APP PHY 157 WFY-FX-2

LAB REPORT 5

Image Segmentation

Source code here!

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

Background

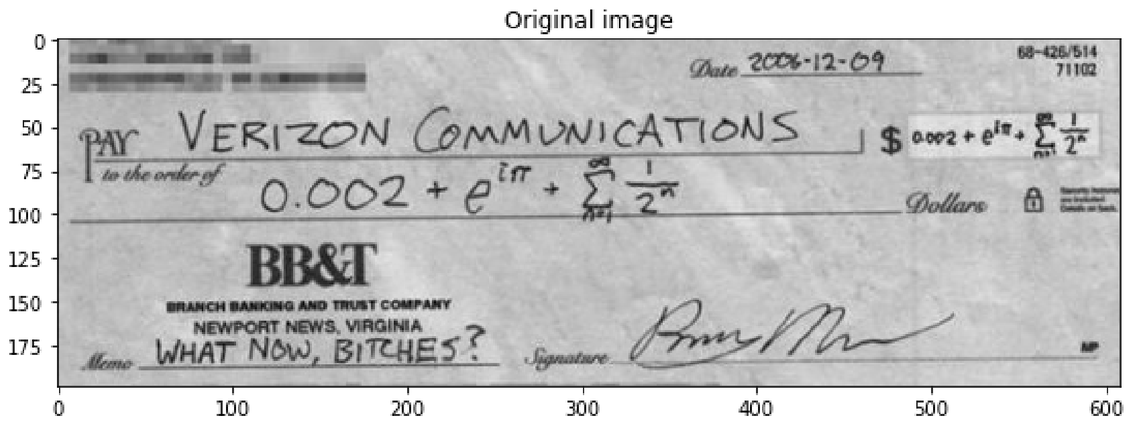
Image segmentation is the first part of image feature extraction. It is where you choose a region of interest (ROI) to perform further processes on. Aside from feature extraction, segmentation is also useful in object recognition, image compression, medical imaging, autonomous vehicles, and many others

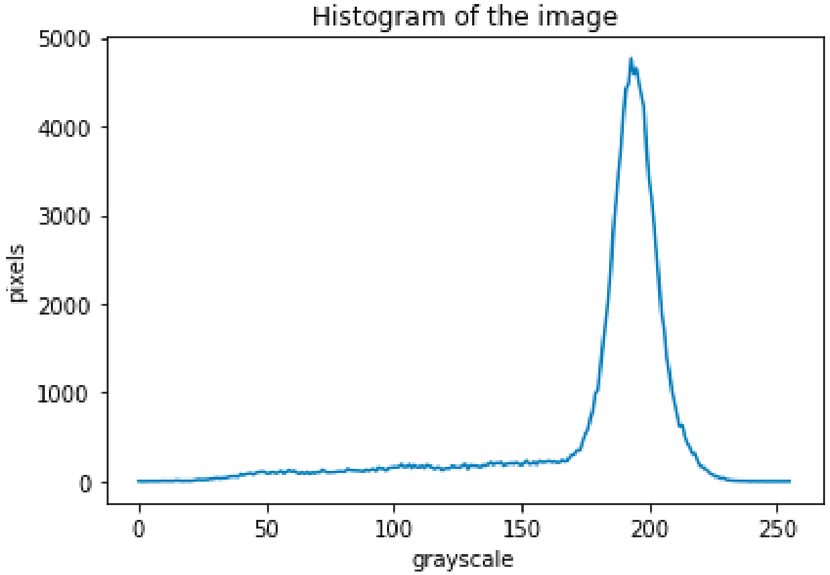
Objectives

In this activity, we aimed to do the following:

1. Demonstrate image thresholding
2. Perform parametric image segmentation
3. Perform nonparametric image segmentation

Results and Analysis

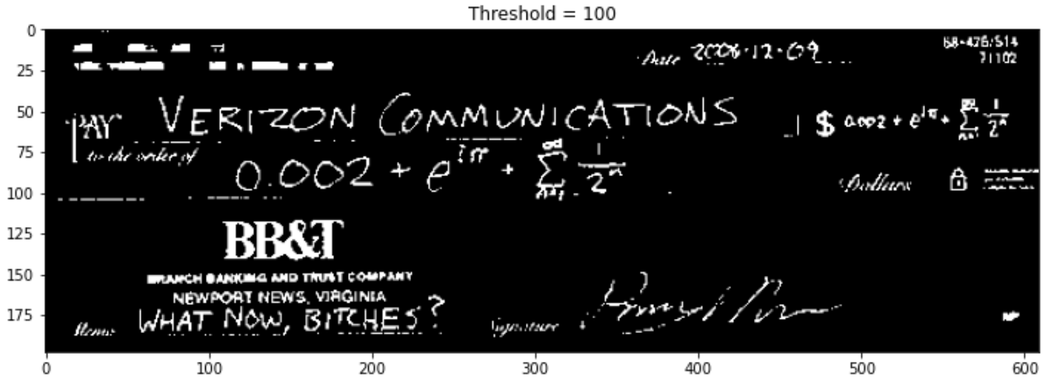


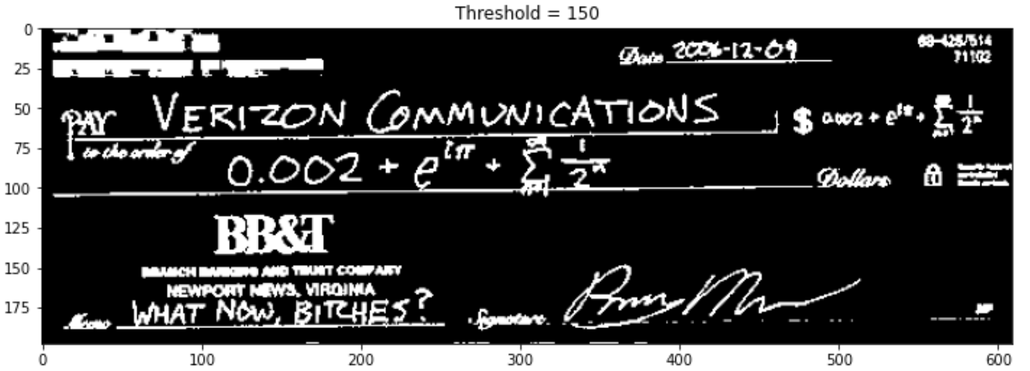


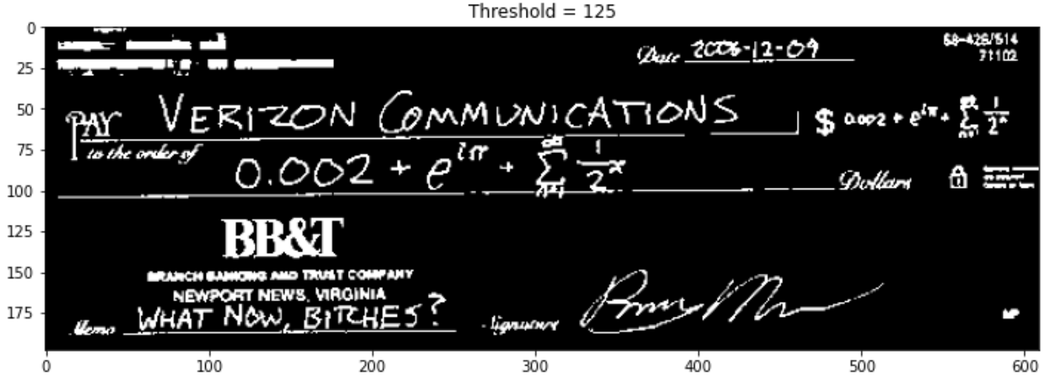
For grayscale images, segmentation is easily done by applying a threshold because they only have one channel of intensity values. So classifying the pixel values to be black or white whether they are above or below a set threshold is the best approach. For this, we want to segment the text and handwriting.

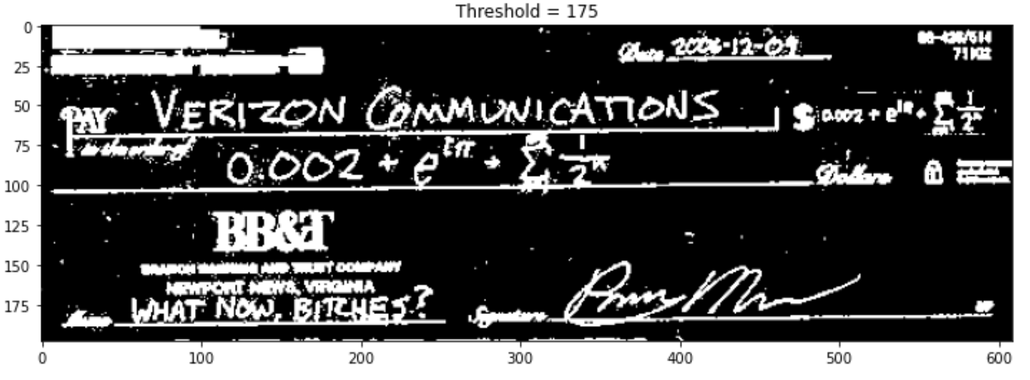
The histogram of the pixel values above shows that the peak values must correspond to the background pixels since those take up a huge space in the image. Hence, we set a threshold within the surrounding range, assuming that those correspond to the pixel of the region of interest.

Grayscale images









Different thresholds were applied, as shown in the figures above. And as observed, increasing the threshold allowed more pixels to be considered as part of the region of interest. Therefore, making the text and handwriting appear more visible. However, setting the threshold too high might also include pixels that are not necessarily part of the region of interest, as demonstrated.

But since images of objects that are 3D usually have color and shading variations, image thresholding is not always the best practice. The next few slides will demonstrate different methods that could account for the limitation of thresholding.

Parametric Segmentation

Parametric segmentation is one of the ways to segment an image based on color. Given an image on the left, we select a region of interest (ROI denoted by the green box on the picture. Gaussian distribution is then used to represent the intensity values present in the patch (shown below). Unlike the previous method, the threshold here is determined by the mean and standard deviation of the distribution.

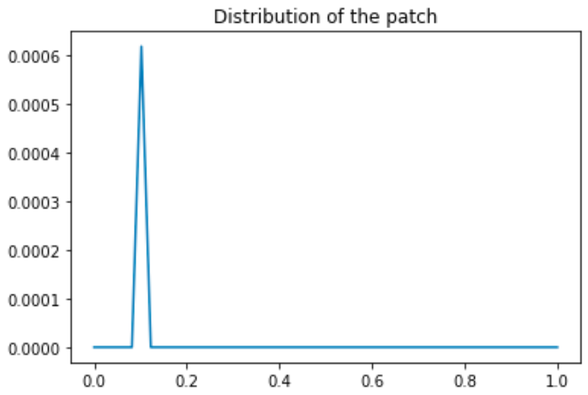
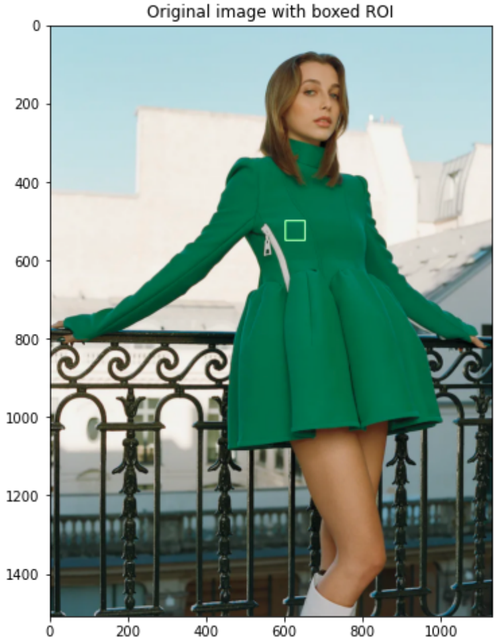
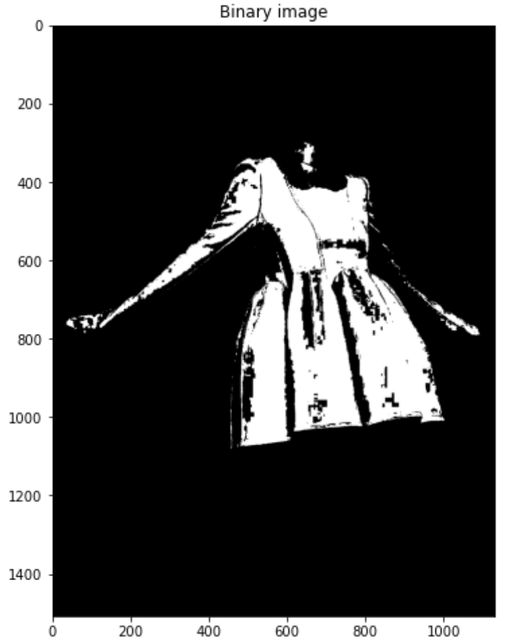
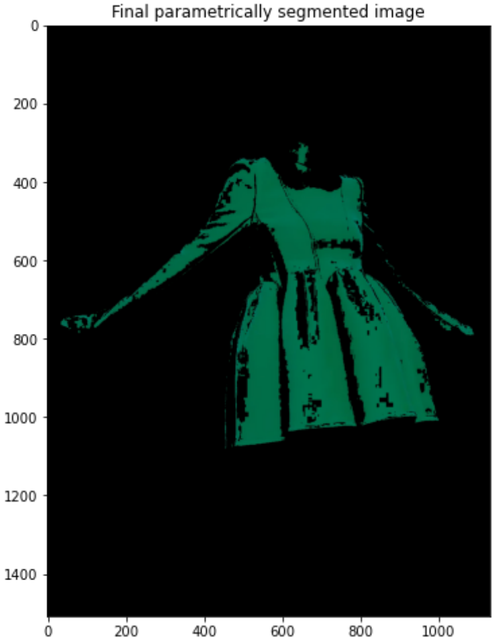


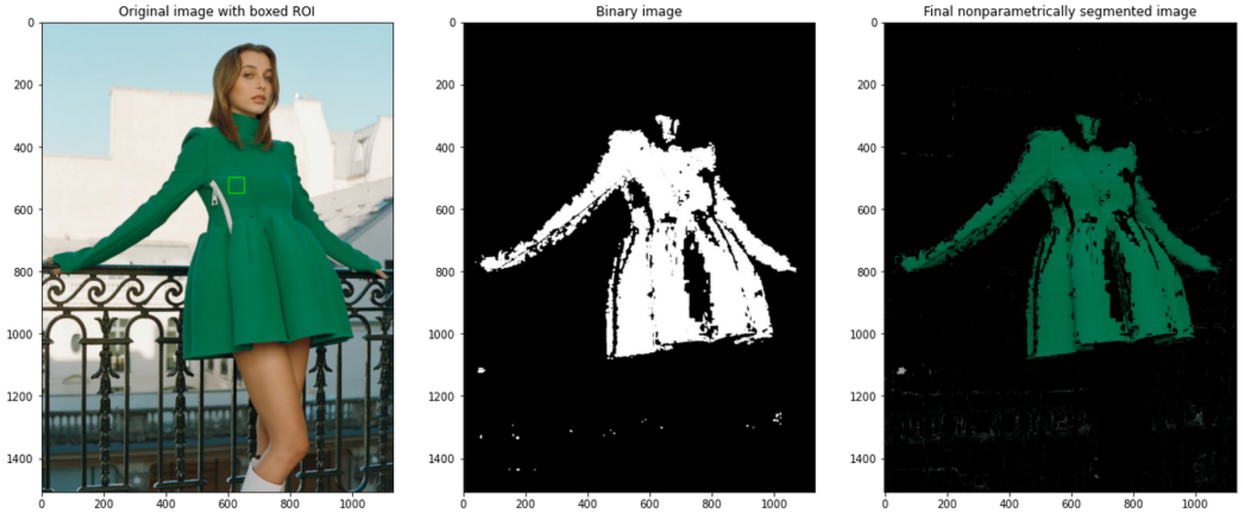
Image source: W Magazine







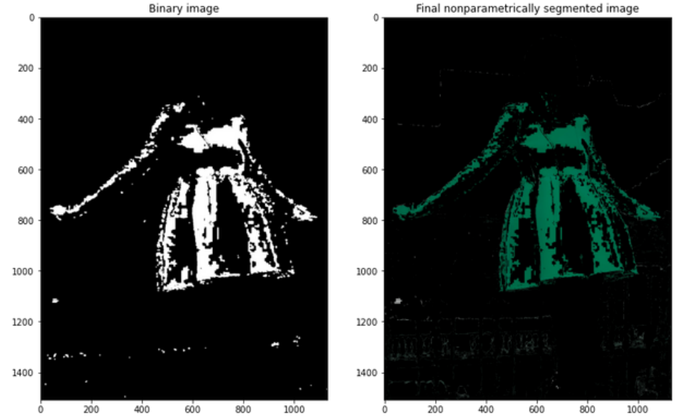
The selection of the patch or ROI really dictates the final segmented image you'll have. For this image, for example, the goal was to segment the dress. By parametric segmentation, the desired region was segmented without background noise. But since the ROI (if zoomed in) is just solid, there is also no depth in the segmented image. It is because it only segmented the pixel values corresponding to that of the ROI, and it was not able to account for the darker parts like the pleats and the sleeve of the dress since their values are already outside the threshold.



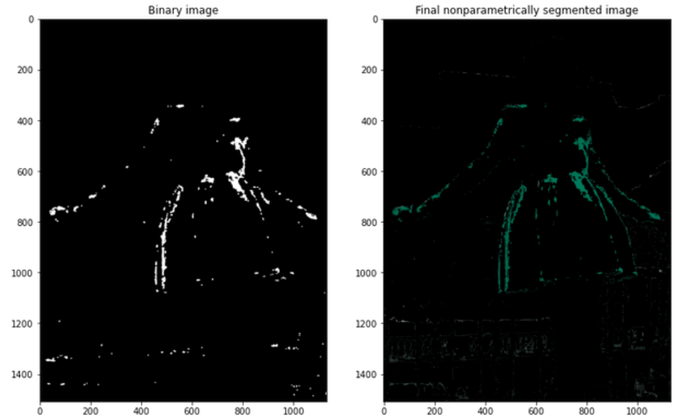
Unlike the previous method, nonparametric image segmentation does not assume the distribution of the pixel values. Instead, it uses histogram back projection to segment the image. It calculates the probability distribution of the pixel values by normalizing the histogram of the ROI, the bin size of the image above is 180. It is then thresholded wherein the white values correspond to the values similar to the ROI.

Comparing it to the results of the parametric segmentation, nonparametric segmentation was able to segment more of the green dress, evidently observed on the sleeves part and some on the pleats of it. But also included a few greenish pixels on the railing in the picture. The bin size was also manipulated (results shown on the right) to see how it would affect the final image. Turned out, increasing the bin size resulted in fewer segmented pixels of the image. This is due to the fact that less number of bins lead to a less pronounced distinction between intensities.

Bin size =190



Bin size =200



Nonparametric segmentation

Different ROIs Comparison

Multiple solid color ROI

For this part, I wanted to see how well would these image segmentation methods perform using images with different ROIs.

In the example on the left, the goal was to segment the dress and so the roi selected was the striped green-gold region (indicated by the green box) of the dress. Using parametric segmentation, most parts of the dress were successfully segmented but it also included the body of the person wearing it. Perhaps the pixel values of the skin color were within the threshold of the ROI.

However, in the nonparametric segmentation, it did not include the skin color but it was also able to segment less of the dress. Hence, I would say for this one, I prefer the results of the parametric segmentation.

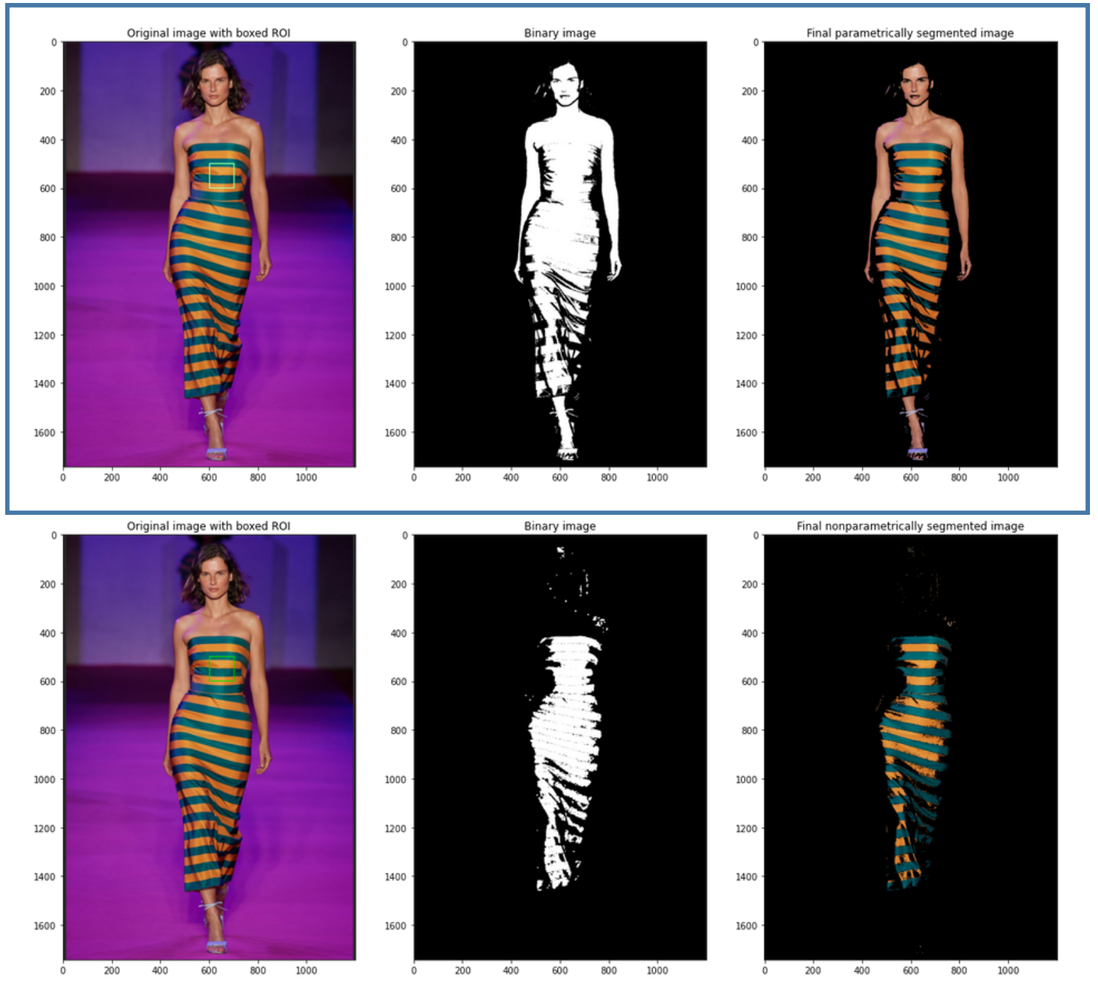


Image source: Voguee

Image source: Stylecaster

Continuous combination of colors ROI

For this example, the goal to be segmented again was the dress. The picture was purposely chosen so that the region of interest includes continuous or 'blended' colors.

Now, in parametric segmentation, a lot of the background pixels were also segmented along with the dress. As observed, most of the parts that were not segmented are the darker pixels.

In nonparametric segmentation, however, it was able to segment just the dress without the background. Most of the parts that were not segmented were also lighter pixels, as opposed to the parametric method. Even the lightest colors or parts of the dress were also excluded. And since the colors are continuous, the segmentation also wasn't that smooth.

Upon overall evaluation, the nonparametric segmentation performed well here.

Continuous combination colors ROI

Same goal as the previous example, but for this one, I wanted to check how well the color would be segmented if it was also 'continuously' dispersed in a different color.

In parametric segmentation, it was able to segment the desired color with a clean background. But in nonparametric results, it was able to segment even the edges and lighter parts of the ROI. It even included the stars in the background.

But since the goal was just to segment the copper/brownish/reddish color, I prefer the results of the parametric segmentation more.

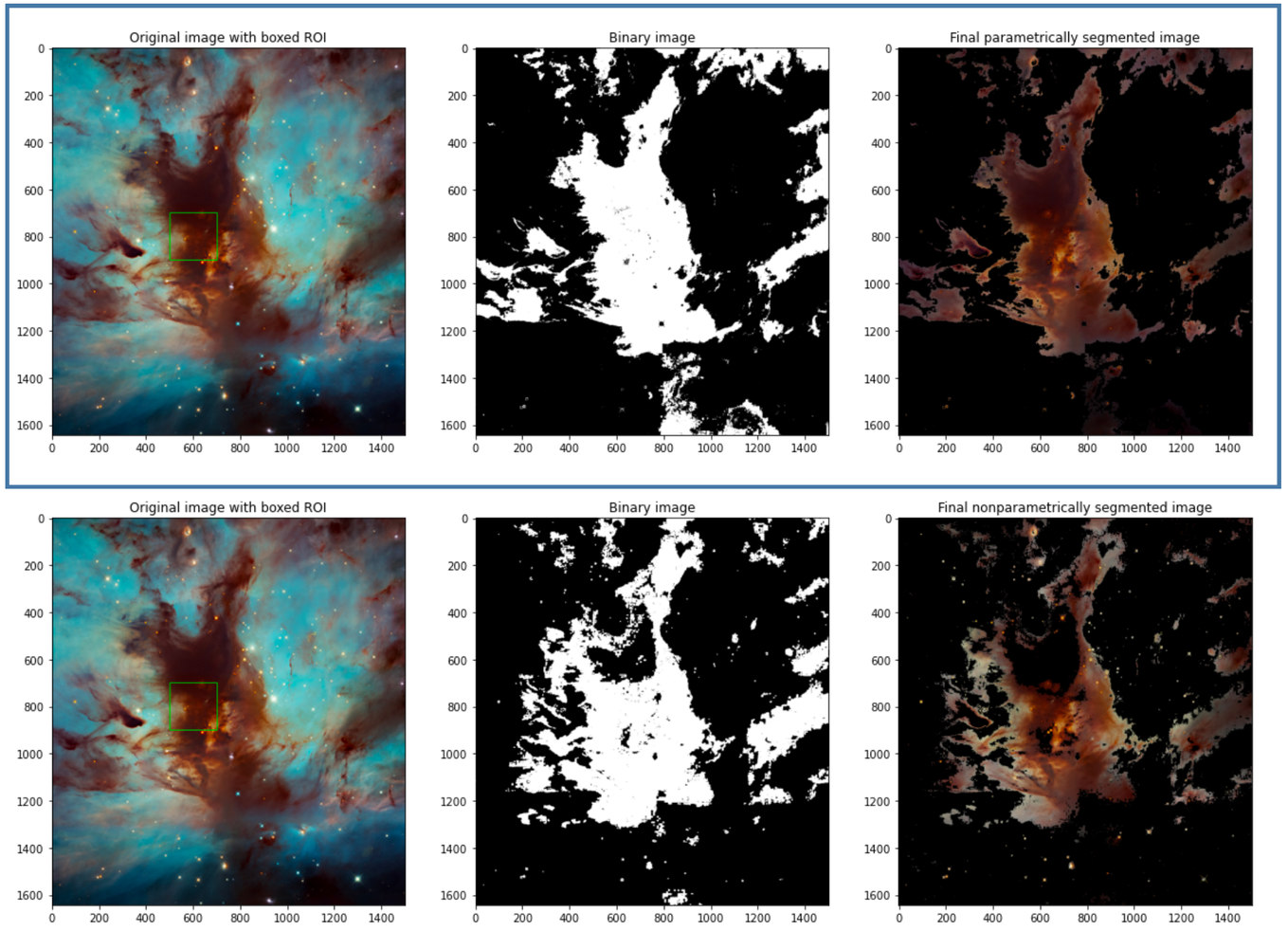


Image source: NASA Hubble

Different shades of same color ROI

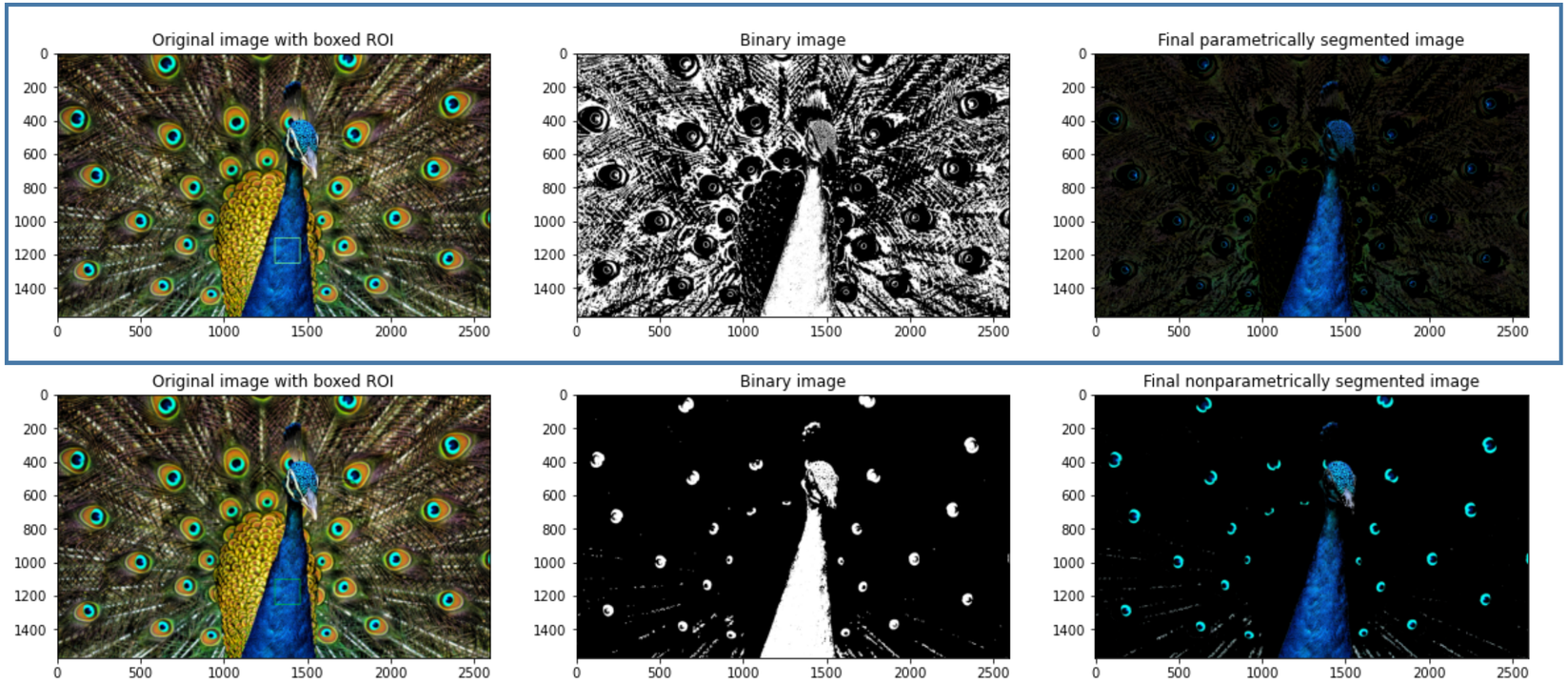


Image source: Wikipedia

For this example, the goal was to segment all shades of blue present on the feathers of the peacock. And after doing the parametric segmentation, it returned only the darkest shades of blue and a dimmed background. Whereas in nonparametric segmentation, it was able to segment even the lighter parts with a much cleaner background, and the resulting image also appears more visually pleasing than the other one. The nonparametric method definitely performed better here.

Takeaway: Image segmentation depends a lot on the nature of the image itself, how the colors are distributed, and the patch or ROI selected. And how well an image is segmented depends on what you want to segment in the first place, and whether or not it was segmented completely or not.

Reflection

I really really enjoyed this activity! Aside from the fact that I am no longer behind schedule, in this activity, I also started creating or defining functions for each of the methods mentioned. I feel like I should have been doing this all along. It made my program much more efficient and concise, and it was a lot easier to apply it to different images or change variables. Moreover, realizing that I am doing image segmentation and actually coding the nitty-gritty of it is pretty cool. Especially because I used to do this a lot before using different image editing tools. Anyway, I hope to keep this momentum for the rest of the lab reports!

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 comparing the performance of the methods with varying ROIs in different images.

References

Here are the materials I used to accomplish this activity:

Soriano, M. (2023). A5 - FEATURE EXTRACTION PART 1 OF 3: IMAGE SEGMENTATION. 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