App Physics 157

ACTIVITY 5 REPORT

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Background
Image Segmentation

Image segmentation is a digital image processing technique that analyzes an image into parts or segments, by differentiating the elements of that image. More specifically, it differentiates the characteristics of the pixels of the image.

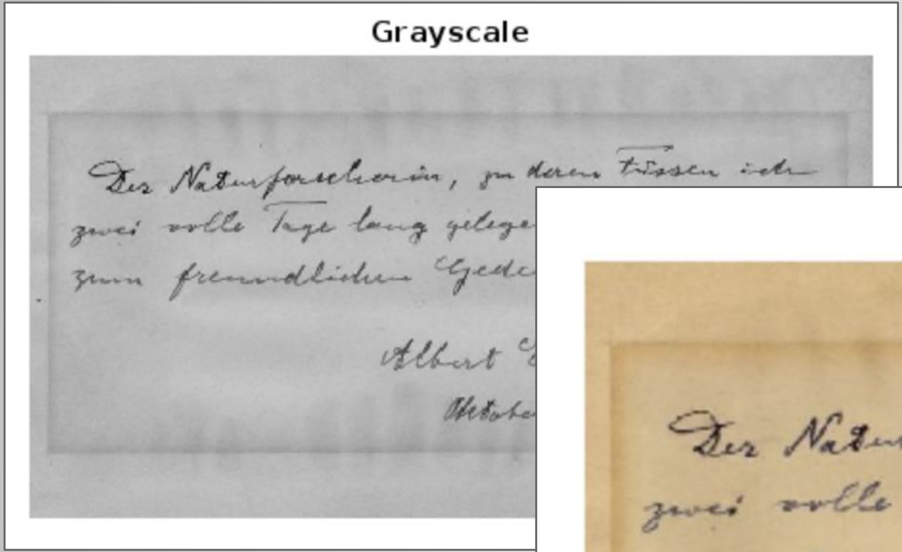
Image segmentation can be used to separate foreground and background, individuate different color groups, or detect the subject in an image.

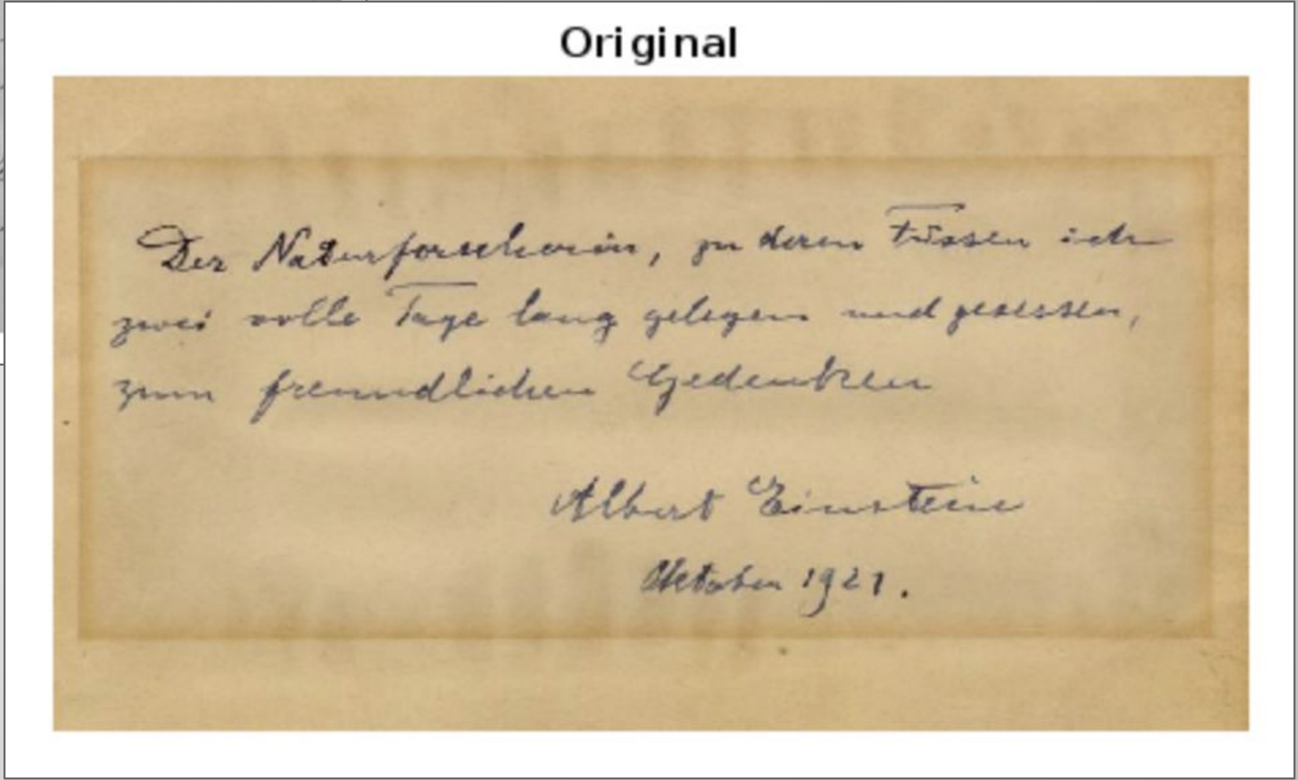
Objective
Grayscale Segmentation

In image segmentation, a region of interest (ROI) is picked out from the rest of the image (background) such that further processing can be done on it. Selection rules are based on features unique to the ROI.

For grayscale images, segmentation can be done through thresholding if the ROI has a distinct grayscale range from the background.

Results & Analysis





Einstein's Note

GRAYSCALE

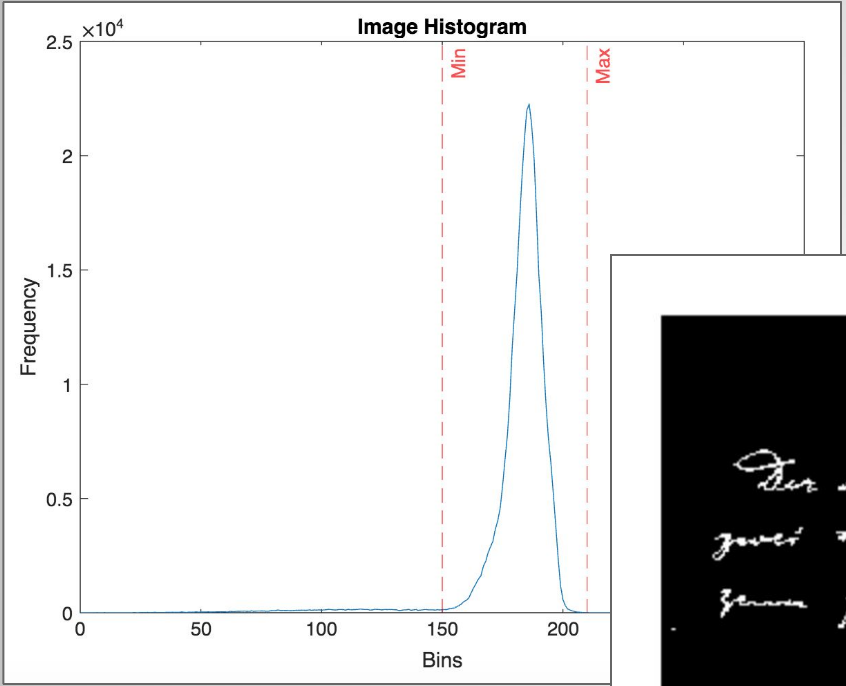
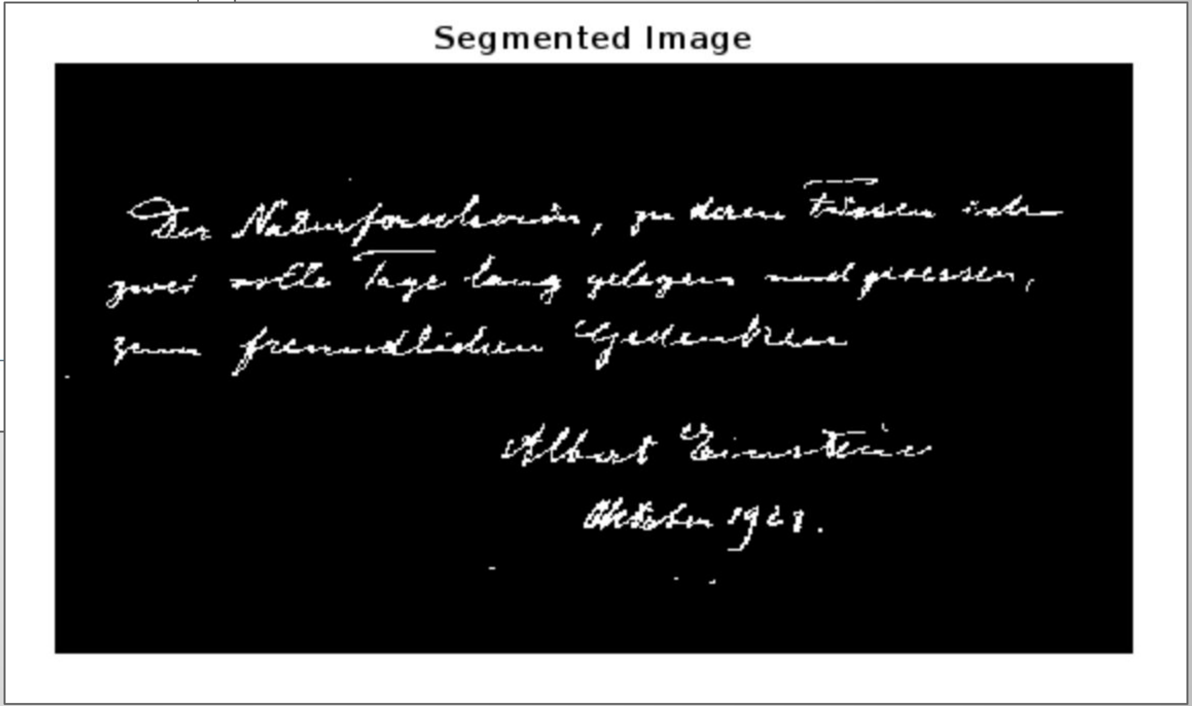
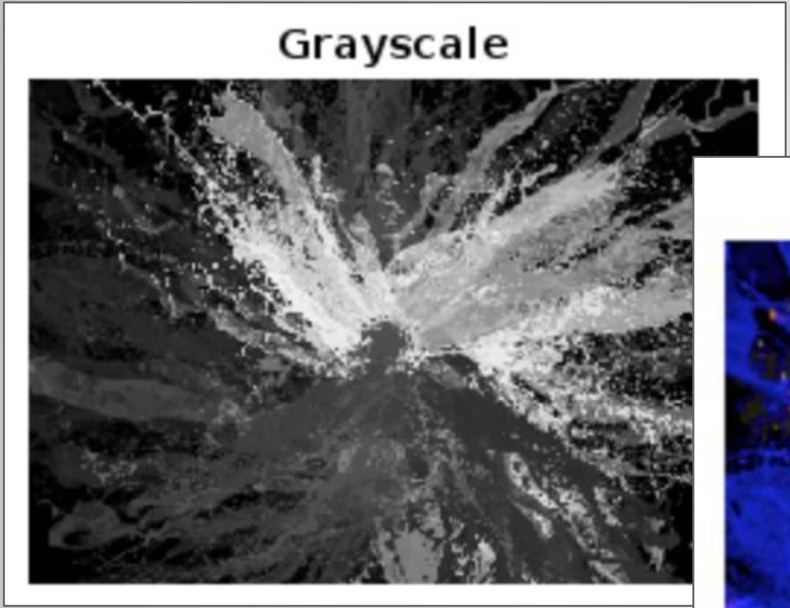
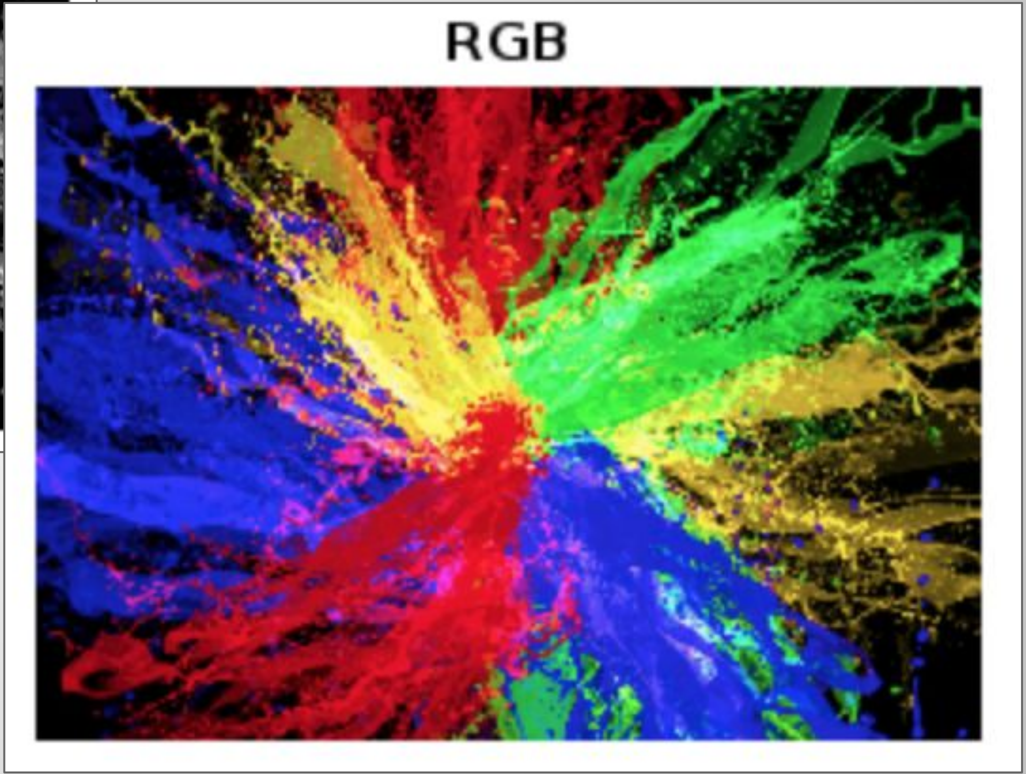


Image Histogram
×10^4
2.5
2
1.5
1
0.5
0
Frequency
0
50
100
150
200
Bins
Min
Max


Segmented Image

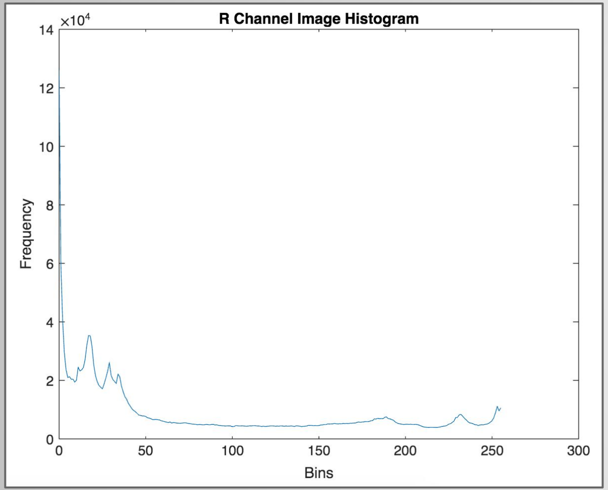
GRAYSCALE





RGB Image

RGB


R Channel Image Histogram
×10^4
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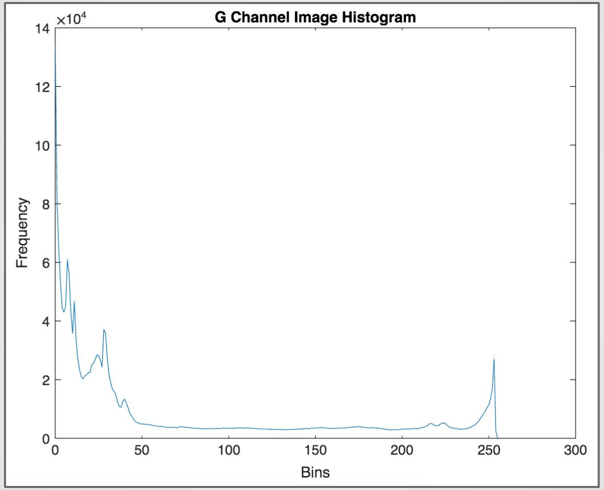
12
10
8
6
4
2
0
Frequency
0
50
100
150
200
250
300
Bins


G Channel Image Histogram
×10^4
14
12
10
8
6
4
2
0
Frequency
0
50
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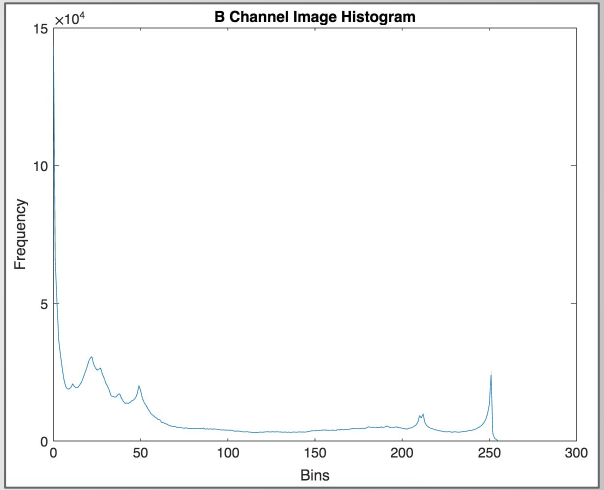
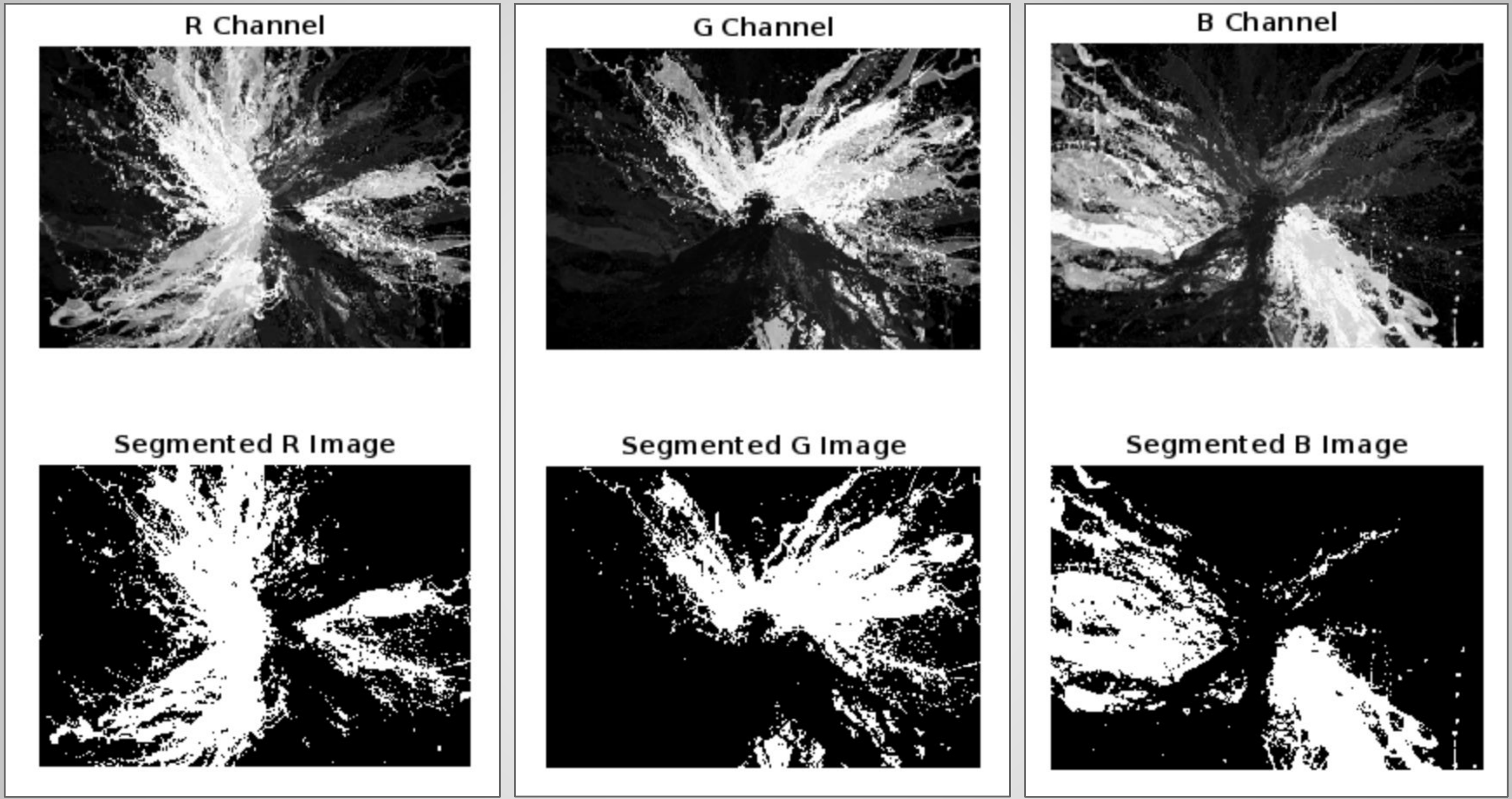
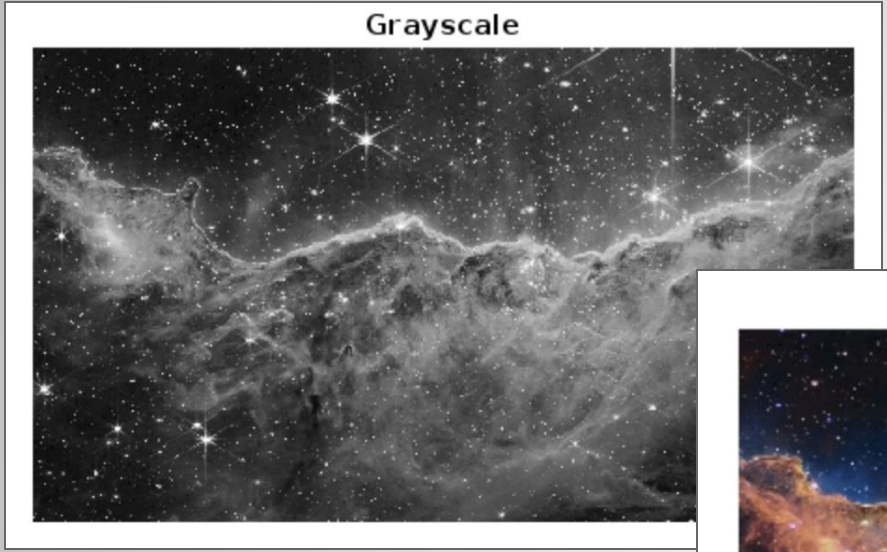
150
200
250
300
Bins


B Channel Image Histogram
×10^4
15
10
5
0
Frequency
0
50
100
150
200
250
300
Bins

RGB

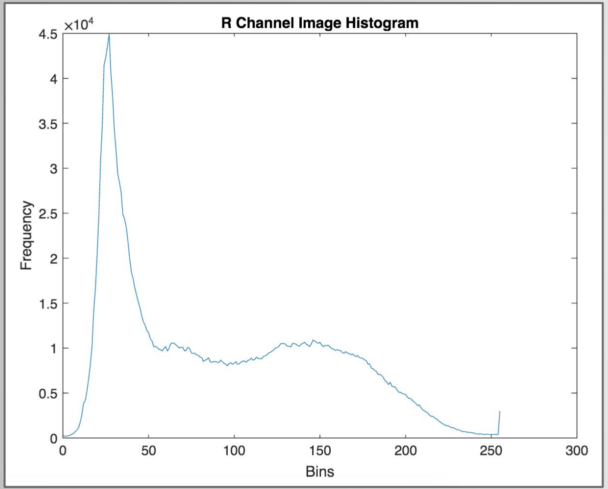

R Channel
Segmented R Image
G Channel
Segmented G Image
B Channel
Segmented B Image

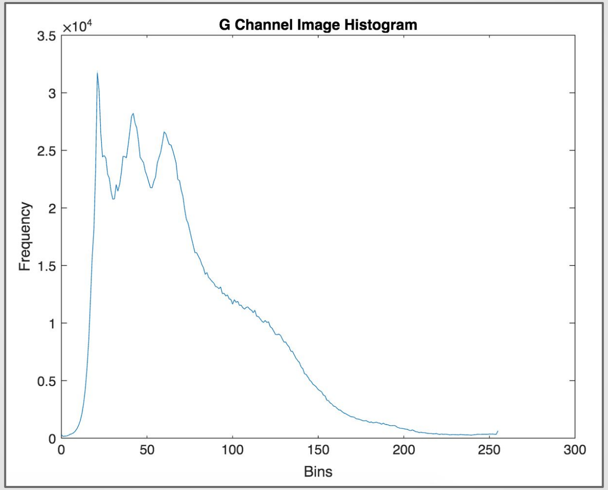
RGB



Carina Nebula
by JWST

RGB


R Channel Image Histogram
×10^4
Frequency
Bins
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300


G Channel Image Histogram
×10^4
Frequency
Bins
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
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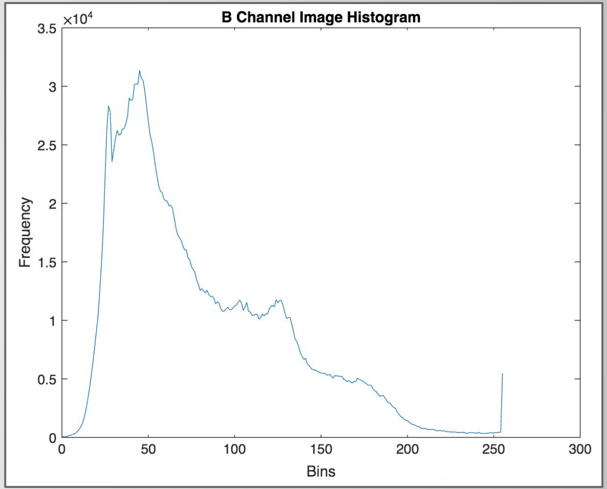
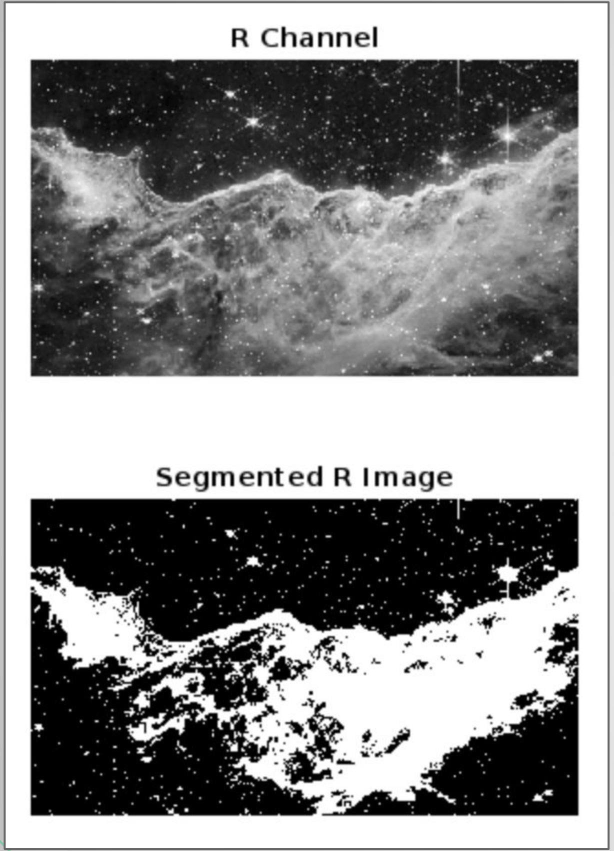
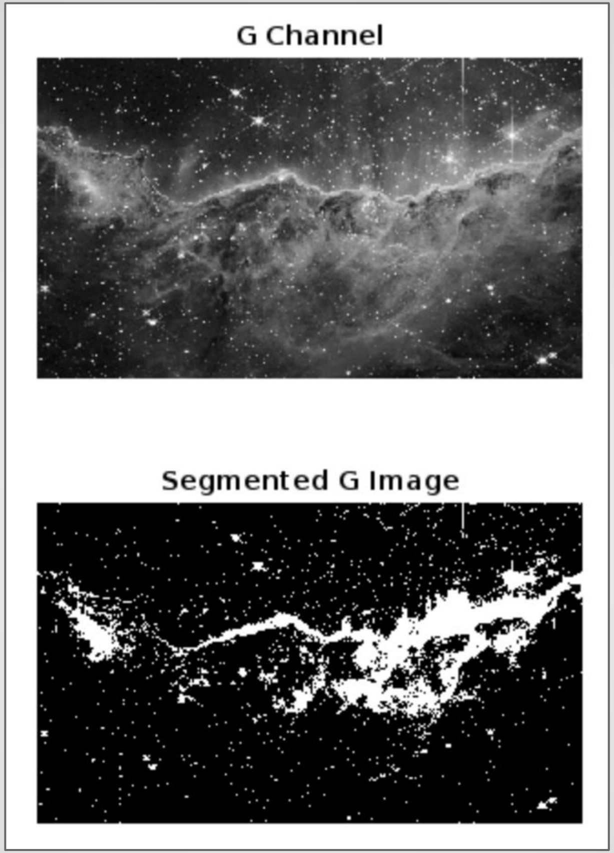
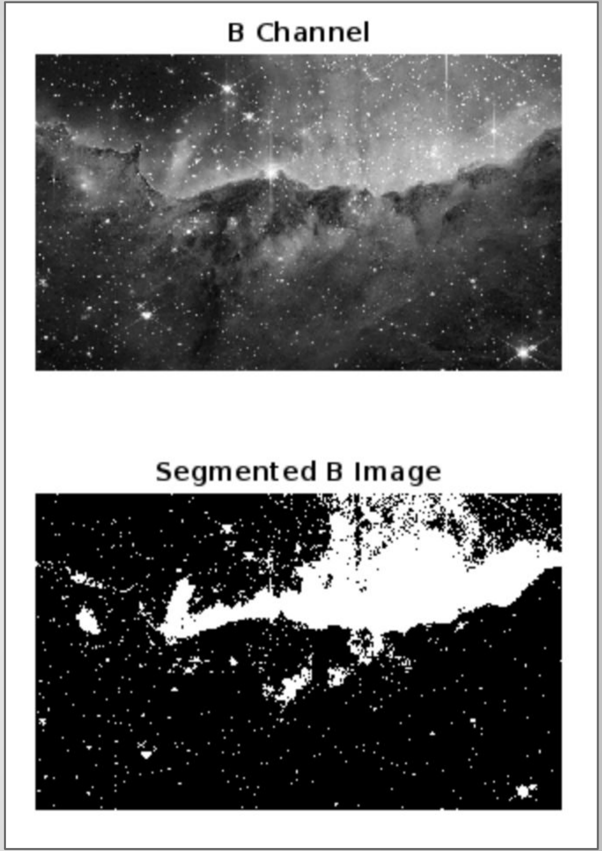

B Channel Image Histogram
×10^4
Frequency
Bins
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300

RGB


R Channel
Segmented R Image


G Channel
Segmented G Image


B Channel
Segmented B Image

RGB

In the grayscale image, the region-of-interest (ROI) is the handwritten text by Einstein. It can be noticed that the visual characteristics of the text is differentiable from the rest of the image, i.e. it is darker.

To separate it, we take the image pixel intensity vs frequency histogram, taking note that since the image is in grayscale, the intensity values are from 0 to 255. We notice that the background pixels are dominant in the image, which is shown as the peak in the histogram. We take the values to the left and right side of the peak as the text and separate it by logical operations, then display the output. We have then successfully segmented the ROI from the rest of the image.

The process of segmentation in an RGB image is similar to that of grayscale, specifically when the objects we want to segment are in a specific color channel. Instead of taking the grayscale of an image, we simply take the separate RGB channels of the image and get its histogram.

This can be very useful in analyzing astronomical images, such as the JWST image of the Carina Nebula. Since we get to segregate the image of its RGB channels, we get to focus on the particles specific to that channel, and understand its composition by emission and absorption spectrum.

Background Normalized Chromaticity Coordinates

Normalized chromaticity coordinates, often referred to as xy coordinates, are values that describe the color of light in a standardized manner. They are derived from the tristimulus values, which quantify the amount of red, green, and blue light present in a color. By normalizing these values, the chromaticity coordinates eliminate the influence of luminance, allowing for a consistent representation of color independent of brightness. Chromaticity specifies the hue and saturation but not the brightness. One component can always be derived from the other two.

$$x = \frac{X}{X+Y+Z}$$

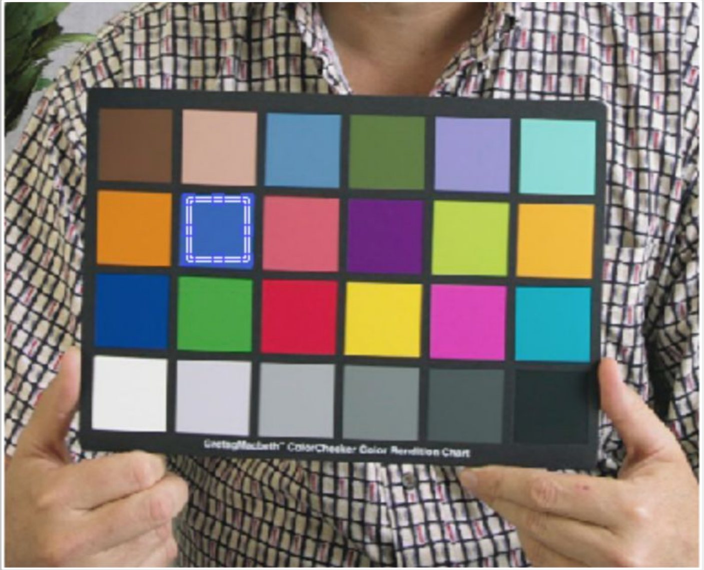
$$y = \frac{Y}{X+Y+Z}$$

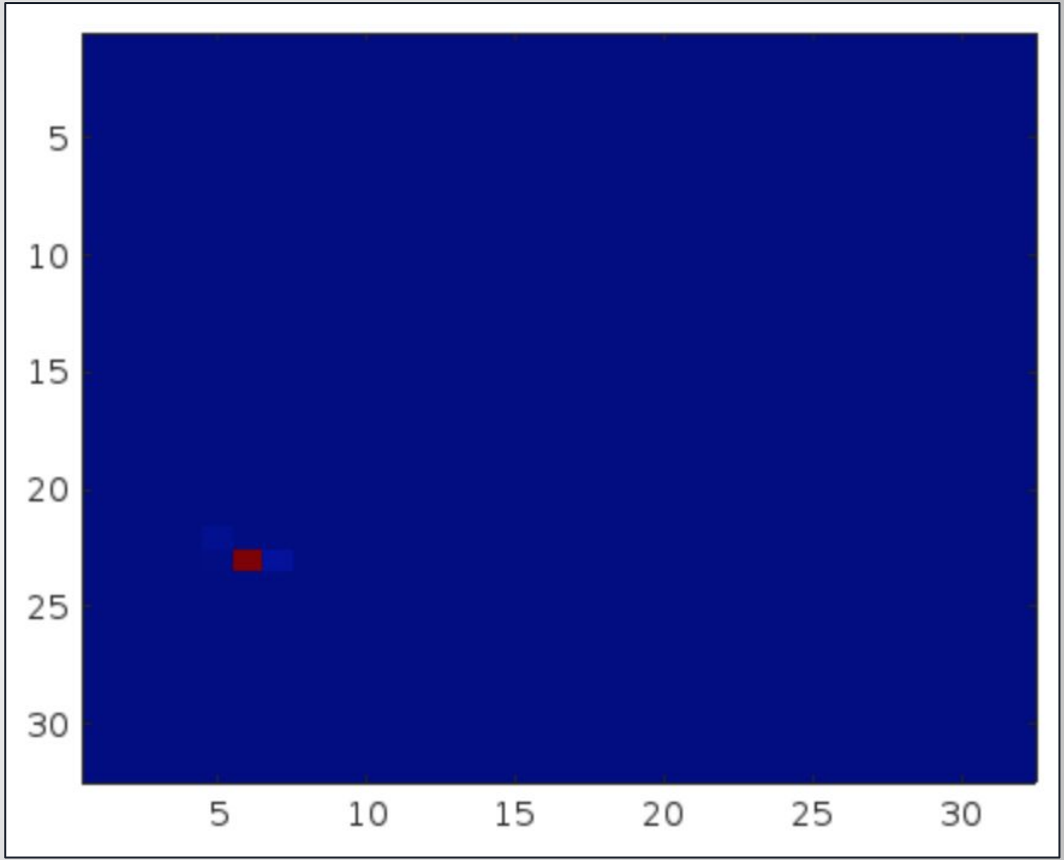
$$z = \frac{Z}{X+Y+Z}$$

Background
Histogram Backprojection

Histogram backprojection is a technique used in image processing and computer vision to locate objects or regions of interest in an image based on their color or texture characteristics. It involves comparing the pixel values of an input image with a reference histogram to generate a probability map that indicates the likelihood of each pixel belonging to the object or region of interest.

Results & Analysis


GretagMacbeth™ ColorChecker Color Rendition Chart


5
10
15
20
25
30
5
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15
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25
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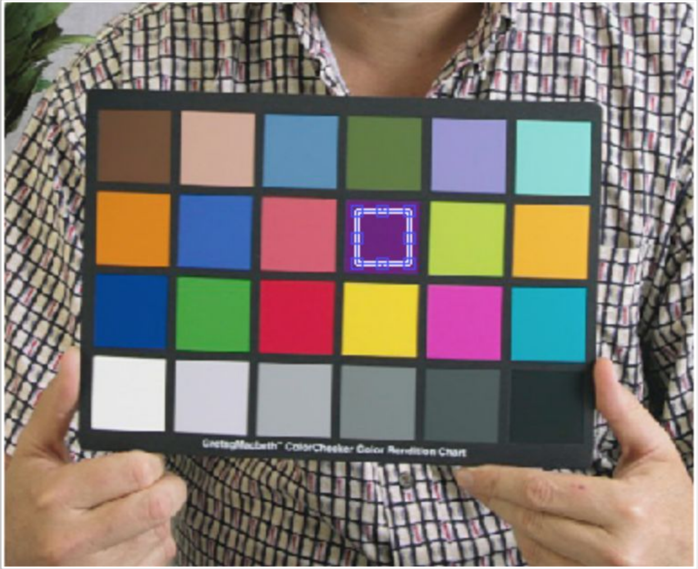
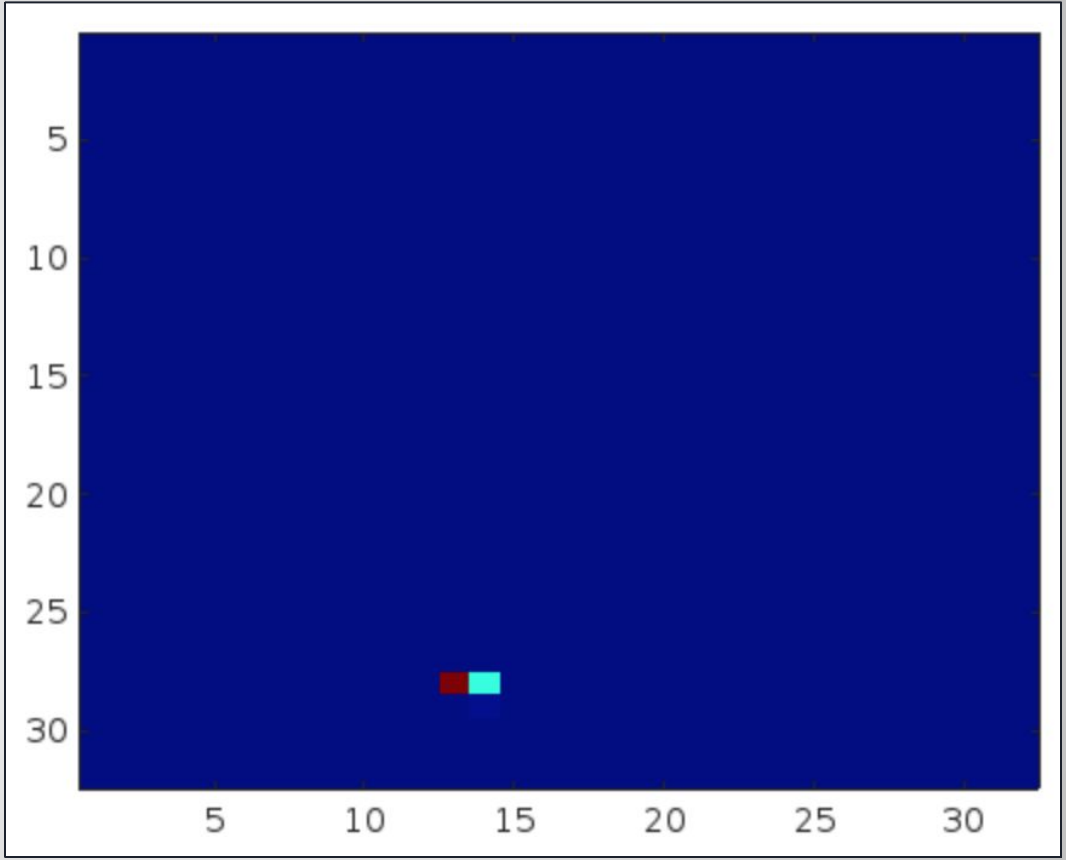
HISTOGRAM





HISTOGRAM

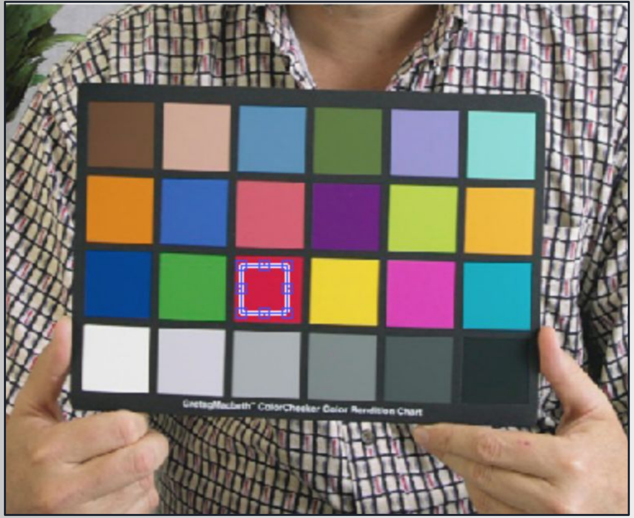
“Fitting an analytic function to the histogram is one way to get a pixel-membership function however it is only as good as the fit of the PDF function assumed. In non-parametric estimation, the histogram itself is used to tag the membership of pixels. Histogram backprojection is one such technique were based on the color histogram, a pixel is given a value equal to its histogram value in chromaticity space. This has the advantage of faster processing because no computations are needed, just a look-up of histogram values.

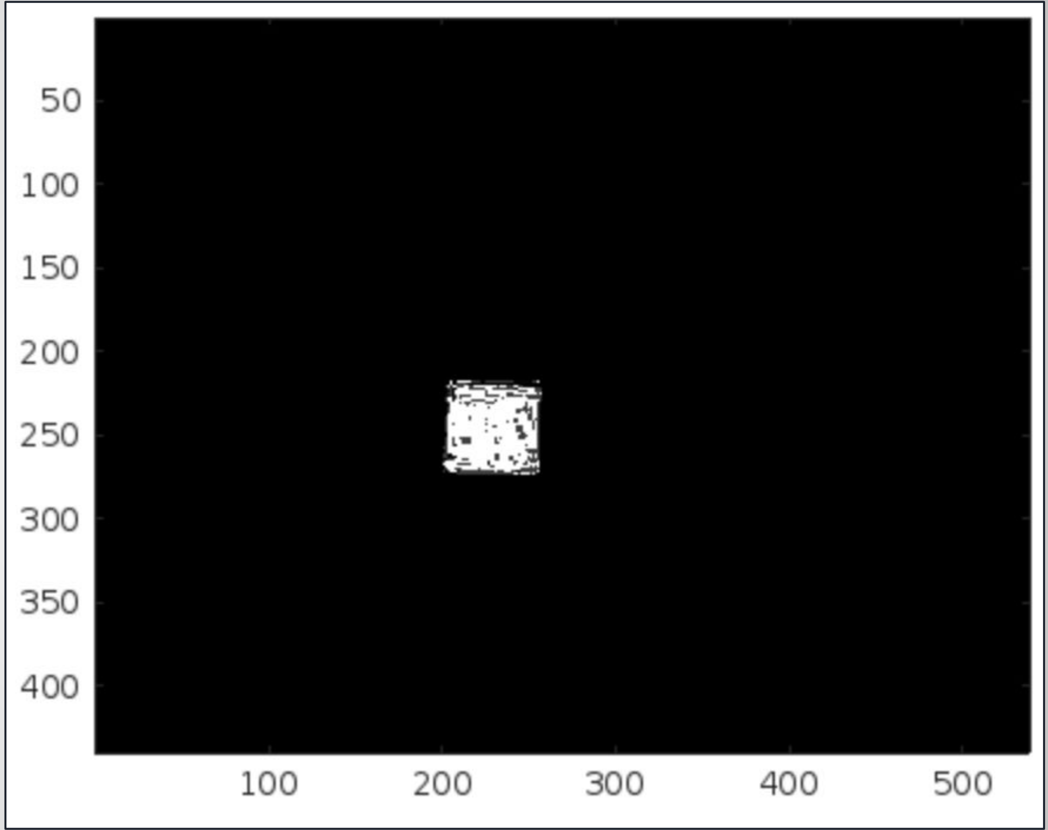
Obtaining a 2D histogram can be implemented rapidly by converting the r,g values into integers and binning the image values in a matrix. The matrix can then be concatenated into a look-up table with the indices being a function of the bin indices for r and g.”

Background
Parametric Vs Nonparametric
Probability Distribution Estimation

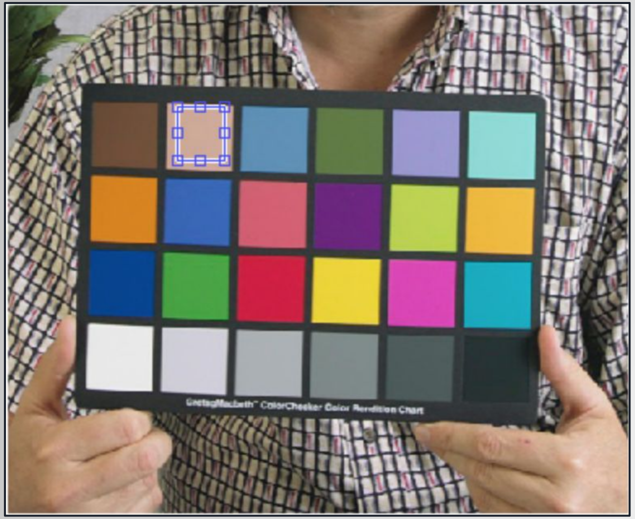
Parametric Methods	Non-Parametric Methods
Parametric Methods uses a fixed number of parameters to build the model.	Non-Parametric Methods use the flexible number of parameters to build the model.
Parametric analysis is to test group means.	A non-parametric analysis is to test medians.
It is applicable only for variables.	It is applicable for both – Variable and Attribute.
It always considers strong assumptions about data.	It generally fewer assumptions about data.
Parametric Methods require lesser data than Non-Parametric Methods.	Non-Parametric Methods requires much more data than Parametric Methods.
Parametric methods assumed to be a normal distribution.	There is no assumed distribution in non-parametric methods.
Parametric data handles – Intervals data or ratio data.	But non-parametric methods handle original data.
Here when we use parametric methods then the result or outputs generated can be easily affected by outliers.	When we use non-parametric methods then the result or outputs generated cannot be seriously affected by outliers.
Parametric Methods can perform well in many situations but its performance is at peak (top) when the spread of each group is different.	Similarly, Non-Parametric Methods can perform well in many situations but its performance is at peak (top) when the spread of each group is the same.
Parametric methods have more statistical power than Non-Parametric methods.	Non-parametric methods have less statistical power than Parametric methods.
As far as the computation is considered these methods are computationally faster than the Non-Parametric methods.	As far as the computation is considered these methods are computationally slower than the Parametric methods.
Examples: Logistic Regression, Naïve Bayes Model, etc.	Examples: KNN, Decision Tree Model, etc.

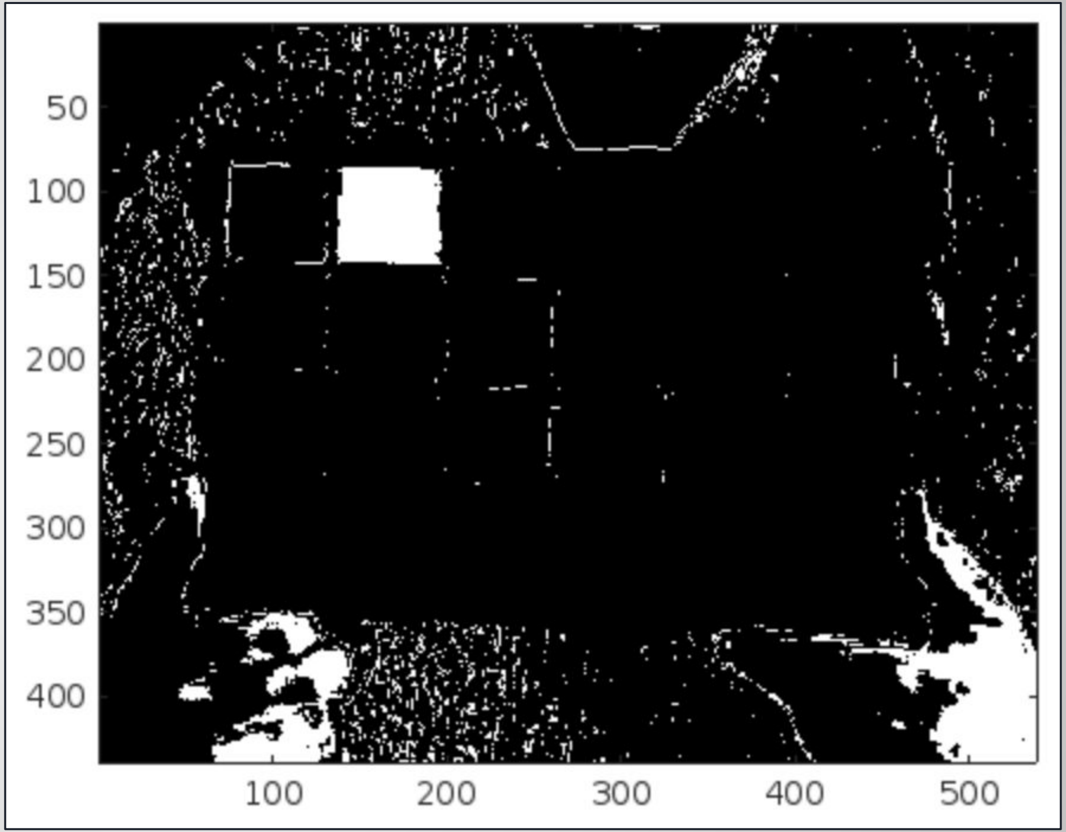
Results & Analysis



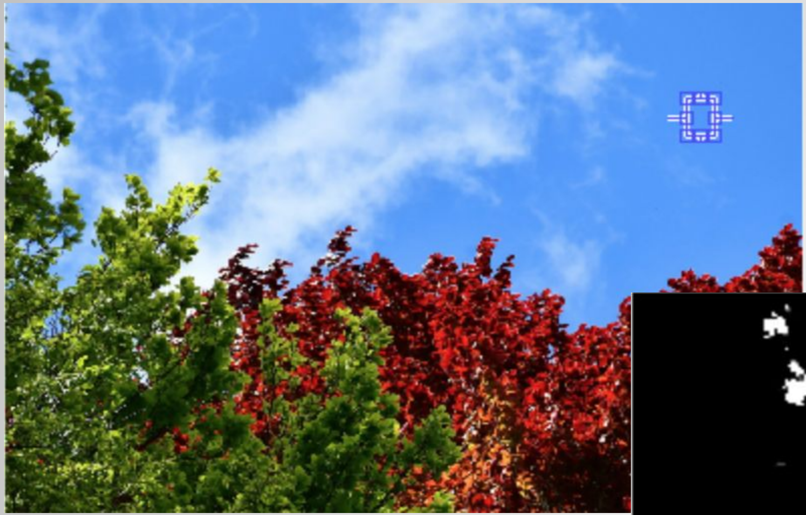


NONPARAMETRIC

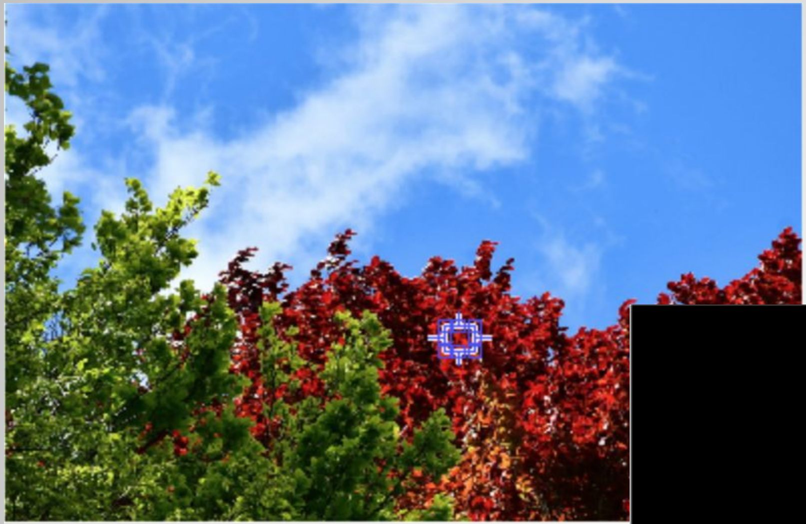


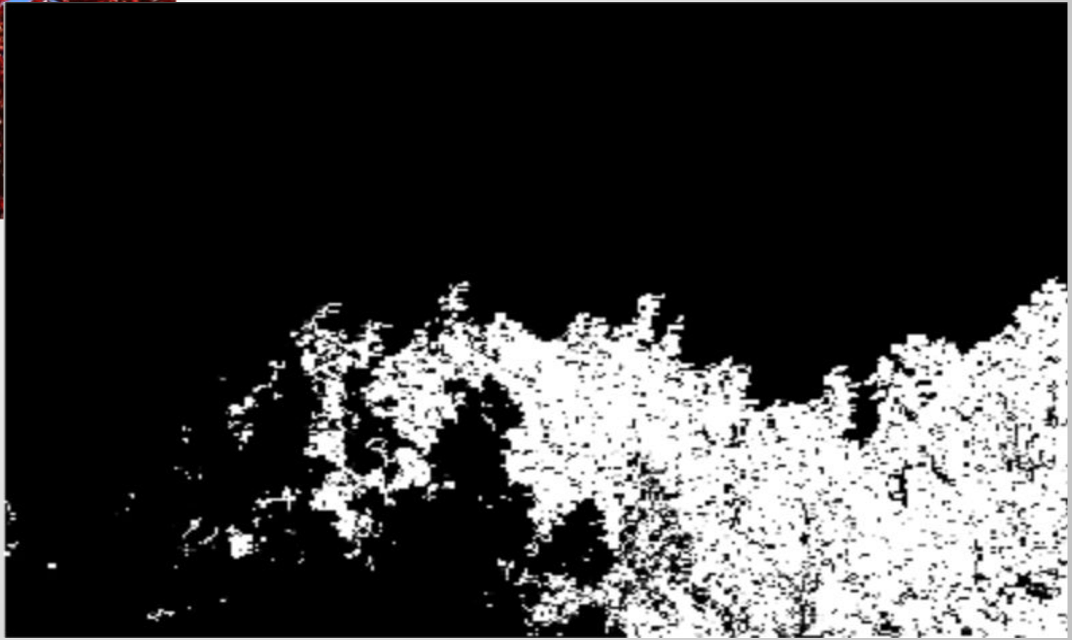


NONPARAMETRIC



PARAMETRIC





PARAMETRIC

“Segmentation based on color can be performed by determining the probability that a pixel belongs to a color distribution of interest. This implies that the color histogram of the region of interest must first be extracted. To do so, one crops a subregion of the ROI and compute the histogram from it. The histogram when normalized by the number of pixels is already the probability distribution function (PDF) of the color. To tag a pixel as belonging to a region of interest or not is to find its probability of belonging to the color of the ROI. Since our space is r and g we can have a joint probability p(r) p(g) function to test the likelihood of pixel membership to the ROI. We can assume a Gaussian distribution independently along r and g, that is, from the rg values of the cropped pixel we compute the mean , and standard deviation , from the pixel samples. The probability that a pixel with chromaticity r belongs to the ROI is then

$$\mathrm{p}(r) = \frac{1}{\sigma_{\mathrm{r}}\sqrt{2\pi}} \exp\left\{-\frac{(\mathrm{r}-\mu_{\mathrm{r}})^2}{2\sigma_{\mathrm{r}}^2}\right\}$$

A similar equation is computed for g. The joint probability is taken as the product of p(r) and p(g).“

ANALYSIS

Reflection

This was perhaps the most challenging activity for me so far, because although the coding part was relatively doable for me, translating the concepts to code was a significant hindrance, since the concepts were not as easy as it seemed to me, more specifically the parametric vs nonparametric distribution. Although the code was already available, I had to analyze its logic for me to be able to get a sense of the topic and how it was translated in the code.

Nevertheless, I understand the value of image segmentation and how it can segregate data into their corresponding classifications and characteristics, with practical applications such as in medical imaging, video surveillance, face recognition, just to name a few.

Self Grade

CRITERIA	QUALIFICATIONS	SCORE
Technical Correctness	❏ Met all objectives ❏ Results are complete ❏ Results are verifiably correct ❏ Understood the lesson	32
Presentation Quality	❏ All text and images are good quality ❏ Code has sufficient comments/guides ❏ Plots are properly labeled and visually understandable ❏ Report is clear	35
Self Reflection	❏ Explained validity of results ❏ Discussed what went wrong/right in activity ❏ Justified self score ❏ Acknowledged sources	33
Initiative	❏ Experimented beyond what was required ❏ Made significant improvements to existing code	15

References

[1] What is image segmentation? 3 things you need to know. (n.d.). *Mathworks.* Retrieved from https://www.mathworks.com/discovery/image-segmentation.html#:~:text=MATLAB%20lets%20you%20perform%20this,interactively%20apply%20graph%2Dbased%20segmentation.

[2] Sharma, P. (2023, April 27). Computer vision tutorial: a step-by-step introduction to image segmentation techniques (part 1). *Analytics Vidhya.* Retrieved from https://www.analyticsvidhya.com/blog/2019/04/introduction-image-segmentation-techniques-python/

[3] Einstein note fetches US$6100 at Jerusalem auction. (2018, March 7). *Associated Press.* Retrieved from https://www.chinadailyhk.com/articles/60/77/205/1520393414147.html

[4] NASA's Webb reveals cosmic cliffs , glittering landscape of star birth. (2022, July 12). *NASA.* Retrieved from https://www.nasa.gov/image-feature/goddard/2022/nasa-s-webb-reveals-cosmic-cliffs-glittering-landscape-of-star-birth

[5] Dieter_G. (2015, June 1). Play of colors. *Pixabay.* Retrieved from https://pixabay.com/illustrations/colorful-play-of-colors-rgb-to-dye-790254/

References

[6] Bouman, C. (2023, January 9). Chromaticity coordinates. *Purdue University.* Retrieved from https://engineering.purdue.edu/~bouman/ece637/notes/pdf/ColorSpaces.pdf
[7] Soriano, M. (2023). Image segmentation. *App Physics 157.*
[8] Histogram backprojection. (2020, August 26). *Computer VIsion.* Retrieved from https://cvexplained.wordpress.com/2020/08/26/histogram-backprojection/#:~:text=It%20is%20basically%20a%20image,which%20we%20will%20see%20later.
[9] Sikarwar, D. (n.d.). Difference between parametric and non-parametric methods. *Geeks for Geeks.* Retrieved from https://www.geeksforgeeks.org/difference-between-parametric-and-non-parametric-methods/

Warm thanks for Johnenn Manalong for the code on parametric PDE.