ACTIVITY 5. FEATURE EXTRACTION PART 1 OF 3: IMAGE SEGMENTATION

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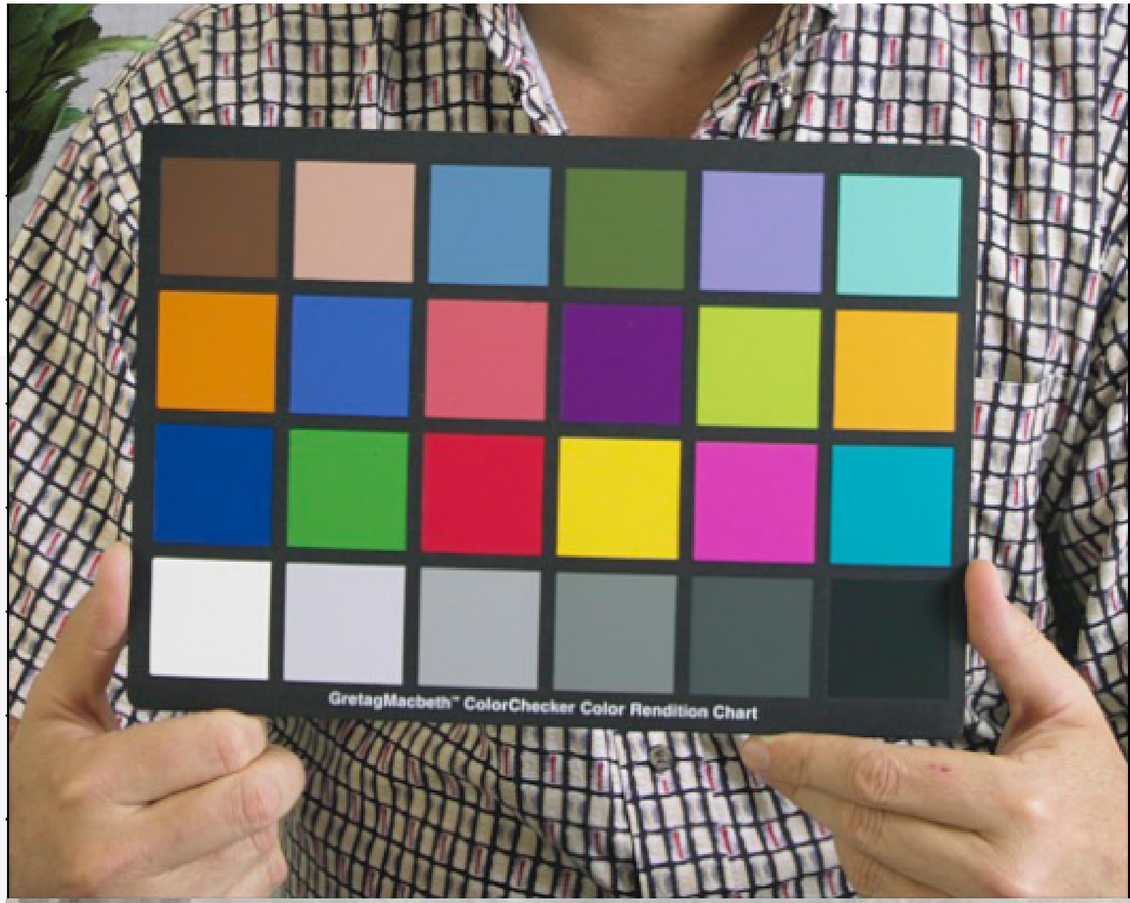
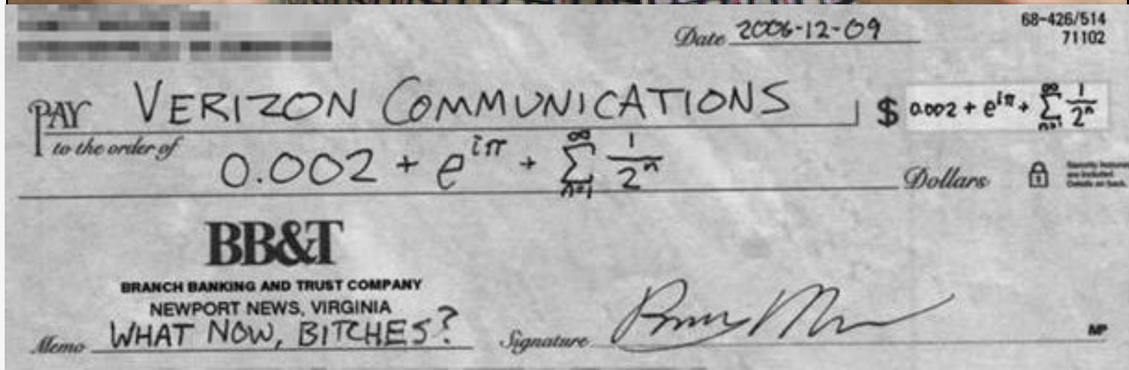
App Physics 157 WFY-FX-1

Objectives

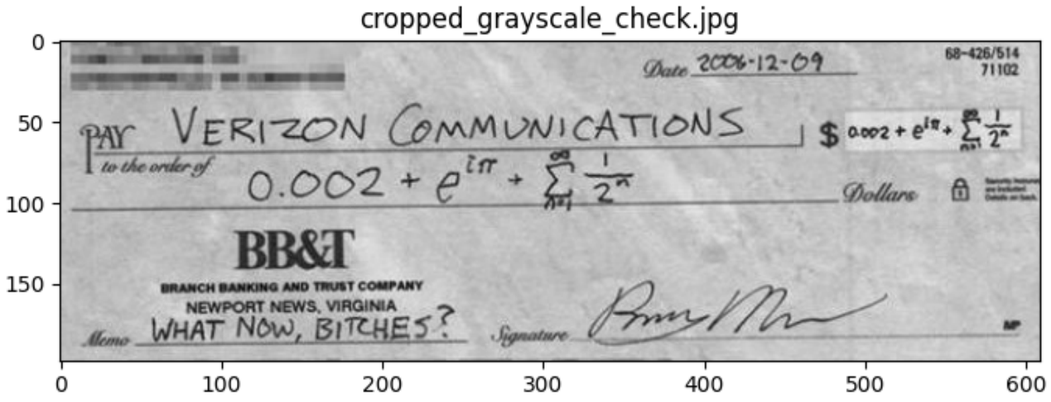
- Apply thresholding on a grayscale image based on its histogram.
- Apply non-parametric and parametric segmentation on different images.
- Investigate the effects of changing the number of bins for non-parametric segmentation.

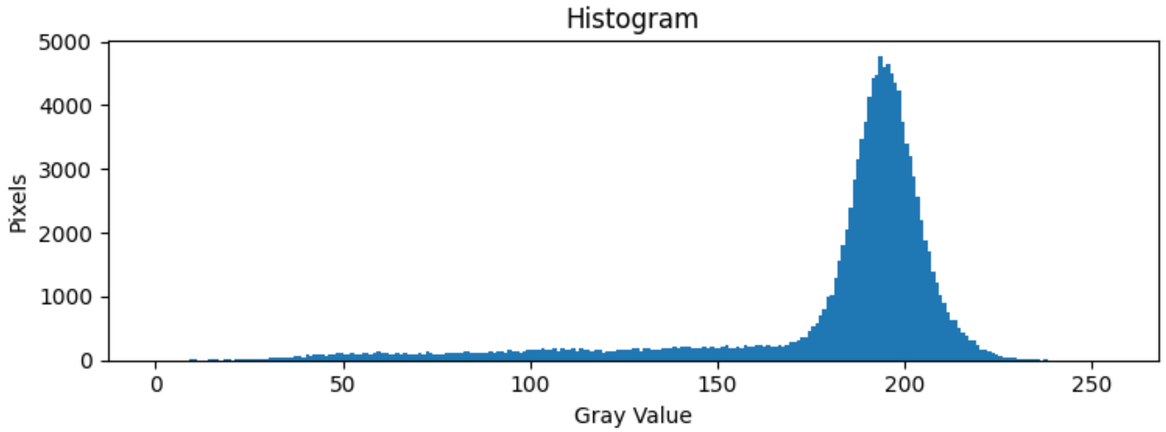




Segmentation of Grayscale Images

I segmented a grayscale image through thresholding. I did this by first getting the histogram of the image, and then applied different thresholds. The following are my results.

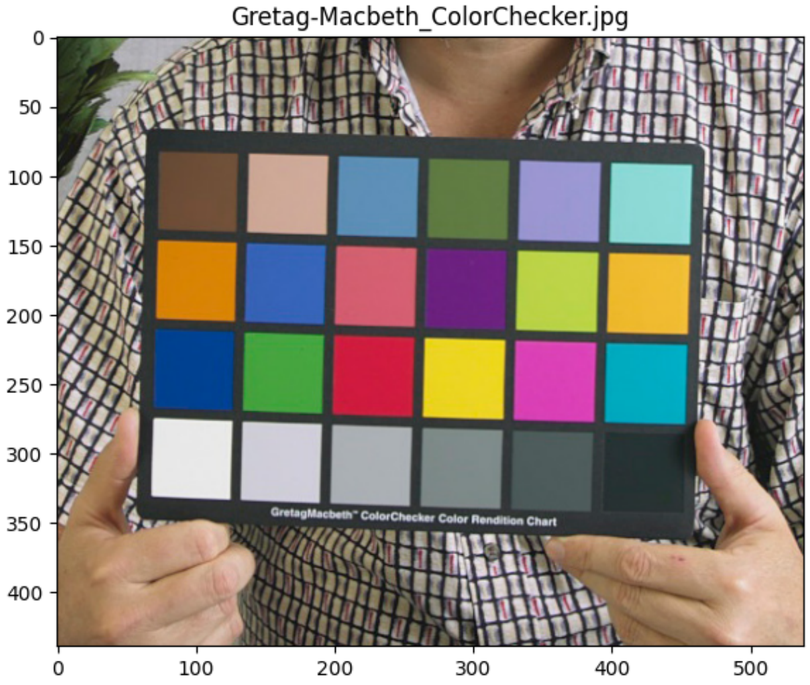


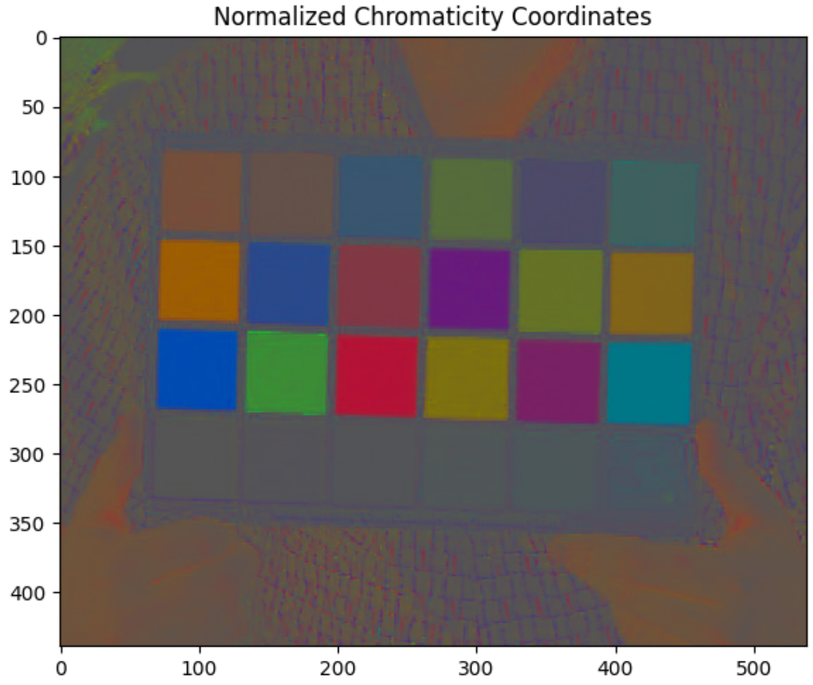


From the histogram above, it can be seen that there is a peak at around the gray value of ~190. Looking at the image, it can be seen that the background is primarily composed of light gray pixels. Thus the peak is where majority of the background is. So I will 0 out the pixels in the peak and set the other pixel values to 1.

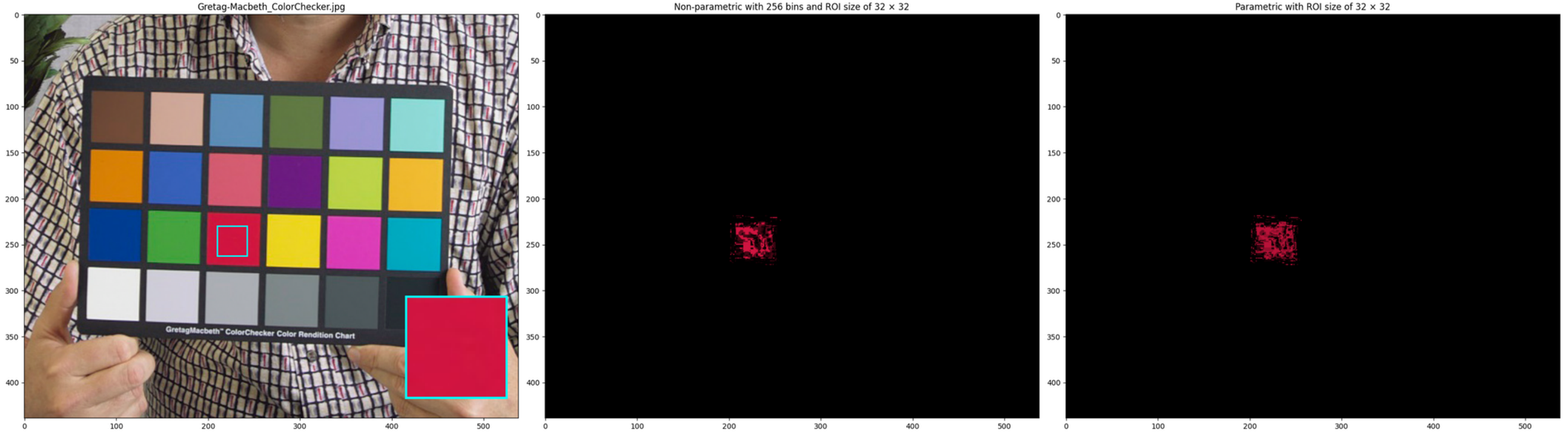
I first tried to zero out the pixel values between 140 and 240 (top most image). I then narrowed the range of the removed values (i.e. the gray values that I zeroes out). It can be seen that as I decrease the range, more noise is introduced into the binarized image. This noise is the background of the image that I wanted to remove. This is because as I made the range narrower, more background pixels are not removed. Thus they appear as noise in the binarized image.

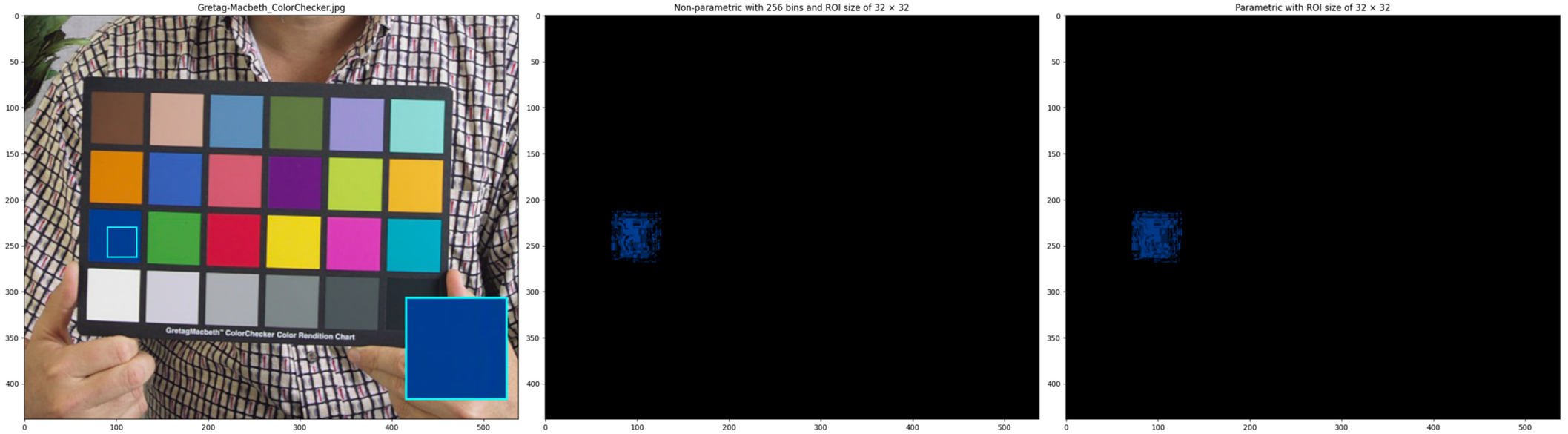
Parametric and Non-parametric Segmentation

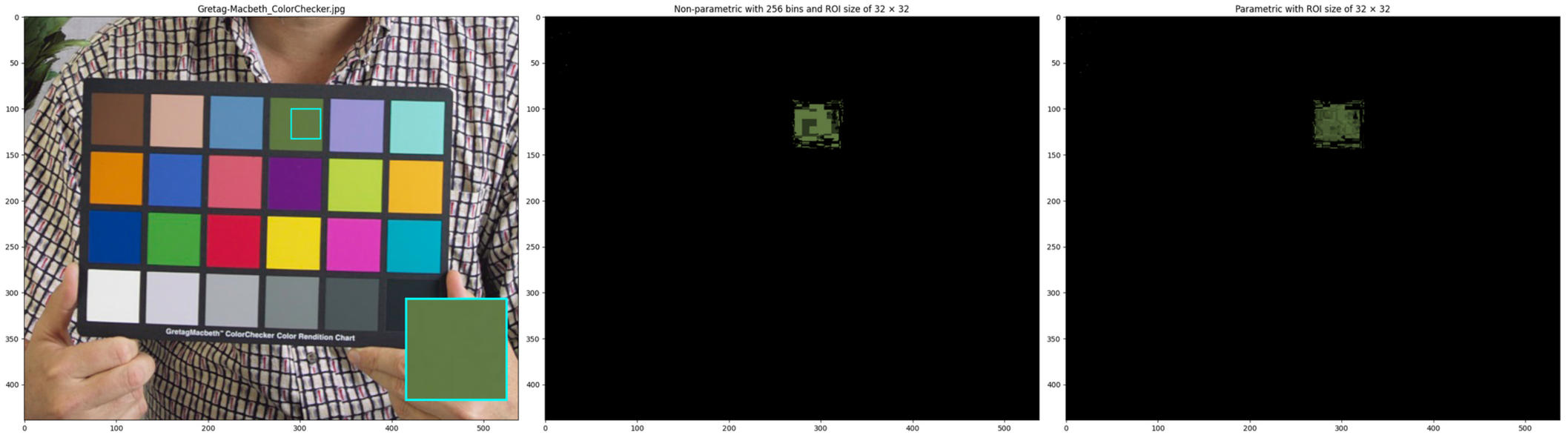




I applied parametric and non-parametric segmentation on the Gretag-Macbeth color checker to see if my code worked. I displayed the segmented images of both methods side by side to compare them. I used 256 bins for the histogram in non-parametric segmentation and used a 32 pixel by 32 pixel ROI size for both types of segmentation. The results are in the following pages.


Gretag-Macbeth_ColorChecker.jpg
Non-parametric with 256 bins and ROI size of 32 × 32
Parametric with ROI size of 32 × 32
GretagMacbeth™ ColorChecker Color Rendition Chart


Gretag-Macbeth_ColorChecker.jpg
Non-parametric with 256 bins and ROI size of 32 × 32
Parametric with ROI size of 32 × 32
GretagMacbeth™ ColorChecker Color Rendition Chart



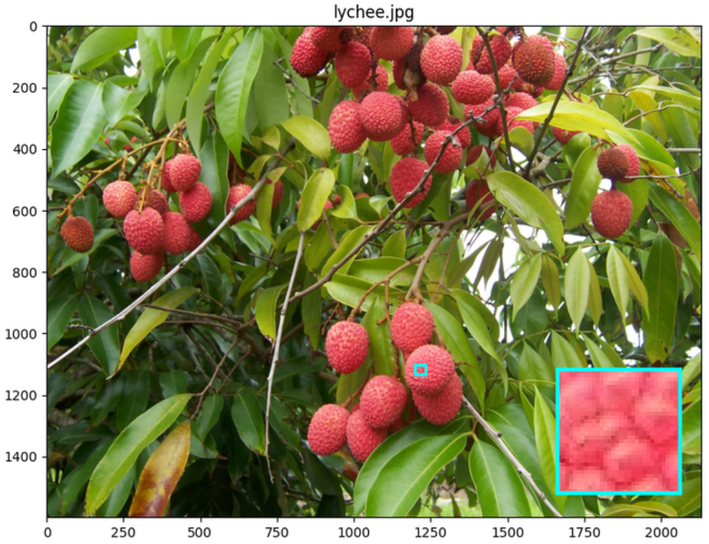
Looking at the results, it can be seen that I have successfully segmented an image based on color. But the segmented images do not look like perfect colored squares, unlike the ones in the original image. This is because of the artifacts in the image which was caused by the camera that took the image and the jpeg compression [1]. But even with these artifacts, I can still say that my program has still successfully segmented this image. Since I now know that my code works, I will then investigate the effects of hte number of bins for the non-parametric segmentation.

Changing the number of bins

Source: By B. Naves, 2006, self-photographed at Saint-Benoît (Réunion island). Picture retrieved from: https://en.wikipedia.org/wiki/Lychee#/media/File:Litchi_chinensis_fruits.JPG

I investigated the effects of changing the number of bins in the 2D histogram for non-parametric segmentation. And for this part of the activity, I used a picture of a lychee tree that was taken by Wikipedia user, B. Naves [2]. I used 4, 16, 32, 64, and 128 bins for non-parametric segmentation and used a 32 pixel by 32 pixel ROI size for both types of segmentation. I showed the parametric segmentation of the image just for comparison.

Additionally, I used a lychee image because I wanted something with a non-uniform color for the ROI. The results are in the succeeding slides.


lychee.jpg
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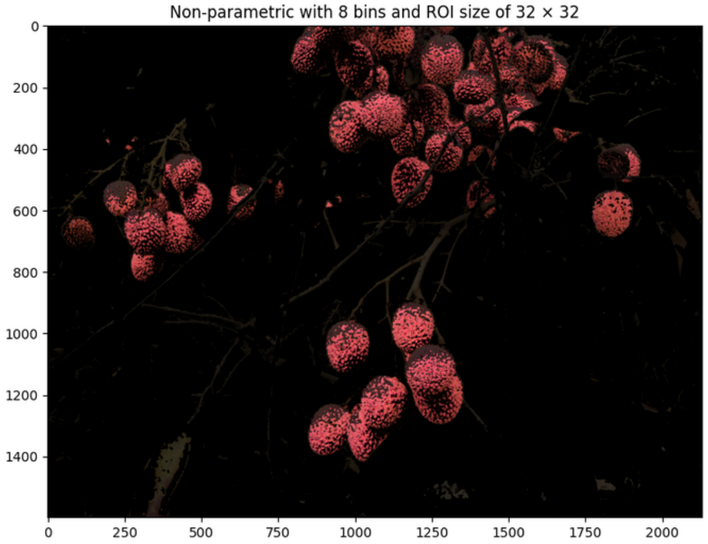
Non-parametric with 8 bins and ROI size of 32 × 32
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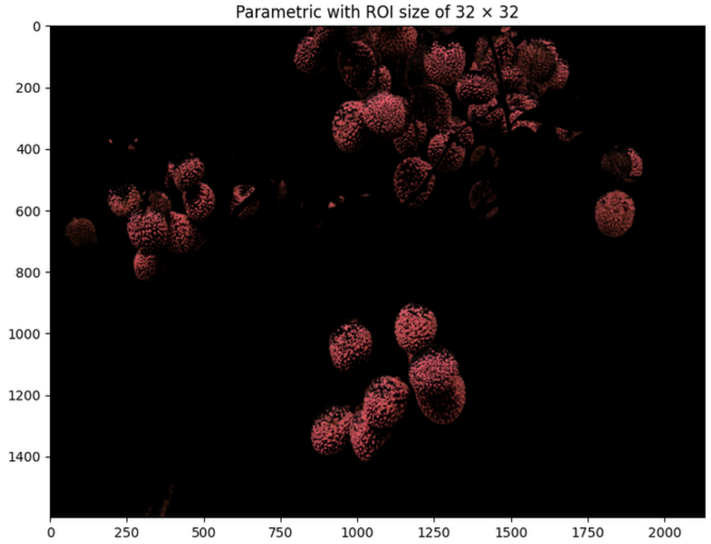
Parametric with ROI size of 32 × 32
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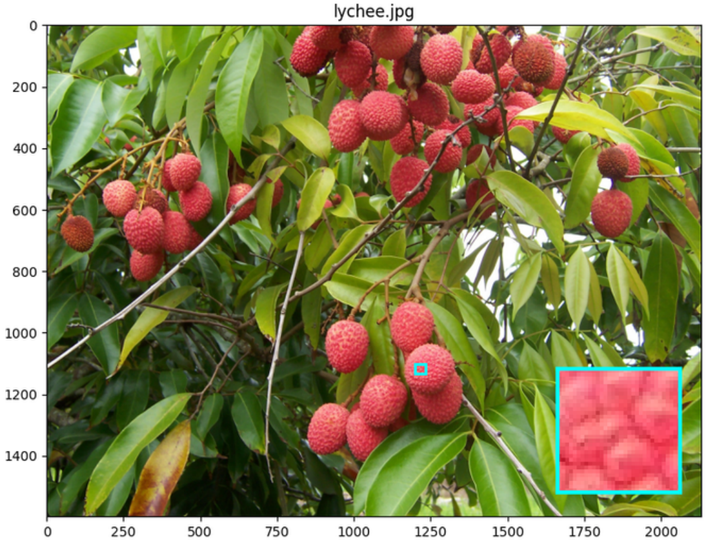
lychee.jpg
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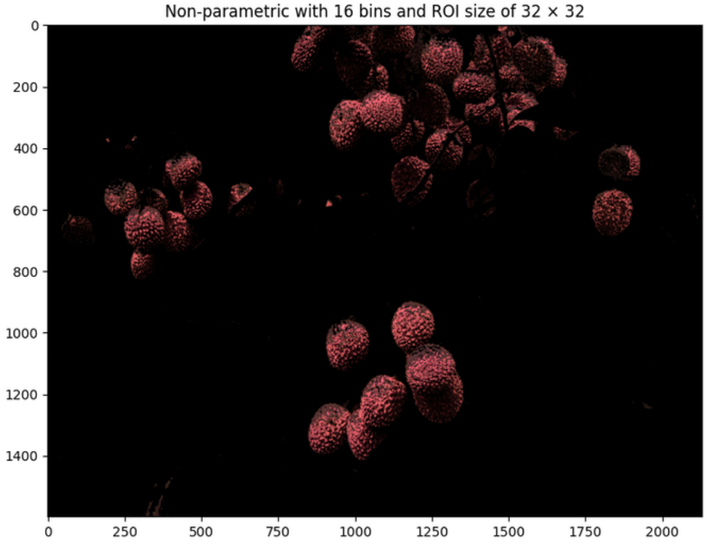
Non-parametric with 16 bins and ROI size of 32 × 32
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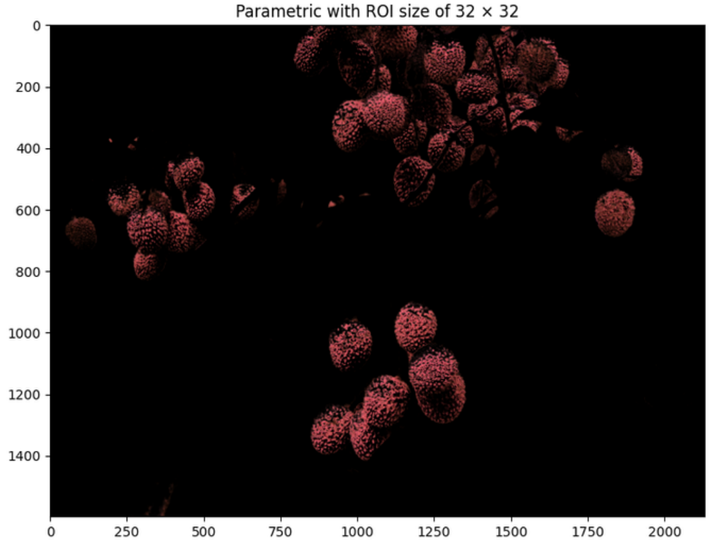
Parametric with ROI size of 32 × 32
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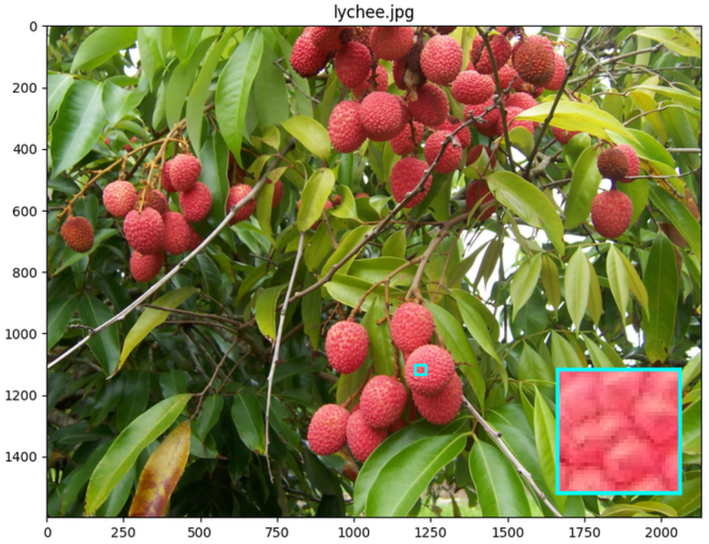
lychee.jpg
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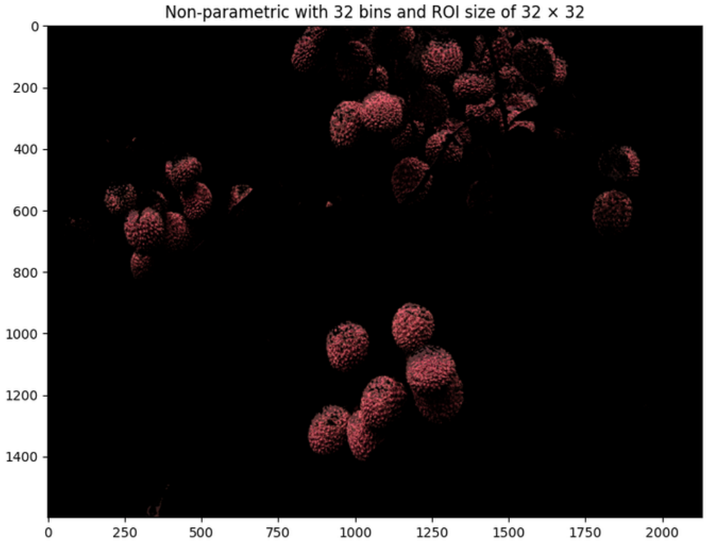
Non-parametric with 32 bins and ROI size of 32 × 32
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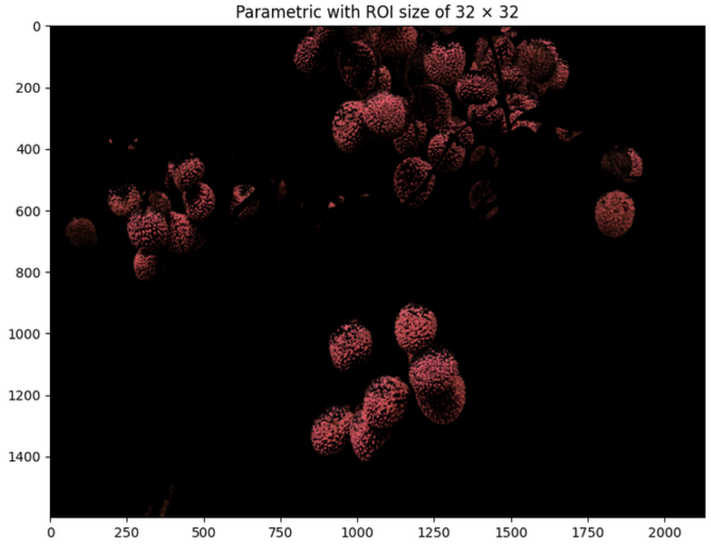
Parametric with ROI size of 32 × 32
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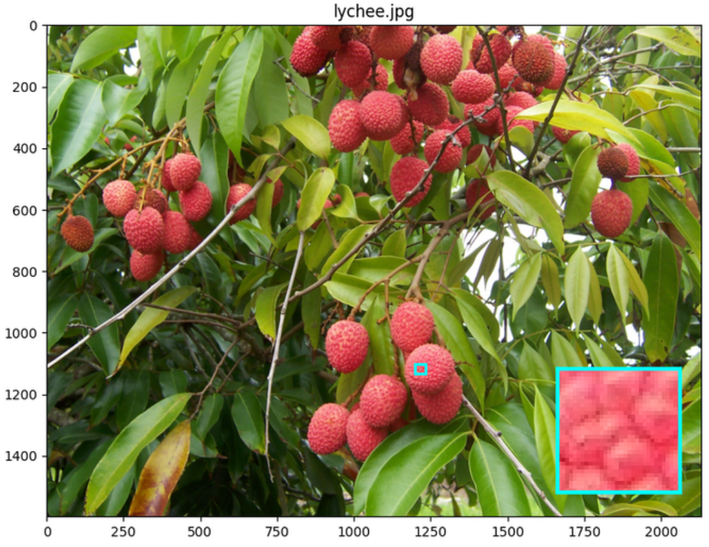
lychee.jpg
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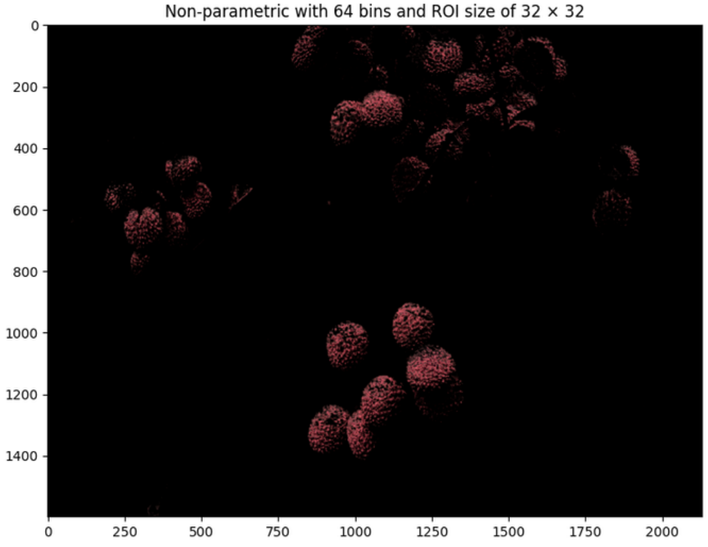
Non-parametric with 64 bins and ROI size of 32 × 32
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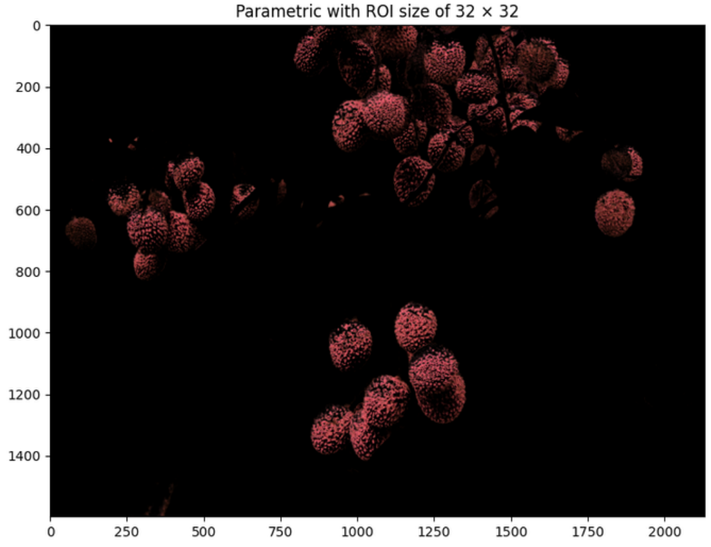
Parametric with ROI size of 32 × 32
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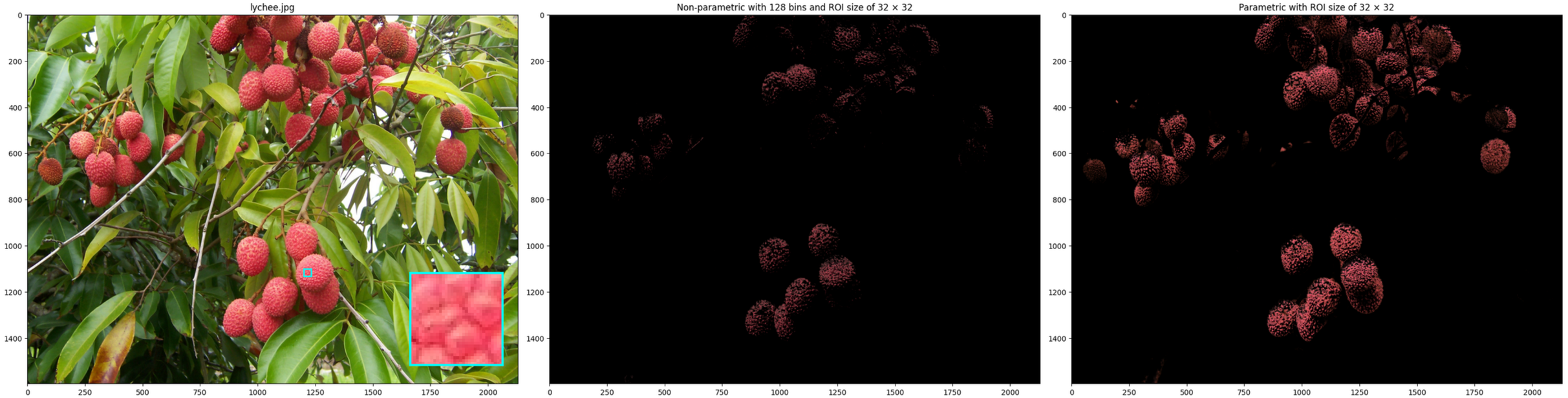
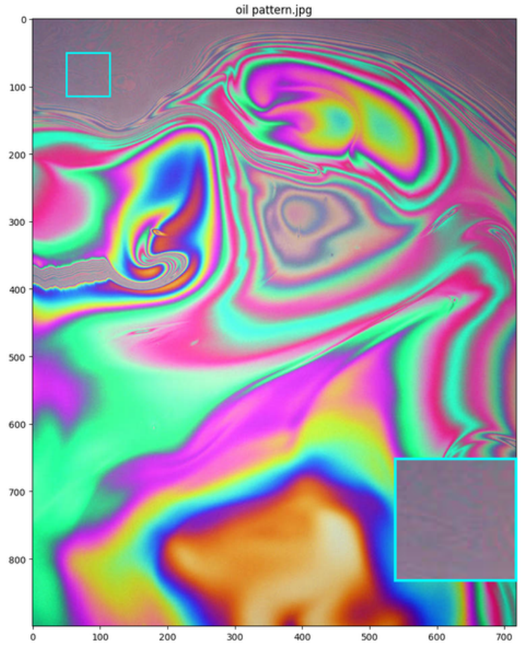


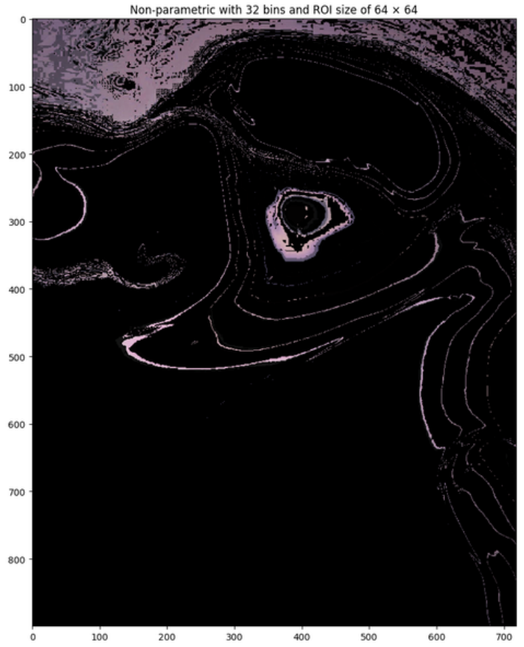
Looking at the non-parametric segmentation images, it can be seen that at a lower number of bins, the lychees, as well as the leaves, are highlighted. But as the number of bins increases, the leaves are no longer highlighted and the lychees become darker. This is because as the number of bins increases, the distribution in the histogram becomes smaller. Its easier to visualize this at extreme cases. If there is only one bin in the histogram, then no colors will be filtered out because all the values of the image are guaranteed to be in that bin. But if the number of bins is a large number, such as 256, then only the pixel values in the original image that exactly match the pixel values in the ROI will show up in the segmented image. This is why you can see other colors in the segmented image at lower bins even though the ROI only has pink and red pixels. And this is also why the lychees become darker as the number of bins increase because fewer pixel values in the original image match the pixel values in the ROI.

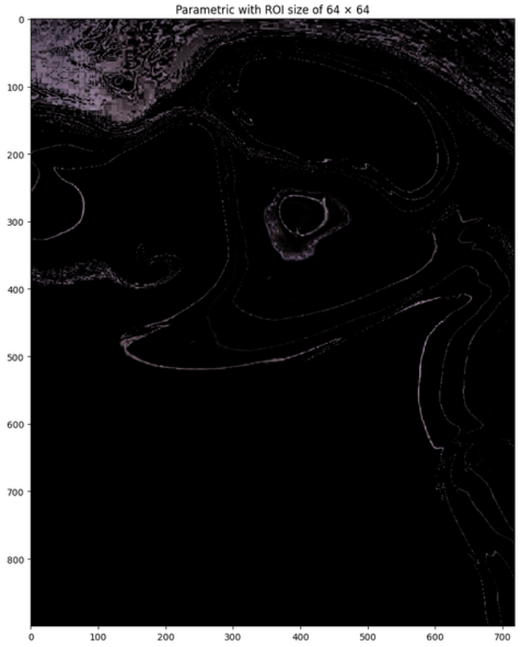
Also, visually, I noticed that the output of non-parametric segmentation with 32 bins looks the most similar to the output of parametric one.

For continuous colors

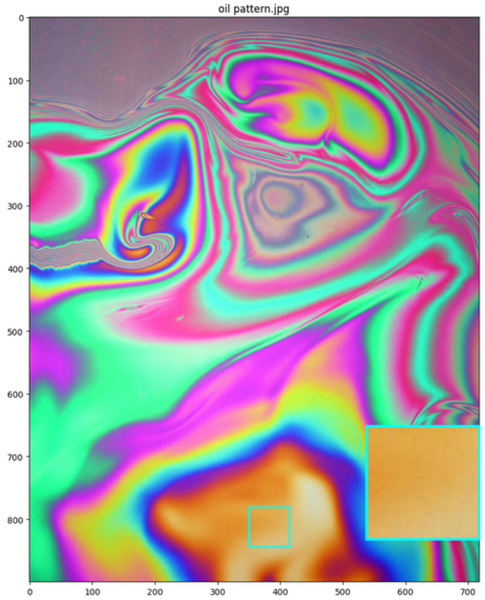
So far, I have applied parametric and non-parametric segmentation on images whose colors are non-continuous. What I mean by "non-continuous" is that you can visually see the edges of an object, and the colors between two objects are not blended into each other (ex. there is a big change in color between the lychees and the leaves). Now I'll apply parametric and non-parametric segmentation on an oil pattern which was made by Peter Aprahamian [3]. Also, I used 32 bins for the non-parametric segmentation and an ROI size of 64 pixel by 64 pixel for both types of segmentation. The following are my results:

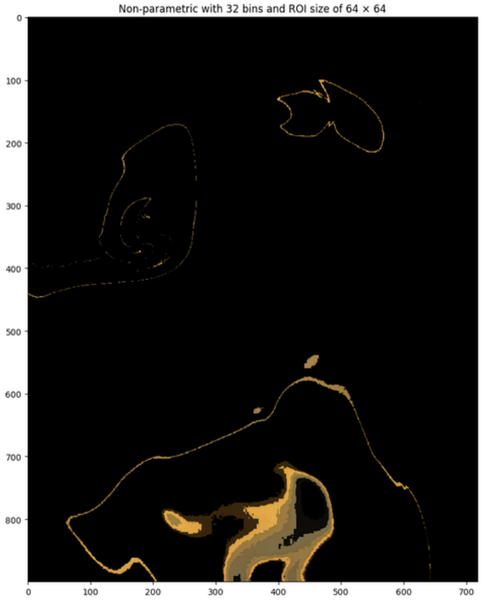


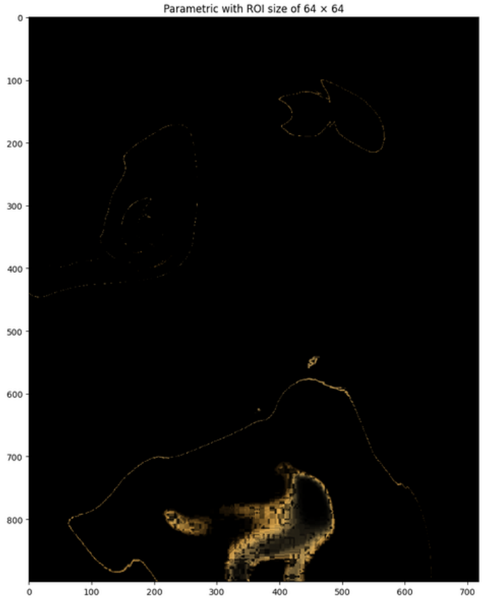


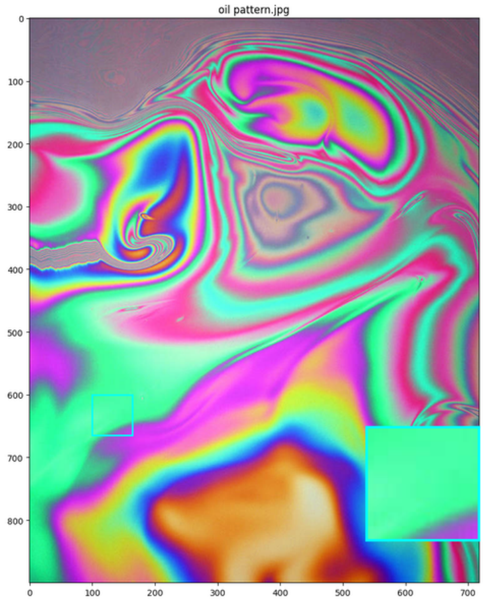


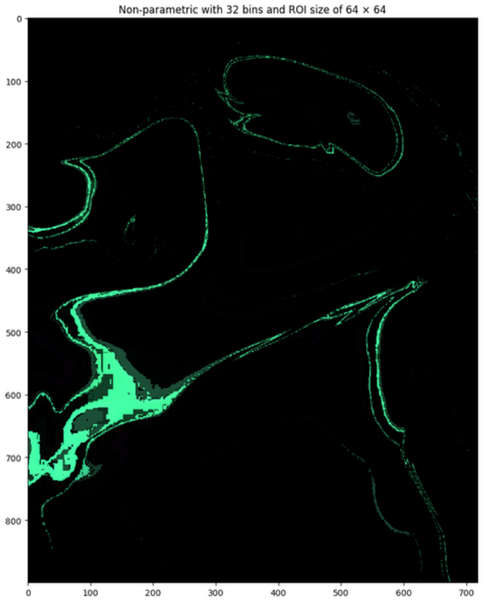
Source: By Peter Aprahamian titled "Interference Pattern Of Film Of Oil On Water", 2018. Photograph. Picture retrieved from: https://pixels.com/featured/1-interference-pattern-of-film-of-oil-on-water-peter-aprahamianscience-photo-library.html

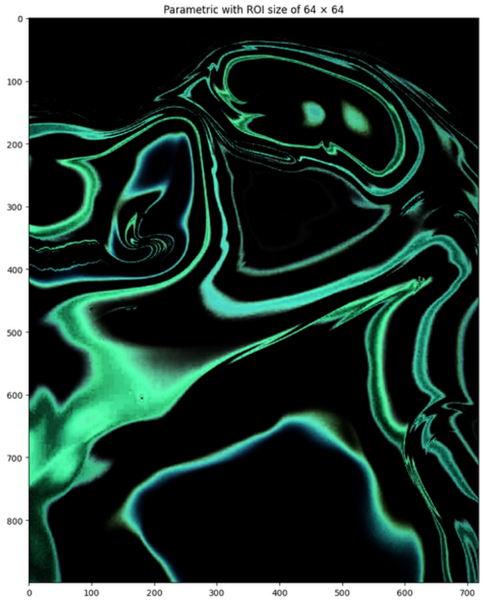

oil pattern.jpg


Non-parametric with 32 bins and ROI size of 64 × 64


Parametric with ROI size of 64 × 64


oil pattern.jpg

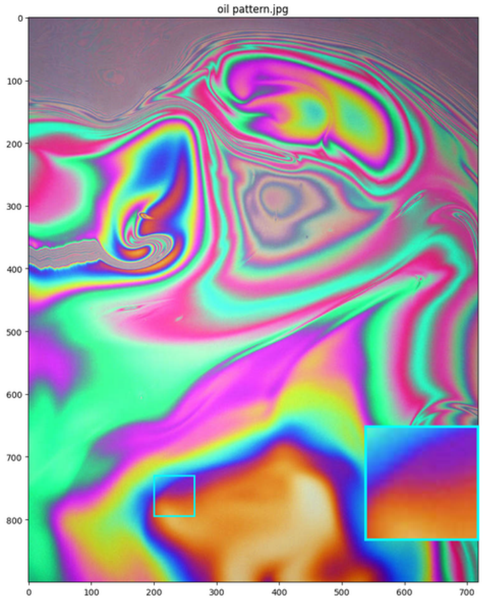

Non-parametric with 32 bins and ROI size of 64 × 64

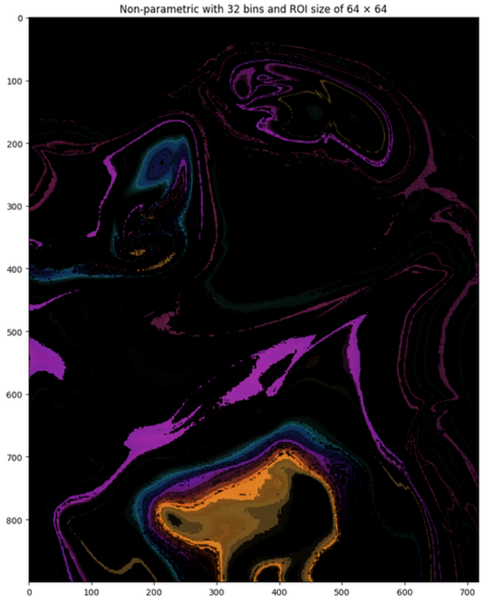

Parametric with ROI size of 64 × 64

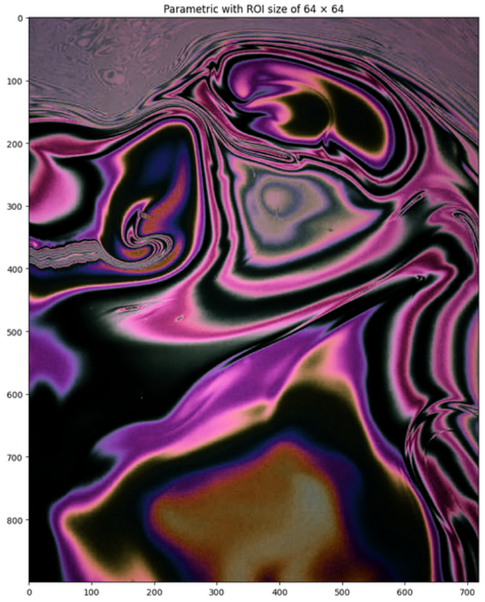
Looking at the segmented images, visually, the non-parametric methods work best for single solid colors while parametric methods work better for a blend of colors in the ROI.

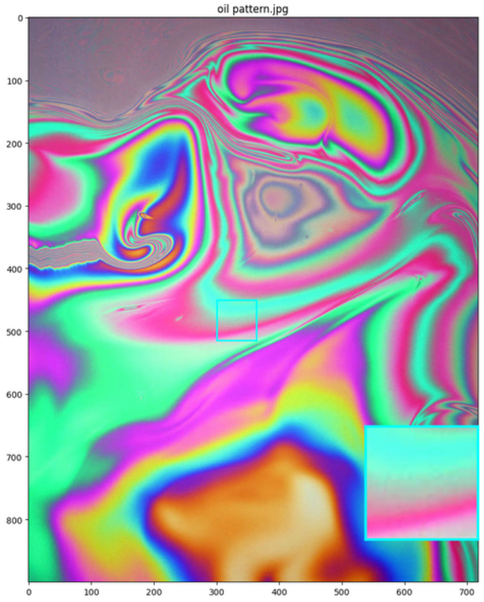
For single solid colors in the ROI (in page 12 and the first image in page 13), it can be seen that non-parametric segmentation was able to segment the colors better. The lines are more solid and brighter compared to the output of parametric segmentation where it contained a lot of artifacts where the color should be solid.

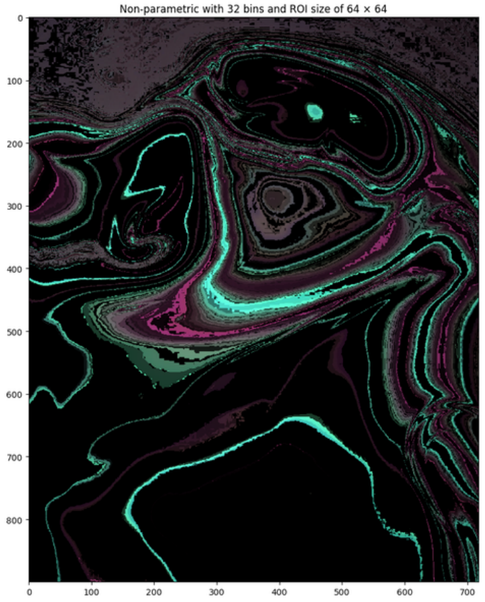
But for the other pictures where the ROI contains a blend of colors, parametric segmentation performed better. It shows the gradient in the blend of colors. As for the non-parametric segmentation the change in color can be seen in discrete steps.

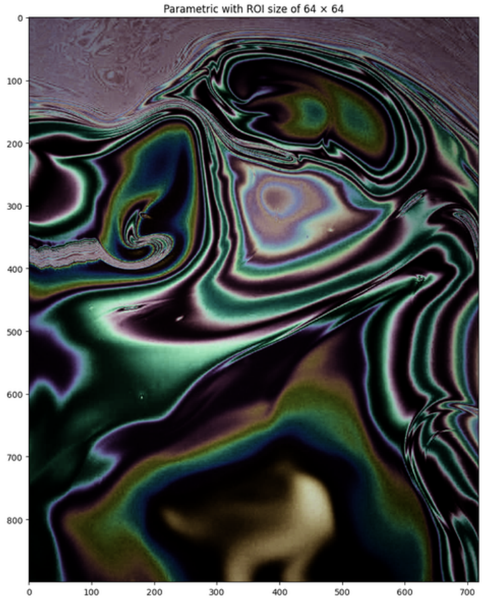












Reflection

Overall, I believe that all of my results are correct. This is because my code made sense and they are the expected results. Although there are artifacts that introduced noise into my outputs, I have still successfully applied parametric and non-parametric segmentation on the images.

The most tedious part for me is the part where I had to make the 2D histogram. I had a hard time visualizing it conceptually. I looked for sample codes online and they were all wrong. I even found a online reference about OpenCV's calcHist function and it gave the wrong information. But I was able to debug it and I made my code work. After that, I was able to automate my code and everything went smoothly.

I'd like to thank my instructors, Sir Rene Principe Jr. and Sir Kenneth Leo, for guiding me throughout the activity. I would also like to thank my professor, Ma'am Jing, for guiding me in my coding while my classmates and I worked in R202. I would also like to acknowledge my classmates: Abdel, Johnenn, Jonabel, Richmond, Lovely, Hans, Genesis, Jeruine, Rusher, and Ron for helping me complete this activity.

Self Grade

Technical Correctness	I understood the lesson and met all the objectives. My results are complete and I got the expected results.	35
Quality of Presentation	The images I added to this report are of good quality and all the graphs are properly labelled. My code is also properly organized and labelled.	35
Self Reflection	I got the expected results, and acknowledged the contributions of my peers while doing this activity. I also properly cited online references.	30
Initiative	Apart from doing the required tasks, I also applied what I learned to sample images online. I also helped my classmates with their code and helped them by cross-referencing my results with theirs.	10
	Total	110

References

[1] Plumridge, J. (2021, December 12). Artifacts are bad in digital photography, learn how to avoid them. Lifewire. https://www.lifewire.com/avoid-artifacts-in-digital-photos-493765

[2] Naves, B. (2006, November 12). *"Lychees (Litchi chinensis), picture taken at Saint-Benoît (Réunion island)"* . https://en.wikipedia.org/wiki/Lychee#/media/File:Litchi_chinensis_fruits.JPG

[3] Aprahamian, P. (2018, September 16). *"Interference Pattern Of Film Of Oil On Water"*. Pixels. https://pixels.com/featured/1-interference-pattern-of-film-of-oil-on-water-peter-aprahamianscience-photo-library.html

[4] Applied Physics 157 Laboratory Manual. A5 – Feature Extraction Part 1 of 3: Image Segmentation.