING EROSION OPERATIONS

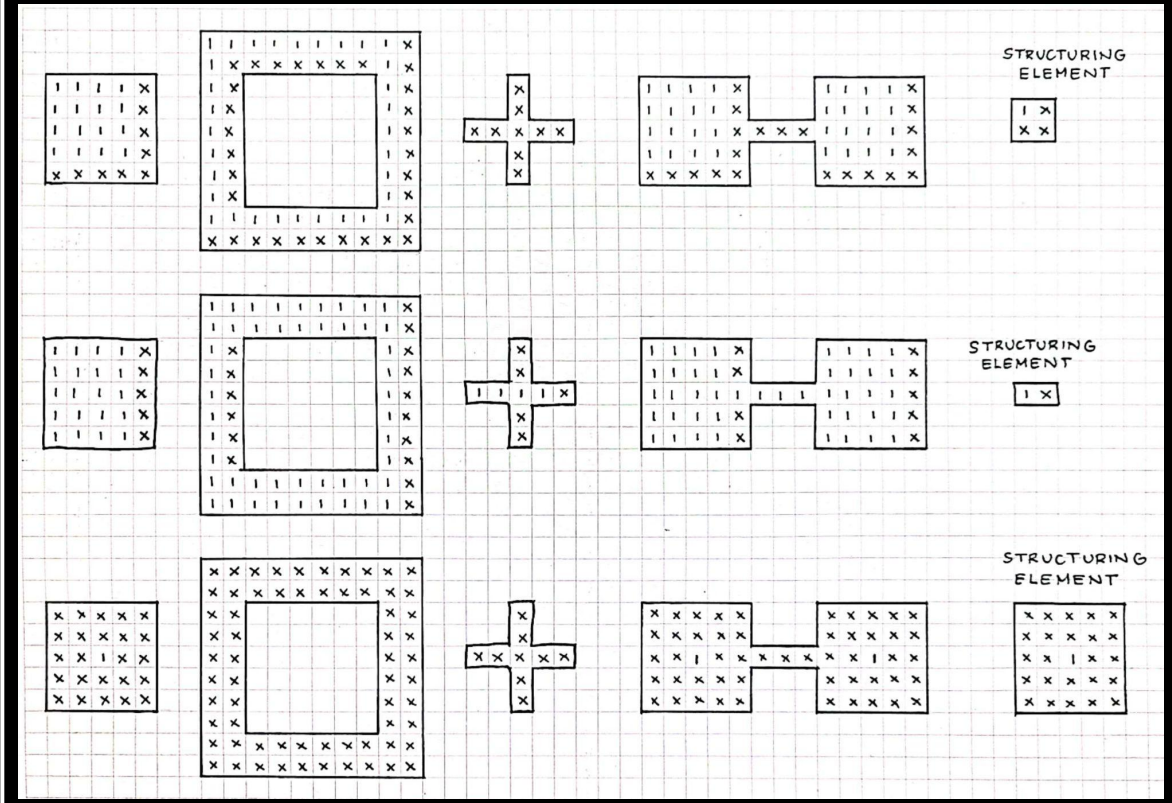


Figure 1. Hand-drawn erosion operations on various shapes using various structuring elements.

Before computationally performing morphological operations on various images, we first perform them on hand-drawn shapes. **The erosion operation 'erodes' an image by removing 'mismatched' pixels on its boundaries.** We choose a structuring element with an arbitrary origin ('1') to traverse the pixels of an image object. **When all of the pixels in the structuring element covers the entire pixels of the object, we fill the pixel with '1'. If there is at least one pixel that did not match, we fill it with 'x' denoting that this pixel has been eroded.**

PREDICTING DILATION OPERATIONS

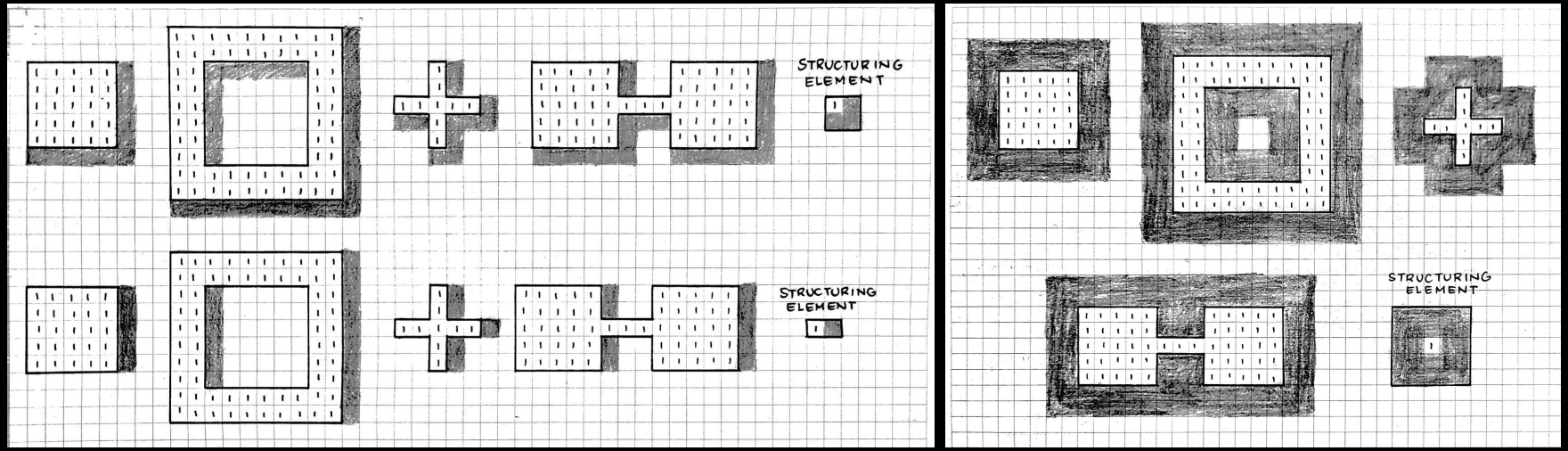
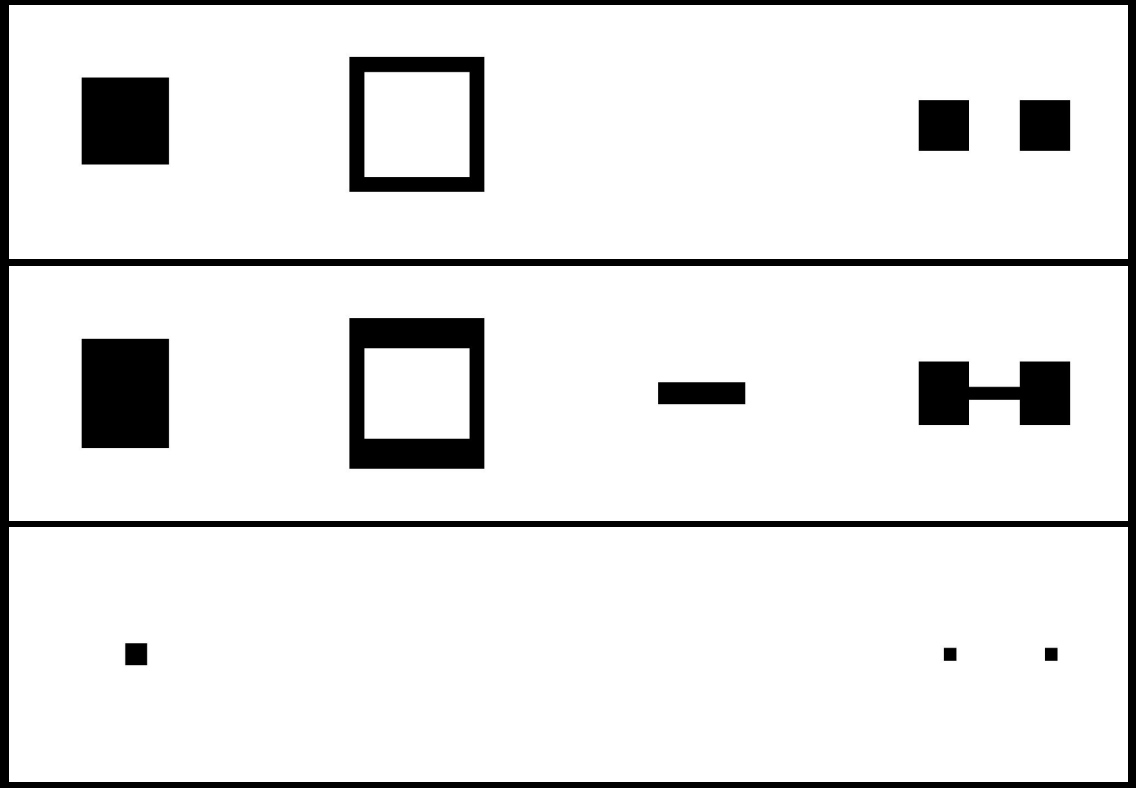


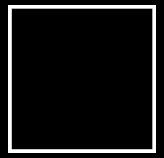
Figure 2. Hand-drawn dilation operations on various shapes using various structuring elements.

The dilation operation involves the expansion of image pixels by 'dilating' the pixel boundaries. Similarly, we traverse each pixel in the image object using a structuring element. **When at least one pixel in the structuring element covers a pixel in the object, we fill the object in with the values of the structuring element.** For the hand-drawn demonstration above, the shaded areas are also 1's but they also represent where the dilation operation happened.

SIMULATING EROSION OPERATIONS

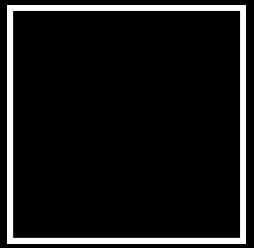


Structuring Elements



a) 2x2 ones

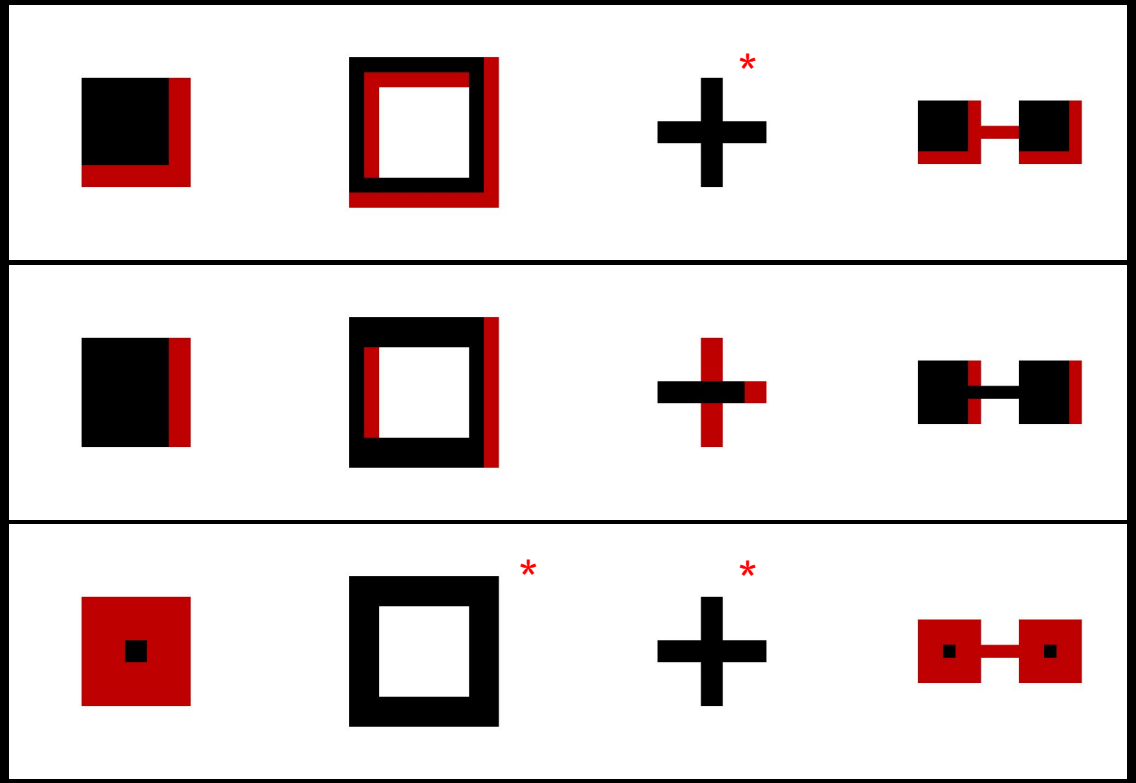
b) 2x1 ones



c) 5x5 ones

Figure 3. Actual erosion operation results. From left to right: 5x5 square, 10x10 square (2 boxes thick), plus sign (5 boxes across), dumbbell (2 5x5 boxes connected by a 3x1 line).

BEFORE AND AFTER: EROSION OPERATIONS



Structuring Elements

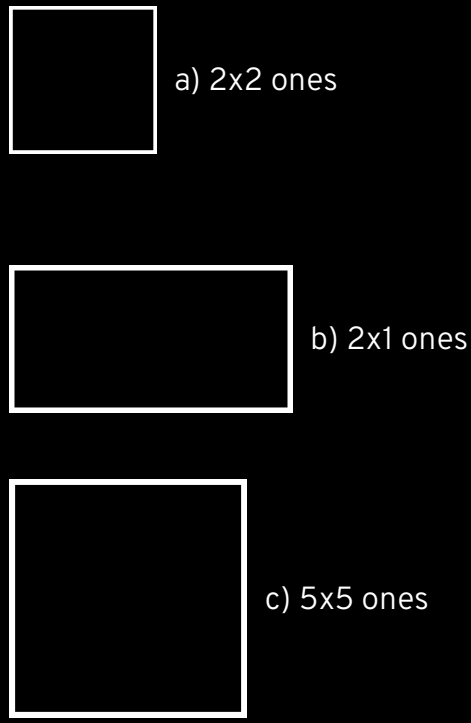
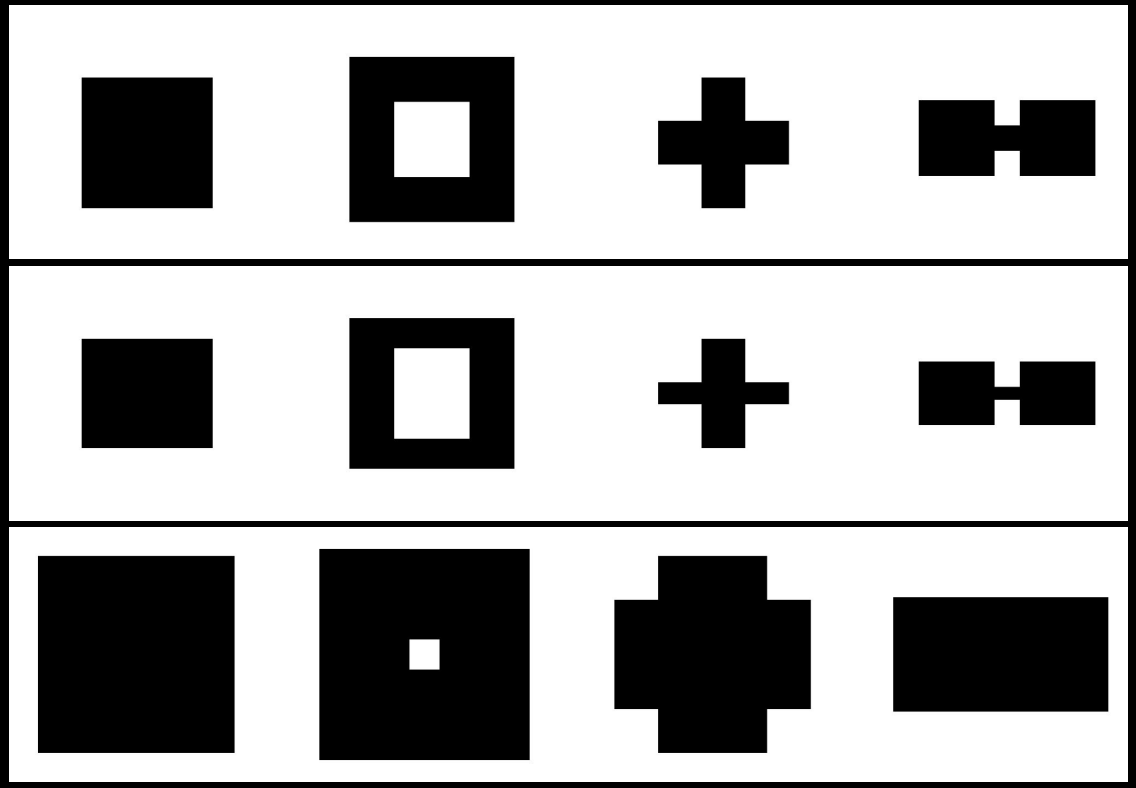


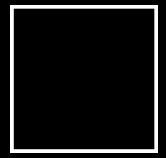
Figure 4. Juxtaposition of before and after the implementation of erosion operations. The red parts highlight the areas where the images were eroded.

*Disclaimer: We remark that these images should be red. After the erosion operations, these images were completely eroded, and thus, we only see the juxtaposition of the original images over the actual erosion operation.

SIMULATING DILATION OPERATIONS

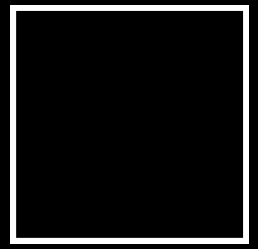


Structuring Elements



a) 2x2 ones

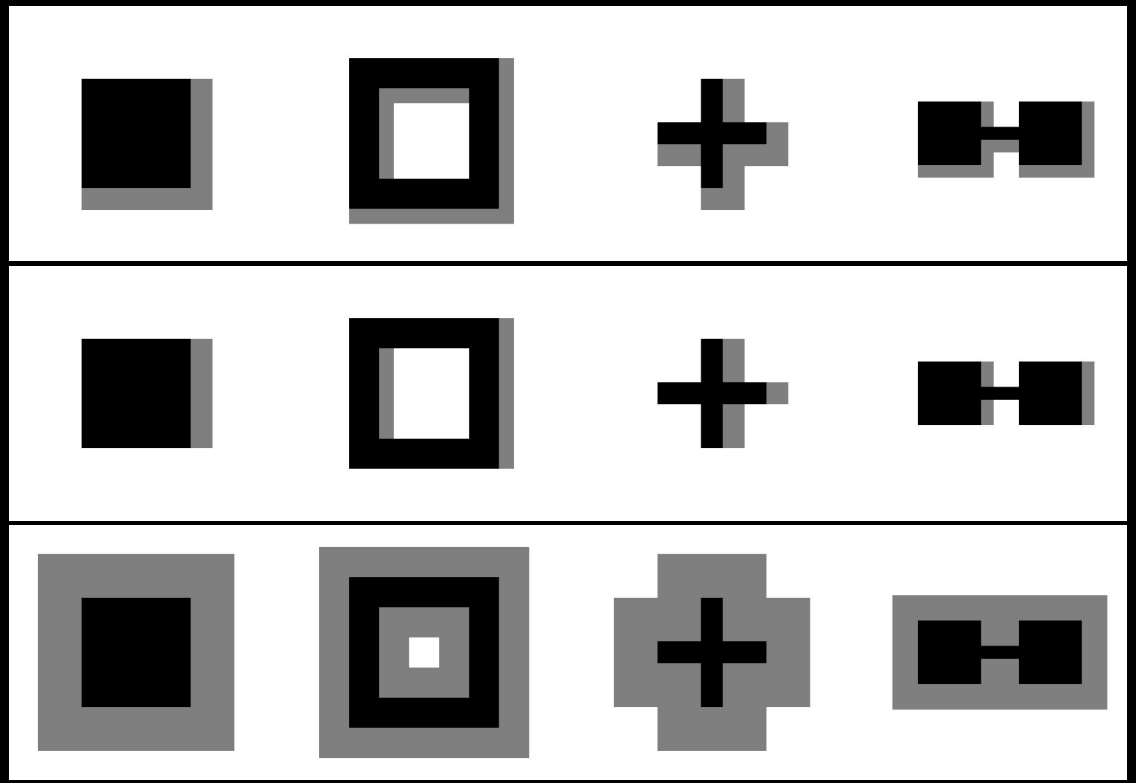
b) 2x1 ones



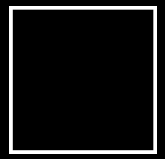
c) 5x5 ones

Figure 5. Actual dilation operation results. From left to right: 5x5 square, 10x10 square (2 boxes thick), plus sign (5 boxes across), dumbbell (2 5x5 boxes connected by a 3x1 line).

BEFORE AND AFTER: DILATION OPERATIONS

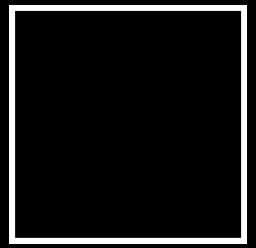


Structuring Elements



a) 2x2 ones

b) 2x1 ones

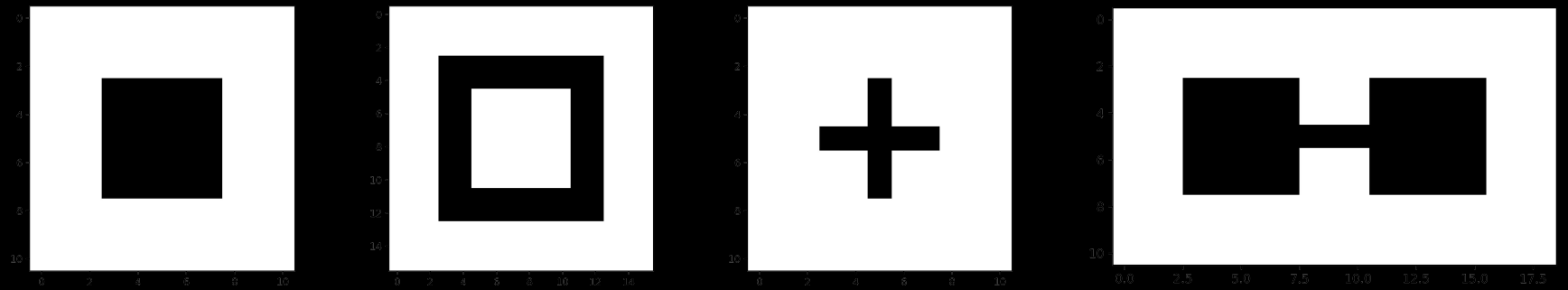


c) 5x5 ones

Figure 6. Juxtaposition of before and after the implementation of dilation operations. The gray parts highlight the areas where the images were dilated.

MORPHOLOGICAL OPERATIONS: CONCLUSIONS

We have successfully implemented erosion and dilation operations in computer simulations. The results suggest a 100 % accuracy in the previously drawn morphological predictions in Fig. 1 and Fig. 2. By specifying the ‘anchor’ parameter in the dilation and erosion packages, we can vary the origin which determines how the structuring elements will traverse and transform the image. Much of the analysis was already discussed in the preliminary slides.



MORPHOLOGICAL OPERATIONS ON MALARIA CELLS

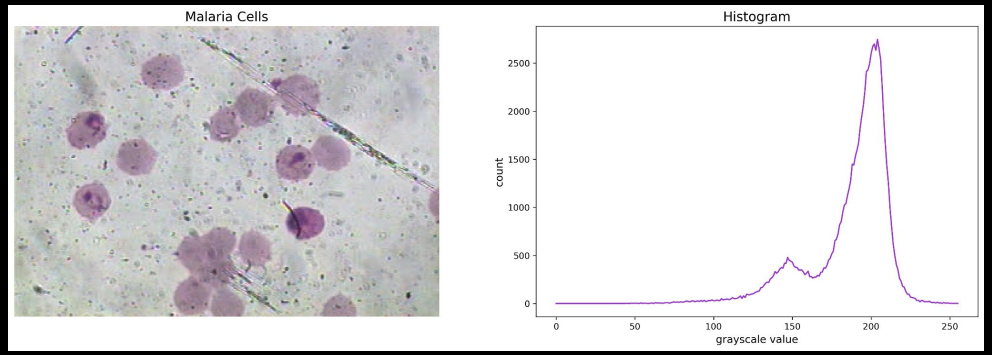


Figure 7. Image of the malaria cells and its corresponding grayscale histogram.

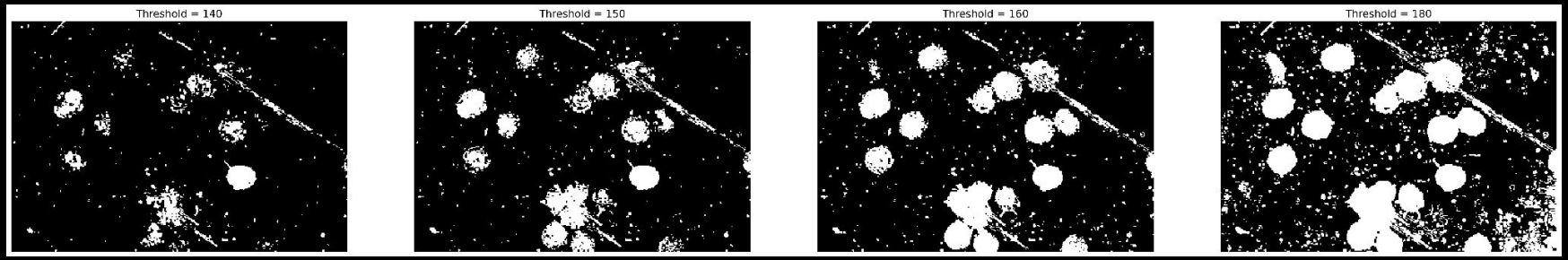


Figure 8. Thresholded images of the malaria cells.

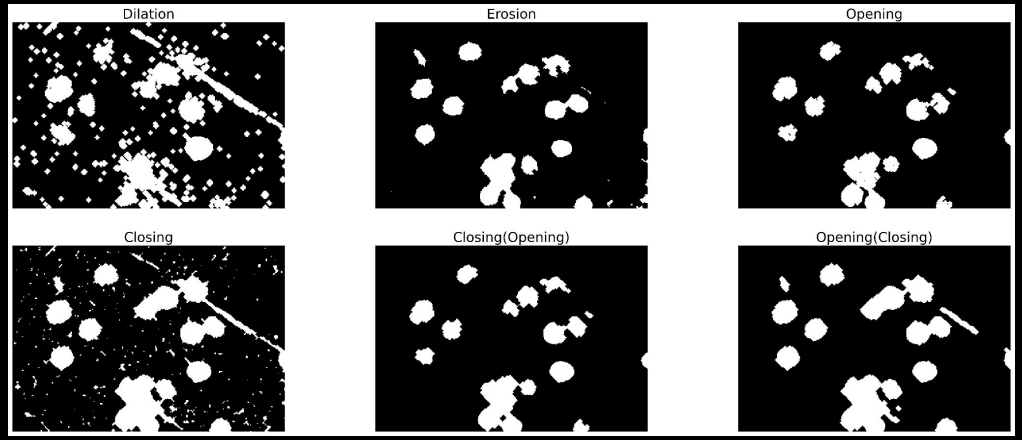


Figure 9. Various morphological operations on the malaria cells using a diamond structuring element.

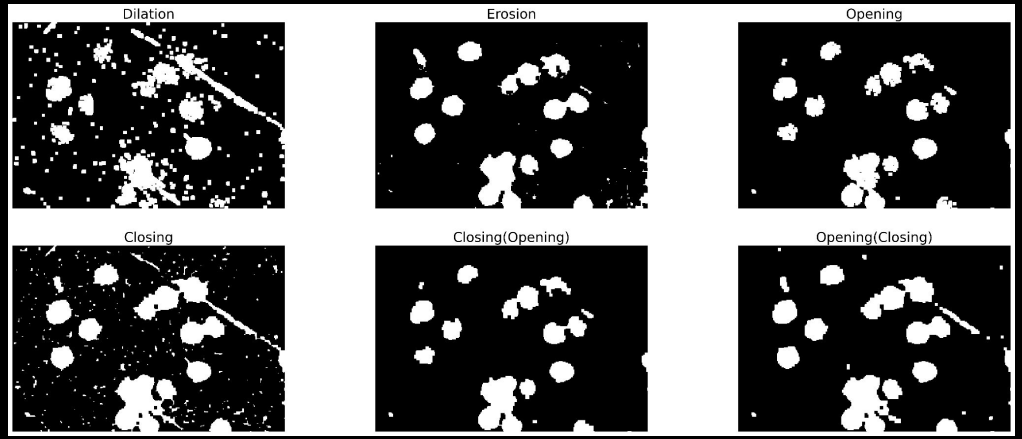
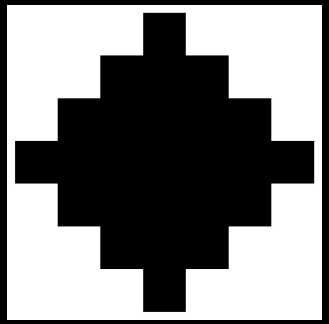
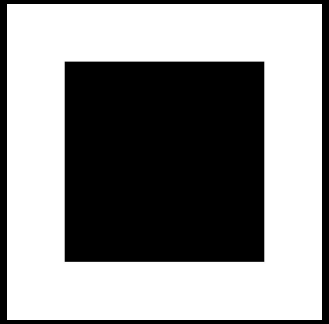


Figure 10. Various morphological operations on the malaria cells using a square structuring element.

Structuring Elements



a) diamond ones
(r=7)



b) 4x4 ones

MALARIA CELLS: CONCLUSIONS

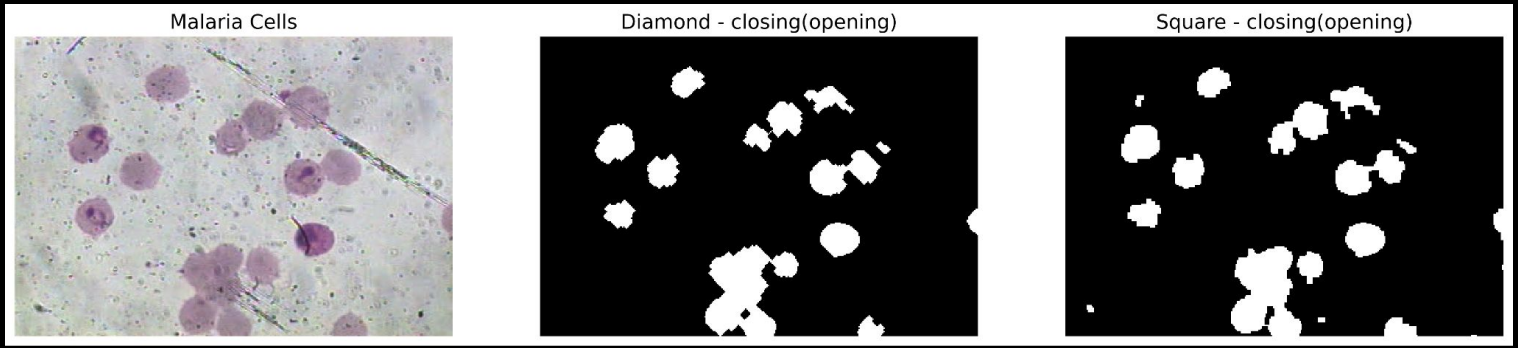


Figure 11. Cleaned images by the closing(opening) operation using diamond and square structuring elements.

From Fig. 8 and Fig. 9 in the last slide, we can clearly see that **the diamond structuring element performed better in cleaning the dust particles from the image.** Since the diamond has a more complex and defined structure, as well as having a better match in eccentricity with the blobs, than the 5x5 square, **it is inherently going to cause more sensitivity when traversing the image** during the subsequent morphological operations. We pick the best result as the closing(opening) operation shown in Fig. 11 above. **First, the opening operation was used to erode then dilate the eroded image.** This is a preliminary step in **removing small objects and thin lines from the image while preserving the shape of the larger objects.** Finally, after performing morphological opening, **the closing operation was implemented on the same image to dilate then erode the dilated image.** As a result, this effectively **fills in any small holes and gaps in the image that the previous algorithm may have missed.**

02 REFLECTION

REFLECTION

Overall, this was a great activity!

Morphological operations is a great break from the complexities of the previous coding sessions. It is also a great refresher for set theory which I sometimes forget. I also greatly enjoyed predicting various morphological operations by free-handing them on a graphing paper. It was kind of therapeutic and peaceful.

Besides that, I believe that my results are accurate and stayed true to the topic, with additional cross references and analyses. I also cross-validated my results with my instructor and with my peers. However, if I was given more time, I would implement these morphological operations on more complex images like satellite data and space data.

SELF-GRADE

Technical Correctness: 35/35

I believe that my results are correct through math, research, and through validation with my peers and with my instructors.

Quality of Presentation: 35/35

I believe that the quality of my powerpoint is up to par with the course expectations. I constructed the figures as instructed, and exported my data accordingly.

Self-Reflection: 30/30

I believe that I have acknowledged and reflected upon the activity well enough. I also have complete citation on the next slide.

Initiative: 10/10

I went above and beyond with my data presentation, and included extra analyses for the activities.

REFERENCES

[1] Chhikara, P. (2022, April 3). Understanding Morphological Image Processing and Its Operations. *Medium*. https://towardsdatascience.com/understanding-morphological-image-processing-and-its-operations-7bcf1ed11756

[2] *Morphological Image Processing*. (n.d.). https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic4.htm

[3] *Morphology - Closing*. (n.d.). https://homepages.inf.ed.ac.uk/rbf/HIPR2/close.htm

[4] *Morphology - Opening*. (n.d.). https://homepages.inf.ed.ac.uk/rbf/HIPR2/open.htm

[5] *OpenCV: Morphological Transformations*. (n.d.). https://docs.opencv.org/4.x/d9/d61/tutorial_py_morphological_ops.html

[6] *Types of Morphological Operations - MATLAB & Simulink*. (n.d.). https://www.mathworks.com/help/images/morphological-dilation-and-erosion.html