

# CS 663 Assignment 1 Report Part 2

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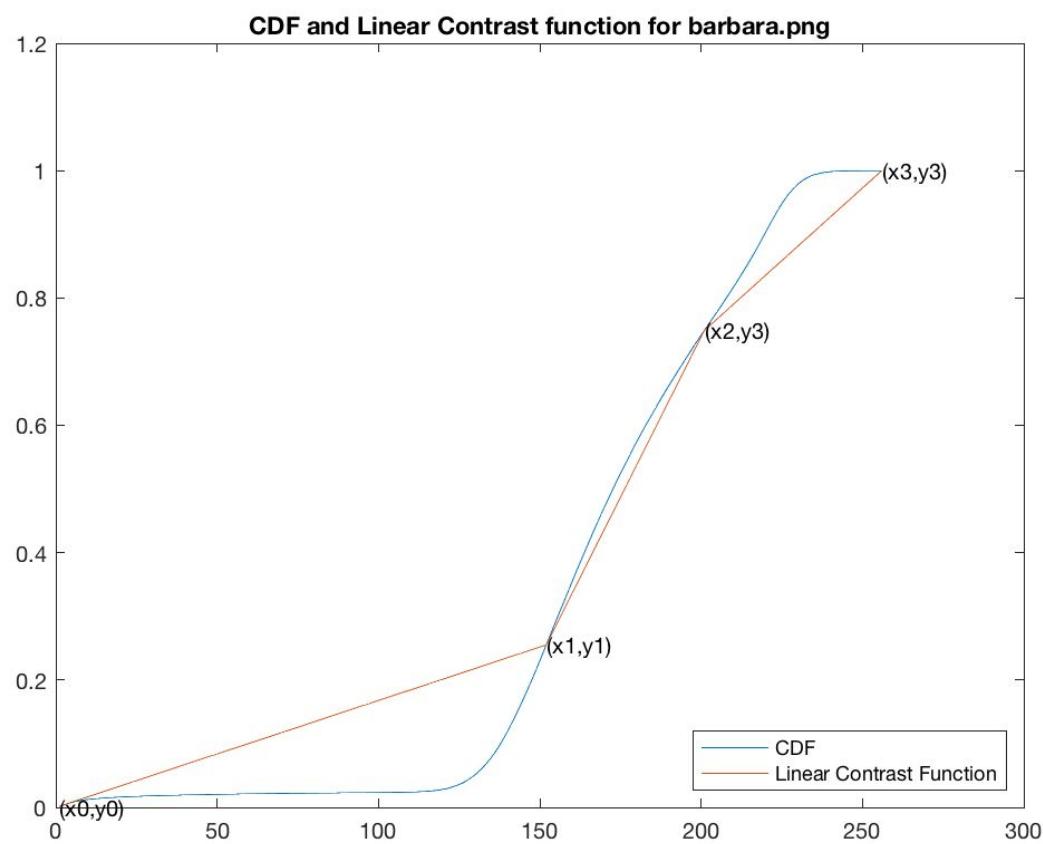
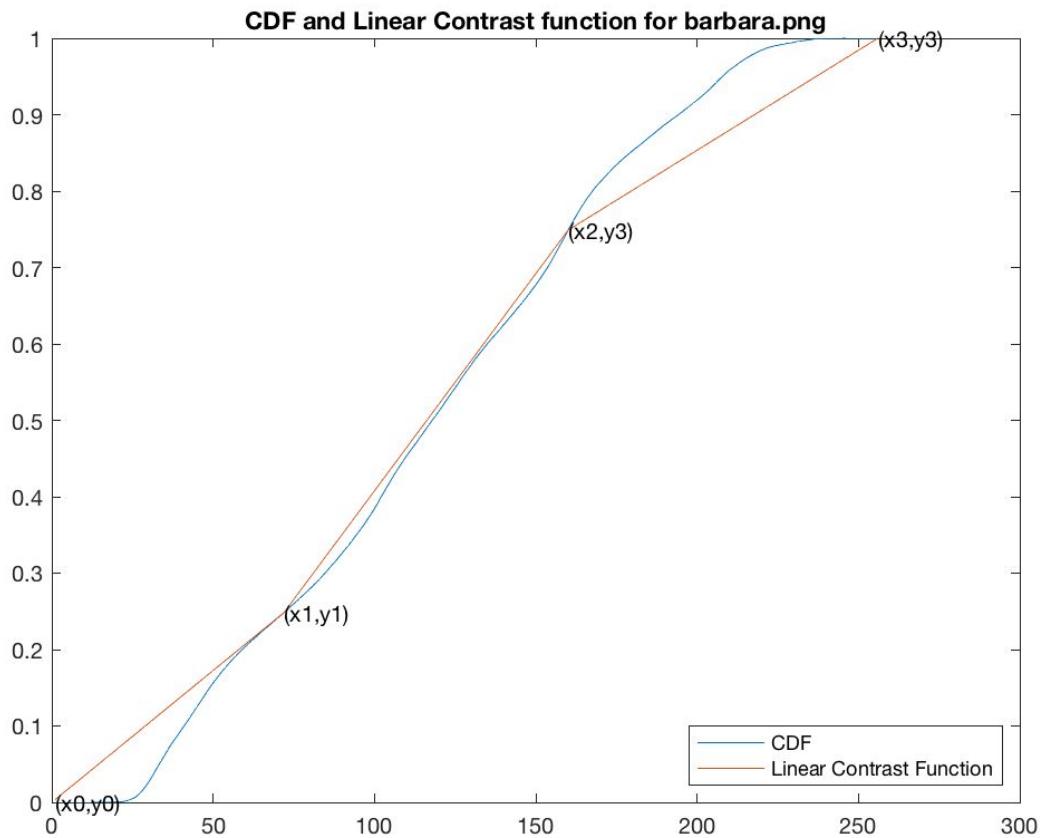
## Question 2 - Image Enhancements

### A. Linear Contrast Stretching

The Linear contrast enhancing function is a piecewise linear function (map) formed from 3 Line segments- map\_1, map\_2 and map\_3. We need 4 points to construct this piecewise function, which are obtained from the CDF of the image. The first point is the origin of the CDF- (1,0). Second point is the point where the value of CDF is 0.25, so second point is (x1,0.25). Third point is the point where the value of CDF is 0.75, so second point is (x2,0.75). Fourth point is the final point of the CDF, that is, (256,1).

PseudoCode:

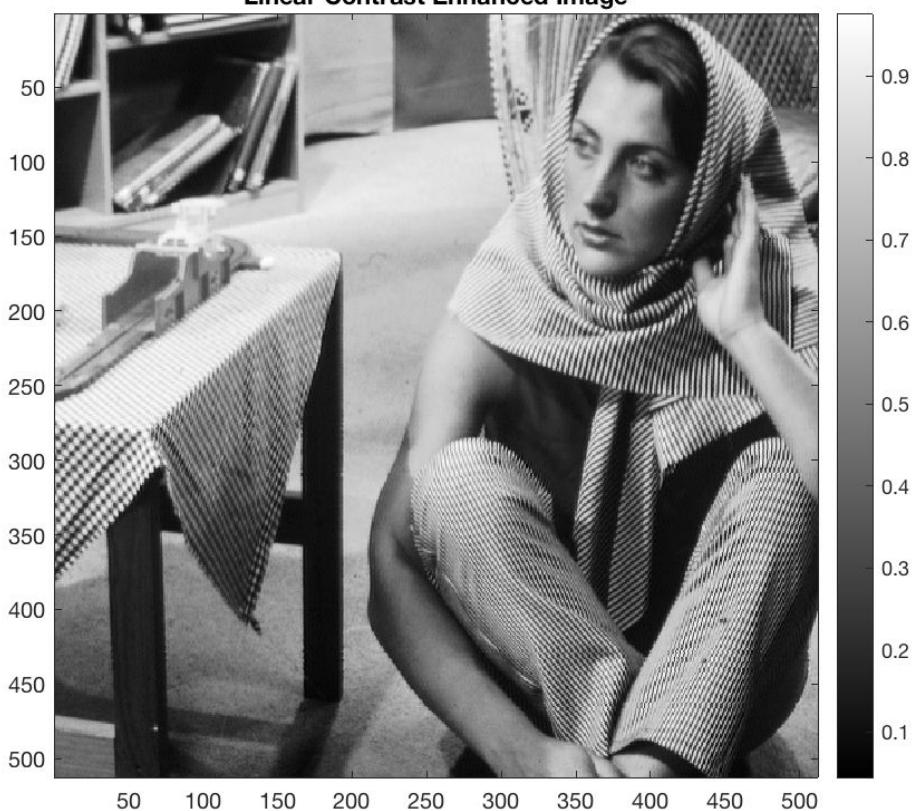
1. For a single channel image, Calculate its CDF
2.  $(x_0, y_0) = (1,0)$
3. Find  $x_1$  such that  $y_1 \approx 0.25$
4. Find  $x_2$  such that  $y_1 \approx 0.75$
5.  $(x_3, y_3) = (256,1)$
6. Define map\_1 as a straight line between  $(x_0, y_0)$  and  $(x_1, y_1)$
7. Define map\_2 as a straight line between  $(x_1, y_1)$  and  $(x_2, y_2)$
8. Define map\_3 as a straight line between  $(x_2, y_2)$  and  $(x_3, y_3)$
9. Concatenate map\_1, map\_2 and map\_3 to get final linear mapping



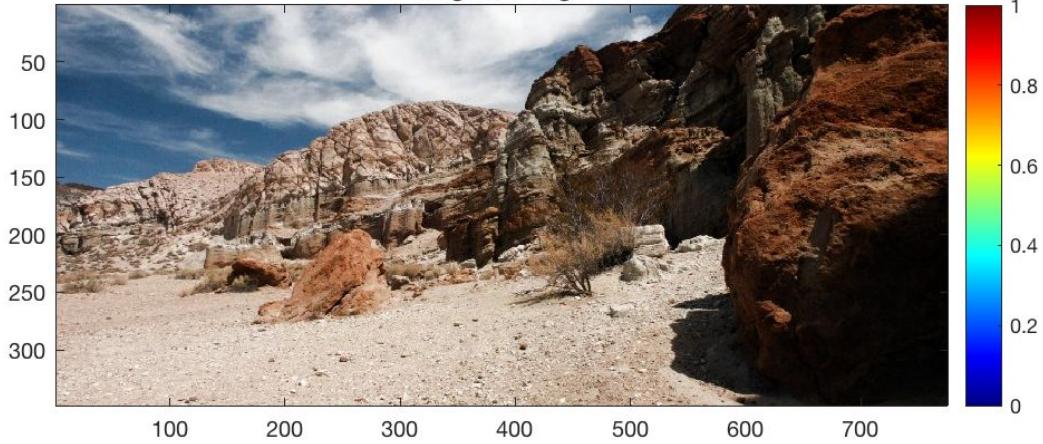
**Original Image**



**Linear Contrast Enhanced Image**

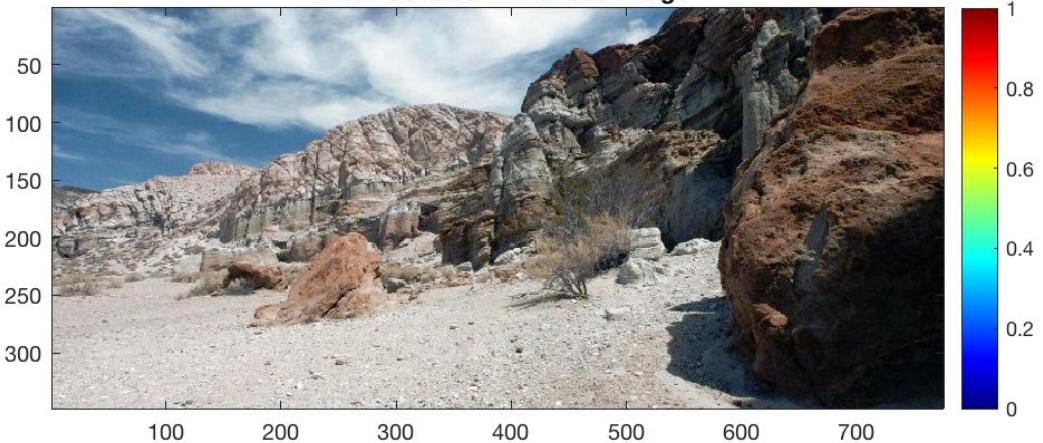


**Original Image**



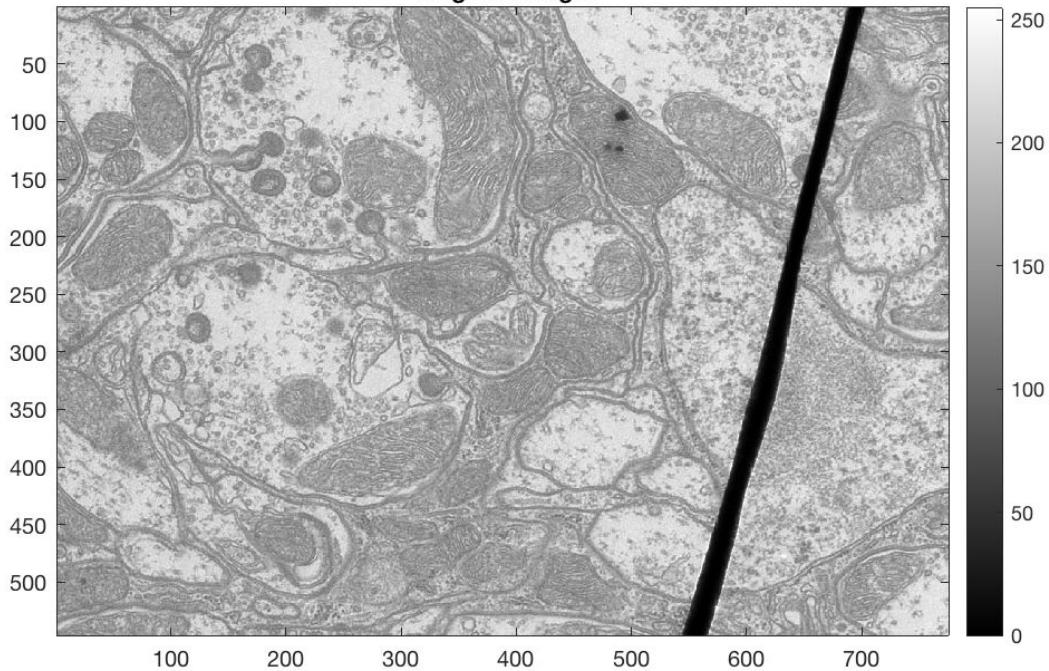
Pixel info: (X, Y) [R G B]

**Linear Contrast Enhanced Image**



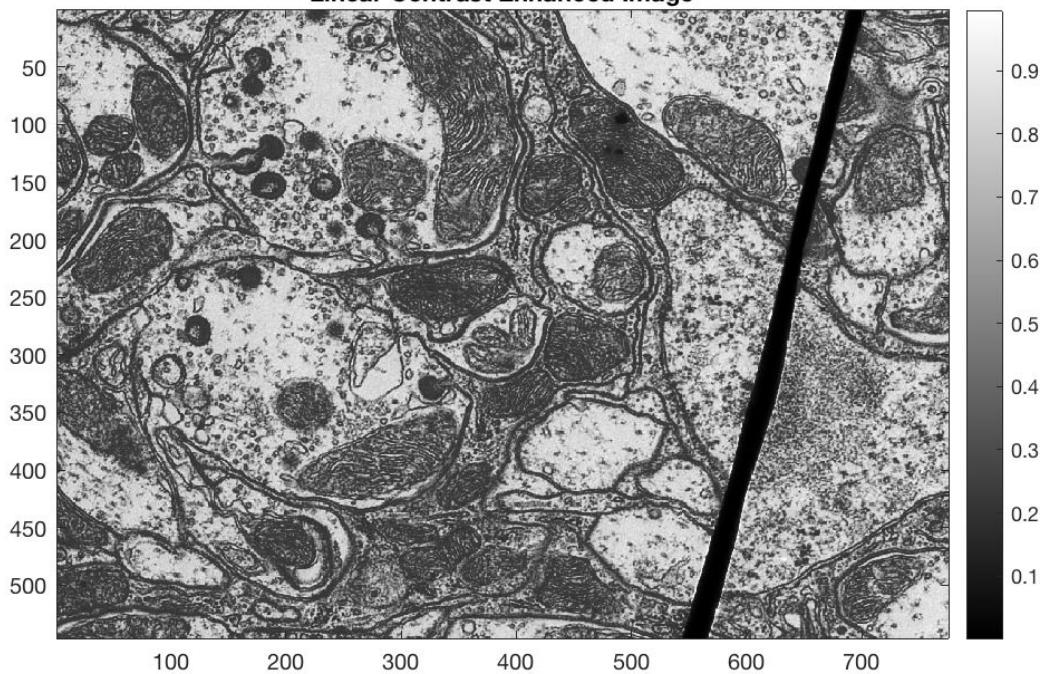
Pixel info: (X, Y) [R G B]

**Original Image**



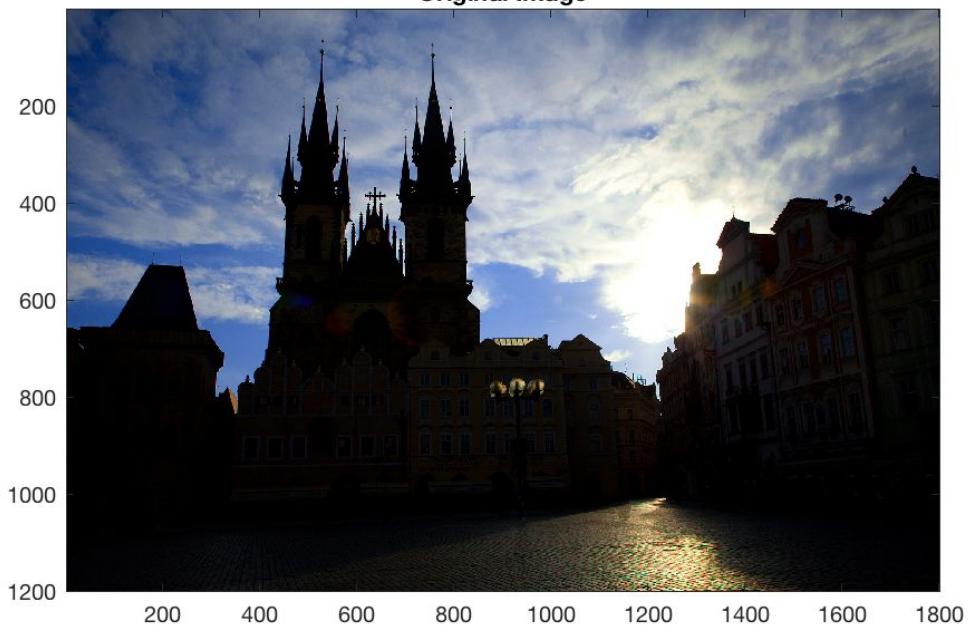
Pixel info: (X, Y) Pixel Value

**Linear Contrast Enhanced Image**



Pixel info: (X, Y) Intensity

**Original Image**



Pixel info: (X, Y) [R G B]

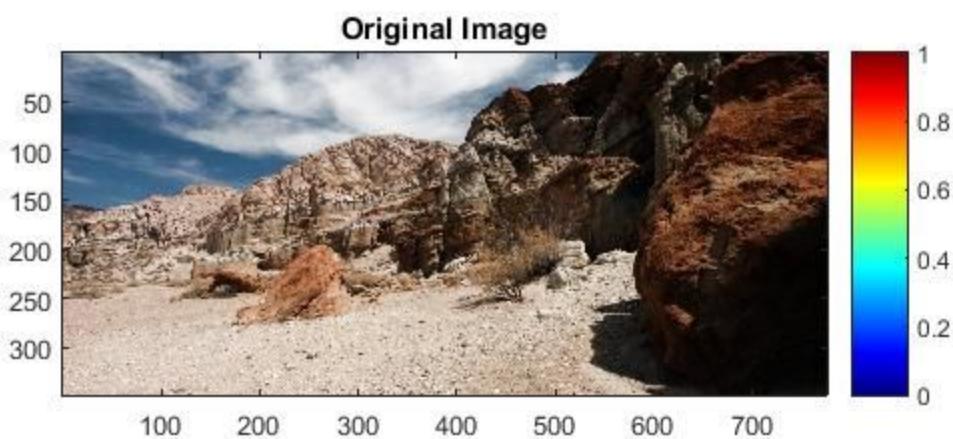
**Linear Contrast Enhanced Image**



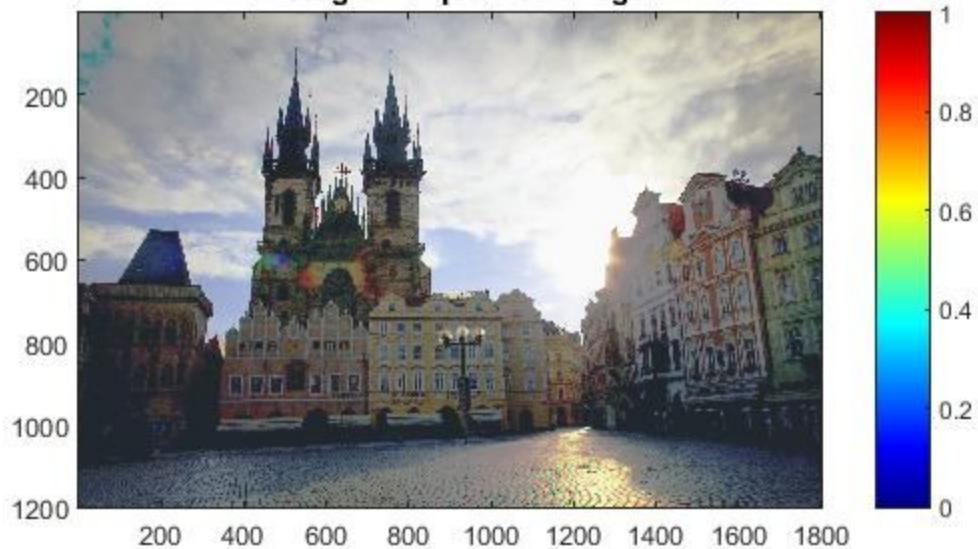
Pixel info: (X, Y) [R G B]

## B. Histogram Equalization

Histogram Equalization increases the contrast very well. The features of the output images are much more clearly visible, especially in the church.png, TEM.png and barbara.png. No significant change is seen in case of canyon.png



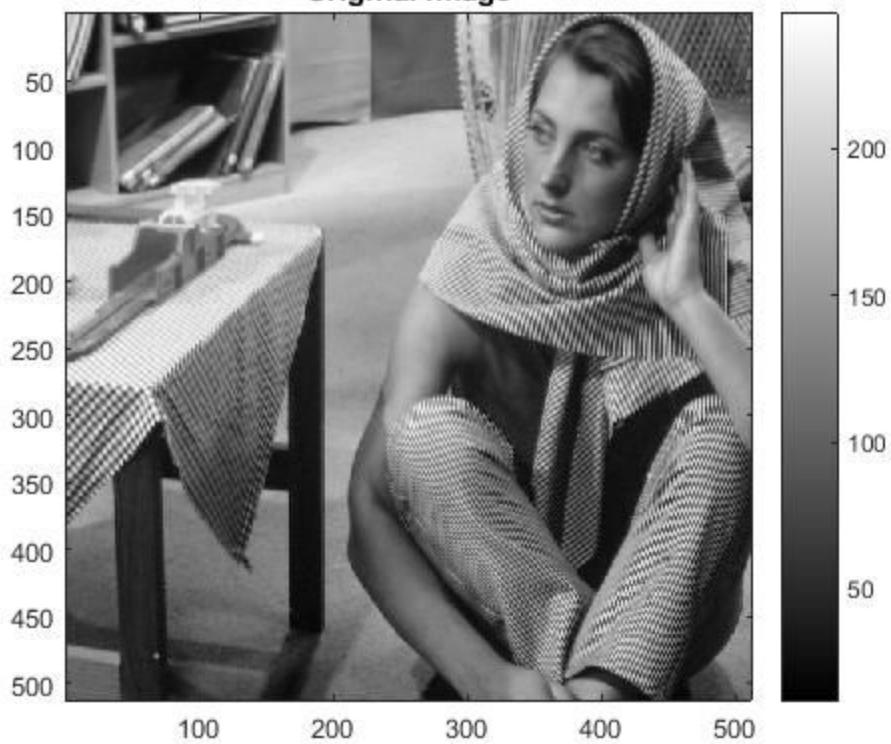
**Histogram Equalized Image**



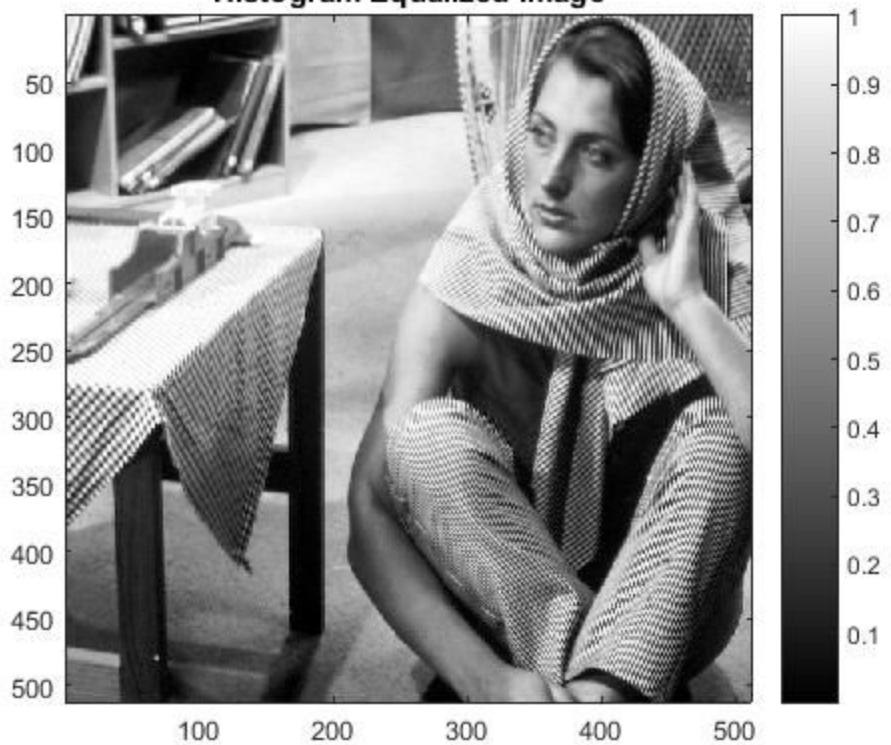
**Original Image**



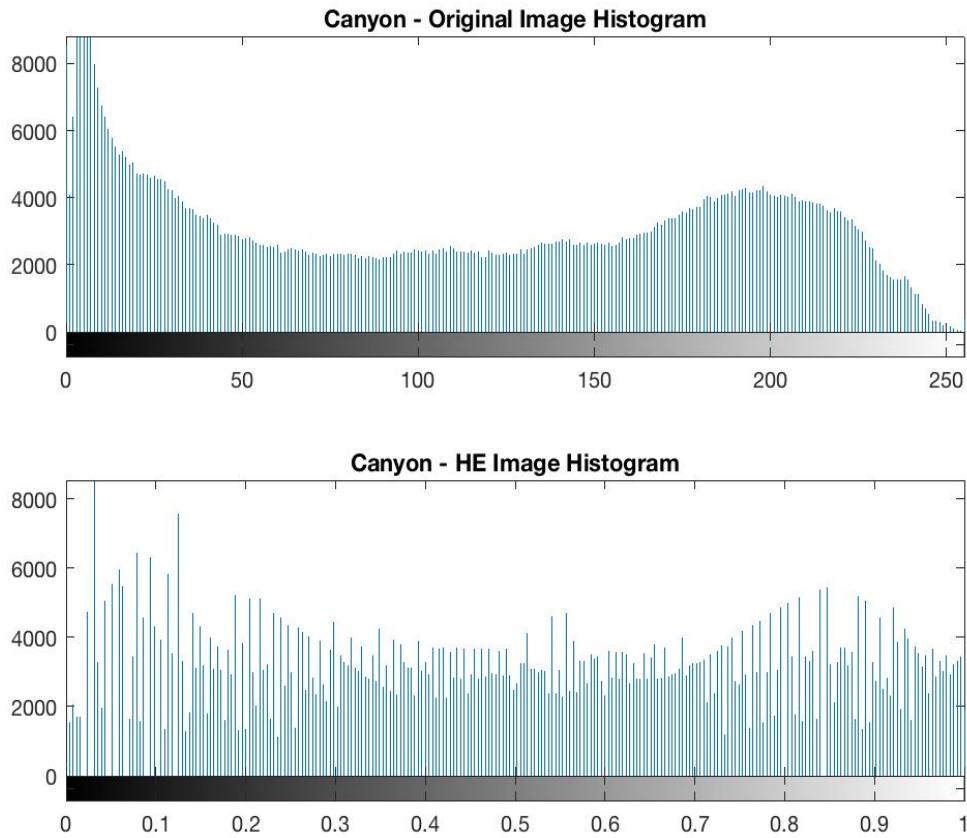
**Original Image**



**Histogram Equalized Image**



## Analysis in Canyon Image



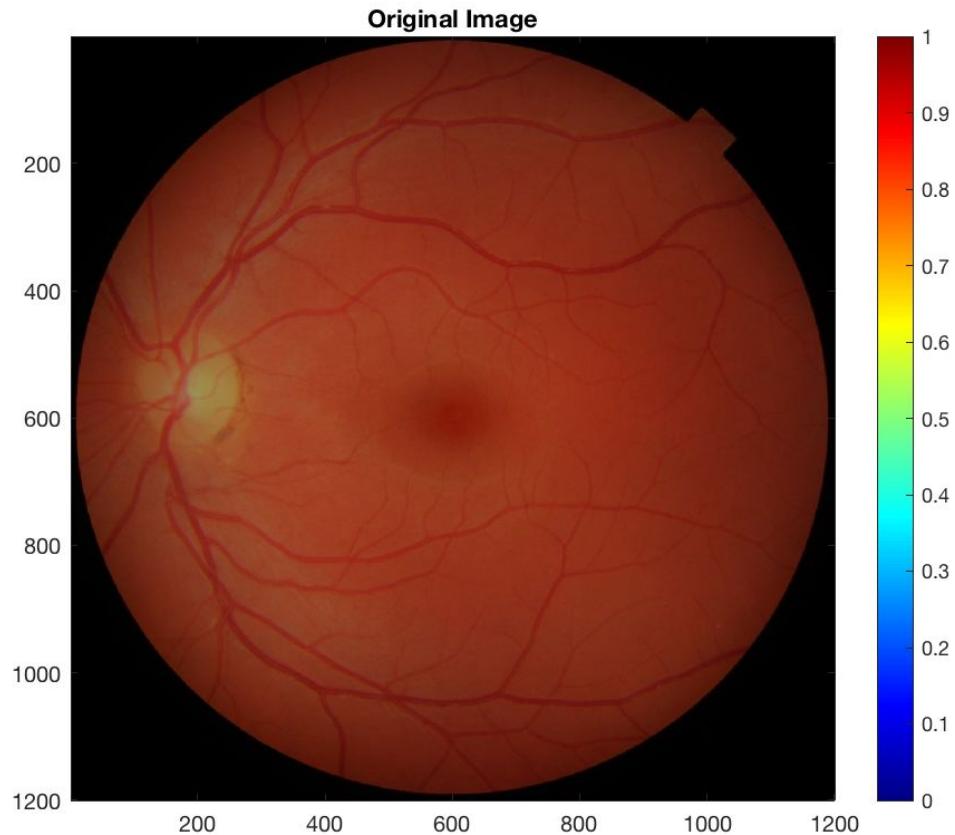
The above comparison of the histogram (of red channel) between the original image of the canyon (above) and Histogram Equalized Image shows that why Histogram Equalization doesn't have a significant impact on canyon image. The histogram in the original image itself is relatively well distributed over the colour intensities.

### C. Histogram Matching

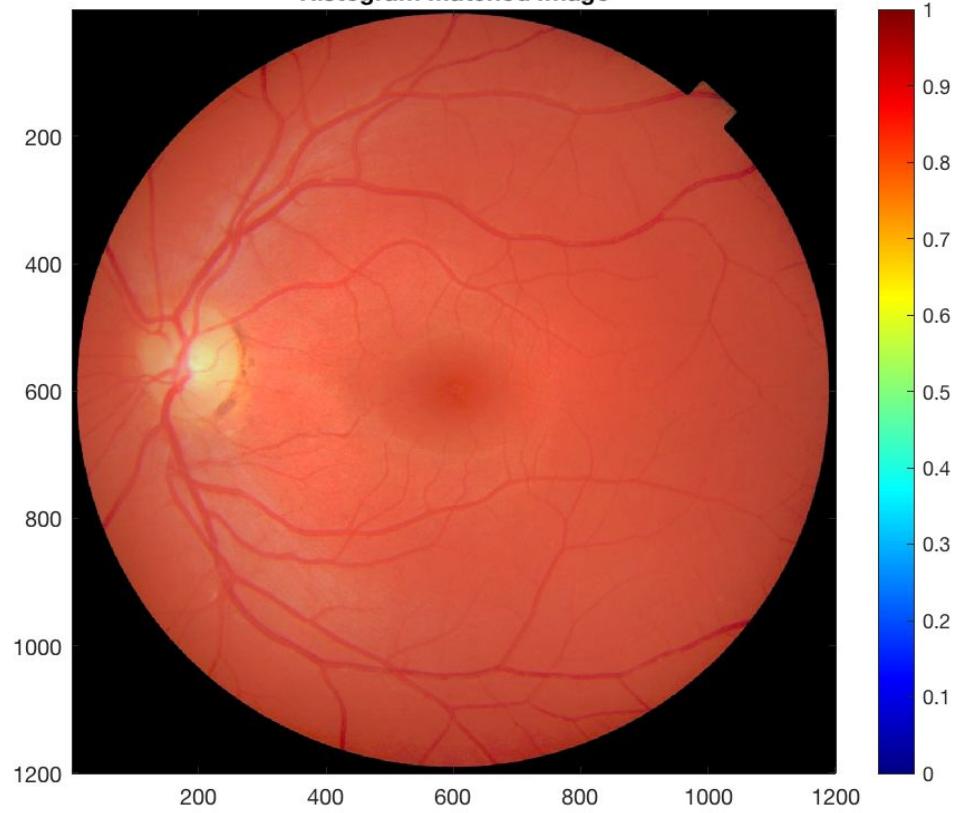
Histogram Equalization image does a good job of enhancing the contrast in the image but it reduces the eye color too much and hence, it does not look like any eye in histogram equalized image.

Histogram matching with the reference image produces the desired effect. It does not reduce the color of the eye too much and retains the essential features, which are much more observable in the output of Histogram Matching.

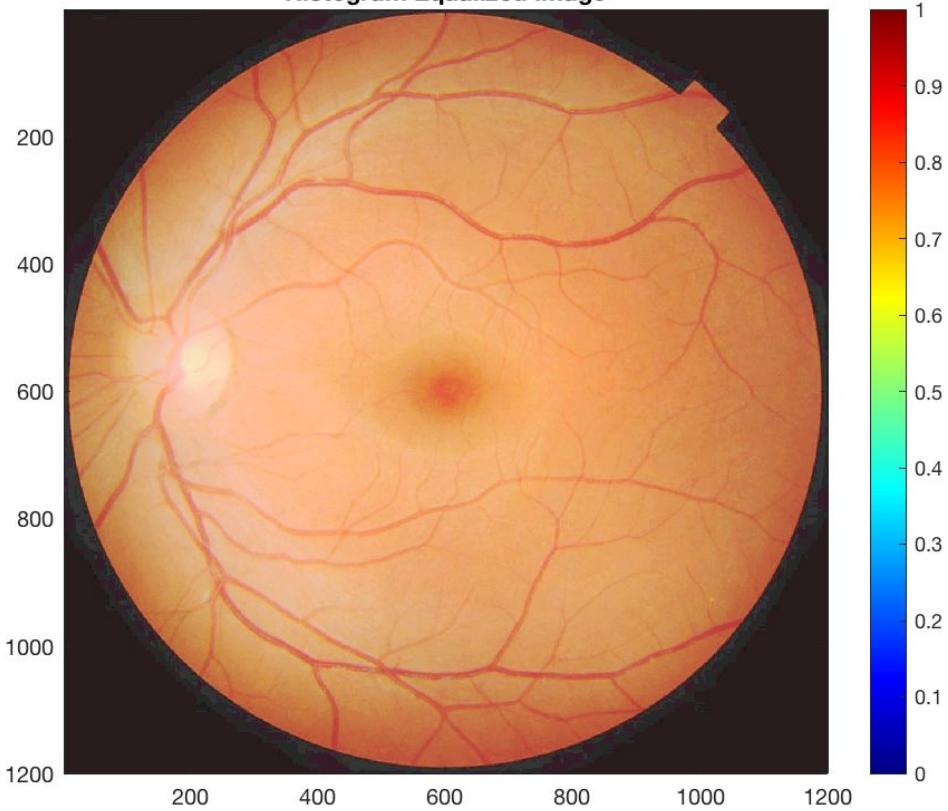
(See Next page for the output of Histogram Matching and equalization on the original image)



**Histogram Matched Image**



**Histogram Equalized Image**



#### D. Adaptive Histogram Equalization

The ideal window choice after fine tuning was chosen as 100. Output images of AHE have better contrast than output images of HE in case of TEM.png. The performance is similar in case of canyon.png while AHE performance is worse in case of barbara.png  
(Window size W means that window was constructed with W pixels on right, left, above and below of the center pixel, which means that at a single iteration a block of size  $(2W+1) \times (2W+1)$  is processed)

Barbara.png (In Order - Original Image , AHE image with W = 100, AHE image with W = 10 (significantly smaller), AHE image with W = 200(significantly larger))

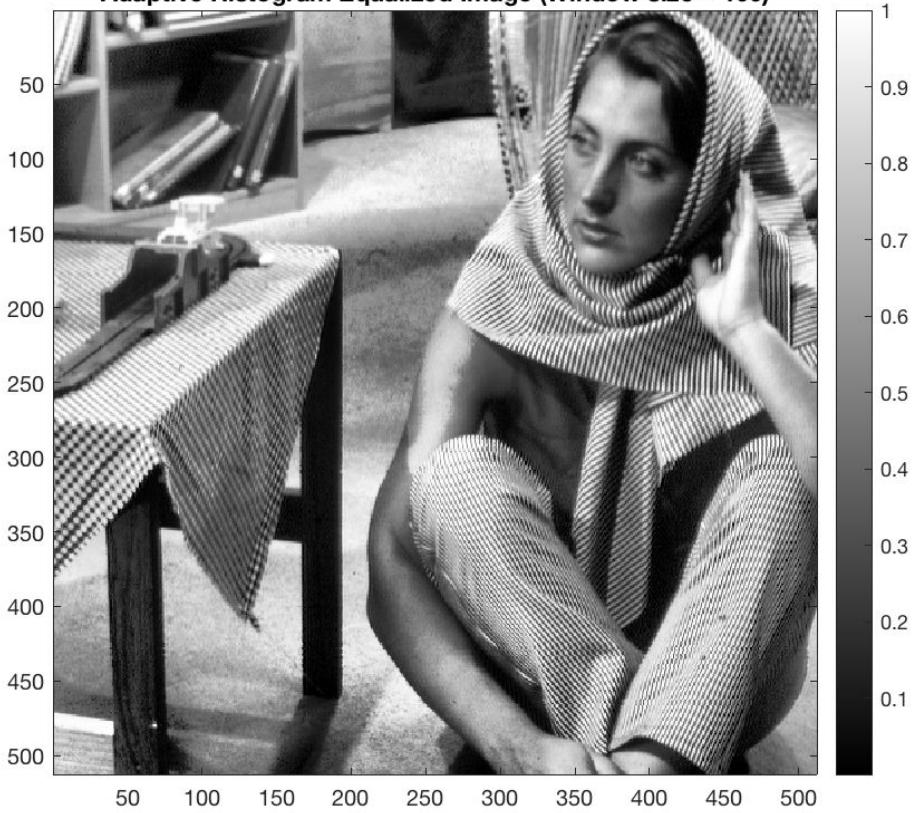
The low contrast in case of small window size can be easily seen.

Noise amplification can also be noticed for large window size. In barbara.png and canyon.png, the noise is evident on the face of the lady and plant at the bottom of the canyon. In TEM.png, the patterns become less subtle due to noise amplification.

**Original Image**



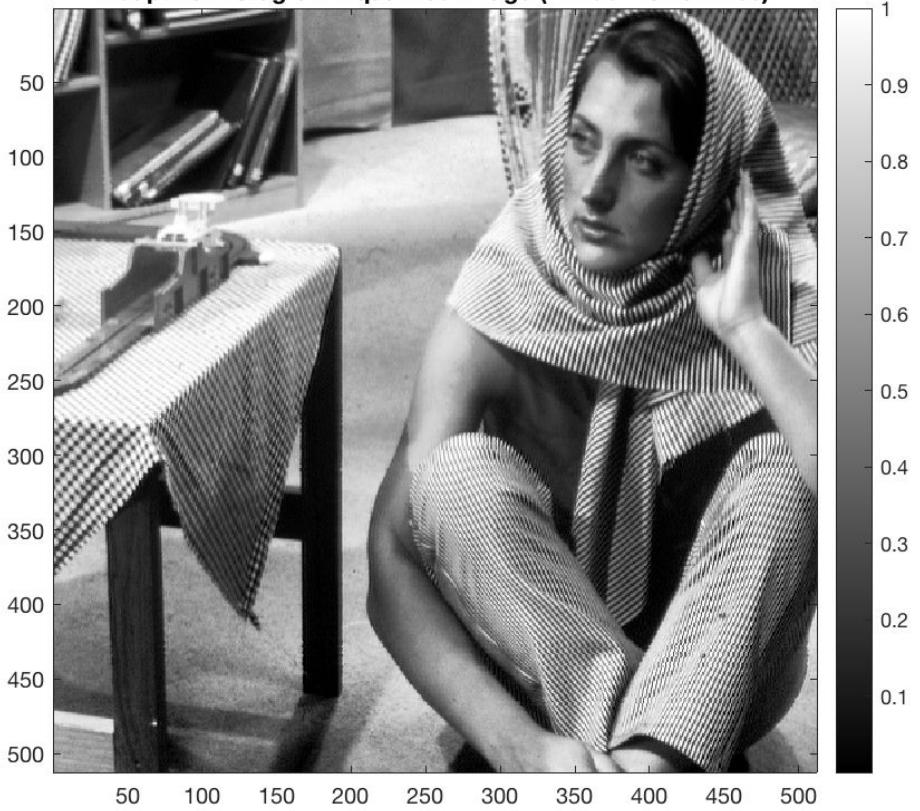
**Adaptive Histogram Equalized Image (Window size = 100)**



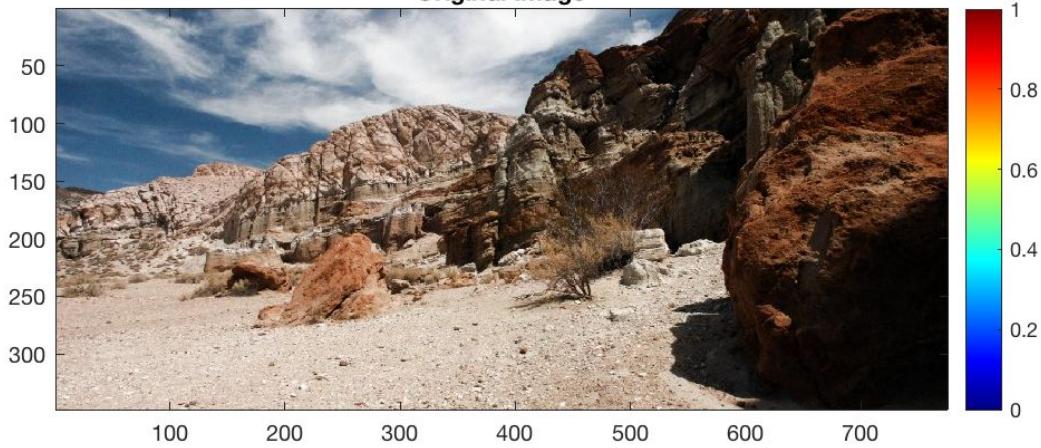
**Adaptive Histogram Equalized Image (Window size = 10)**



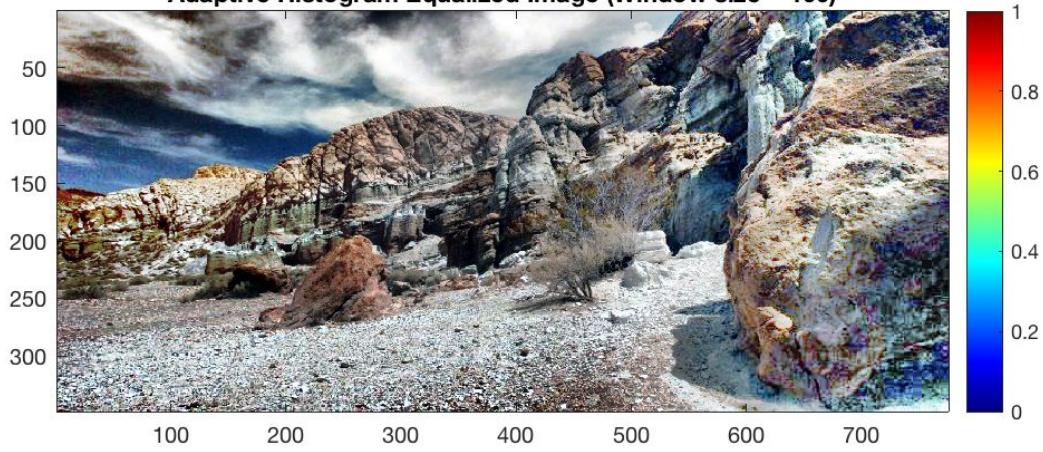
**Adaptive Histogram Equalized Image (Window size = 200)**



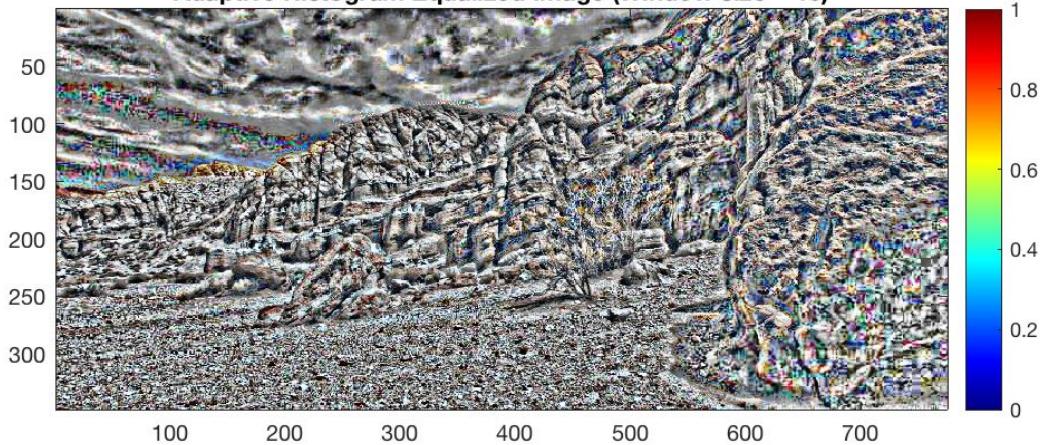
**Original Image**



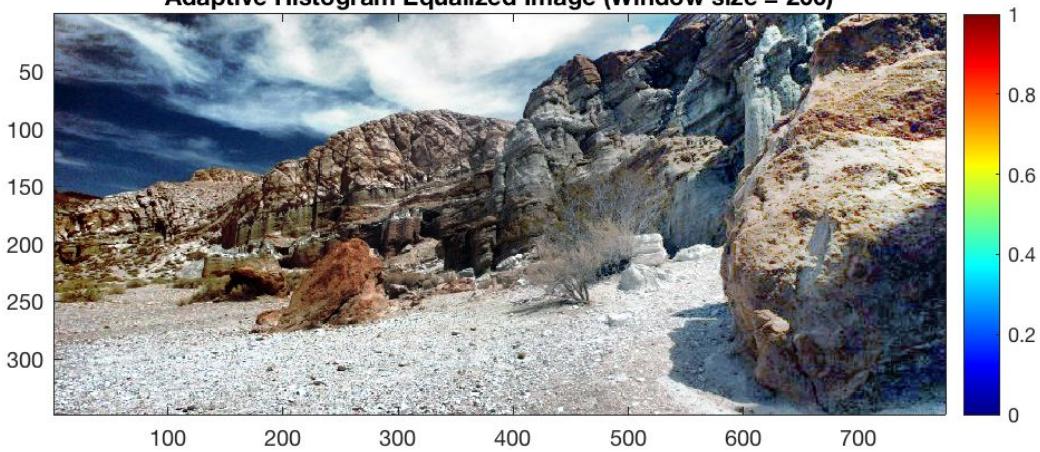
**Adaptive Histogram Equalized Image (Window size = 100)**

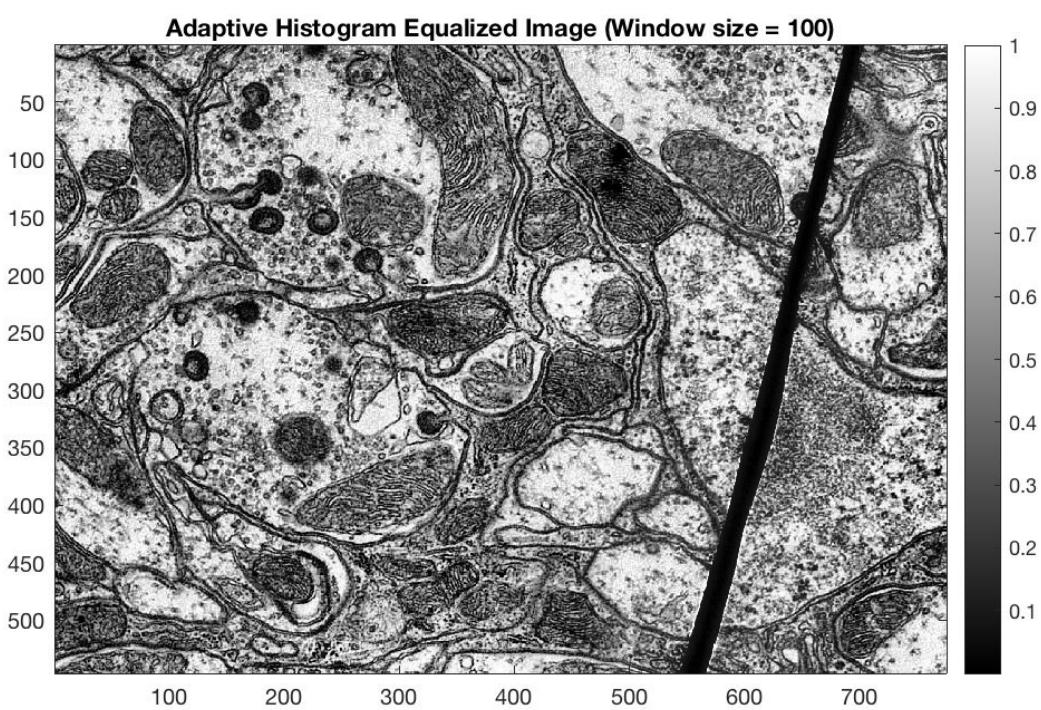
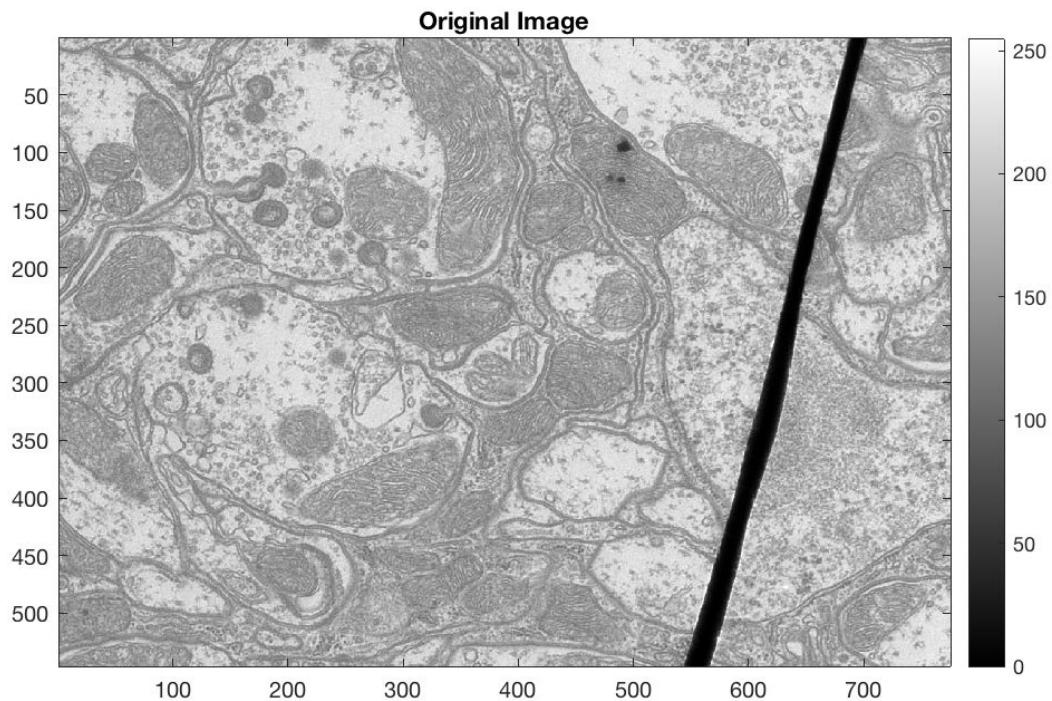


**Adaptive Histogram Equalized Image (Window size = 10)**

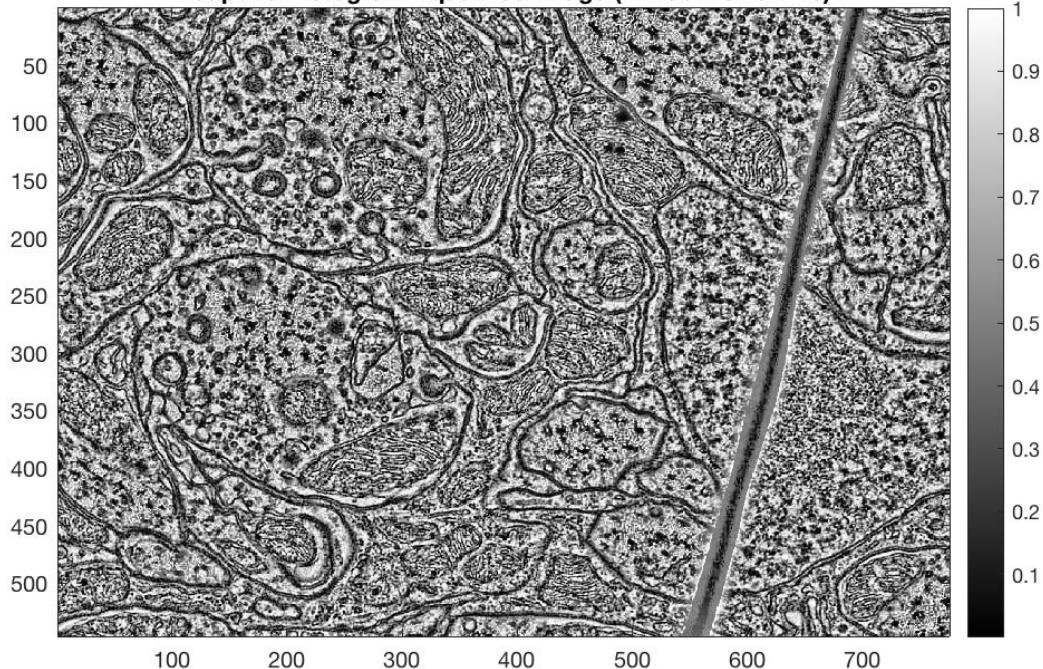


**Adaptive Histogram Equalized Image (Window size = 200)**

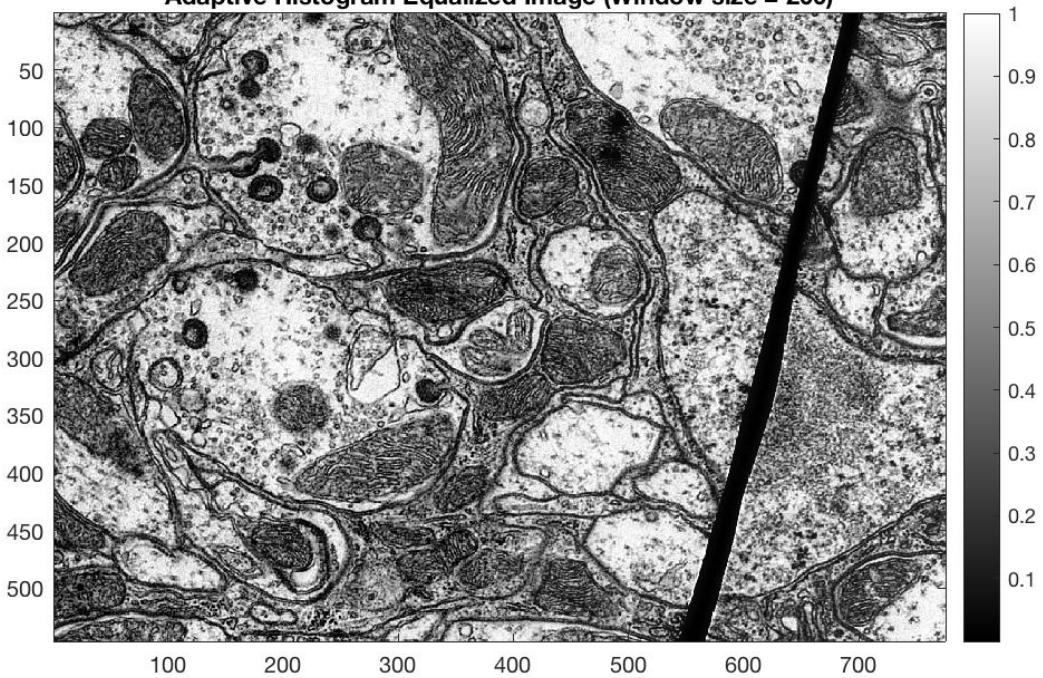




**Adaptive Histogram Equalized Image (Window size = 10)**

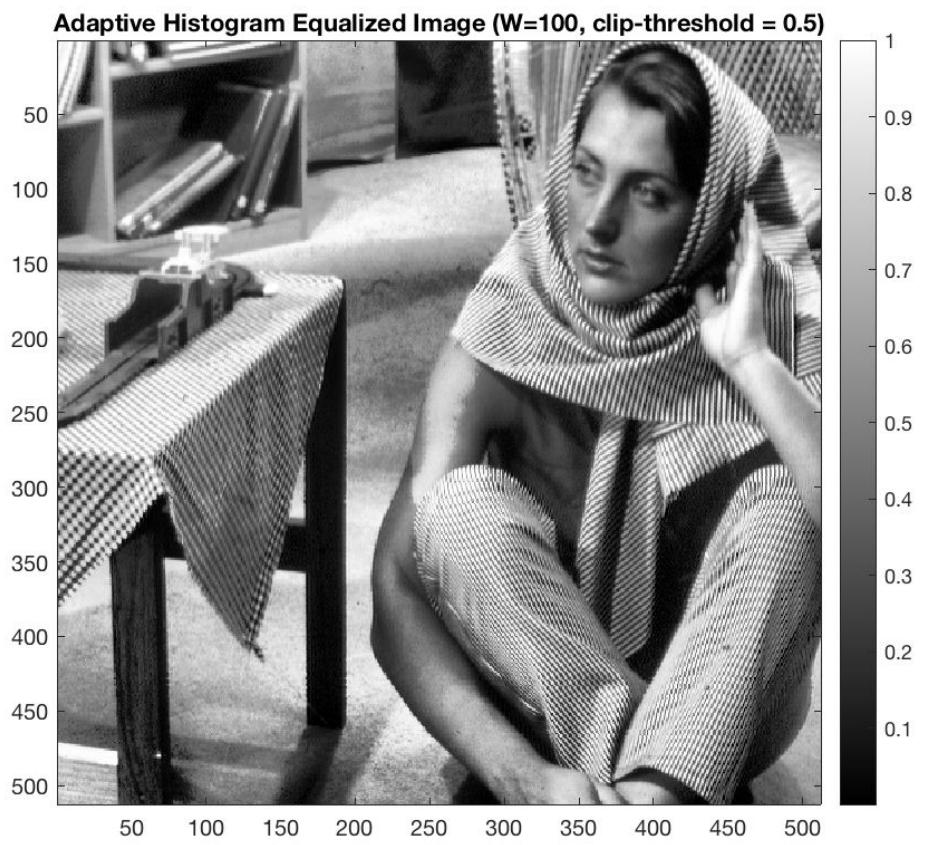


**Adaptive Histogram Equalized Image (Window size = 200)**



### E. Contrast-Limited Adaptive Histogram Equalization

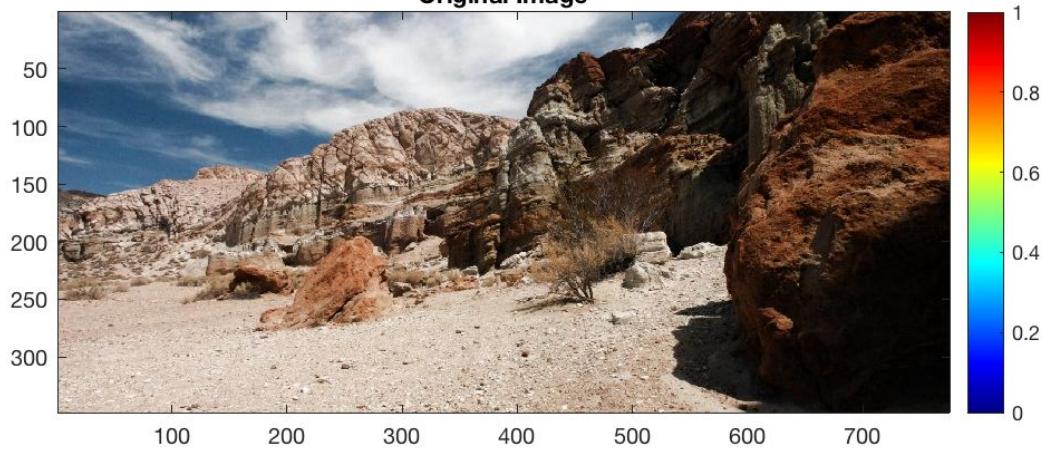
The clipping threshold was taken as 0.5 and window size as in AHE is taken as 100.

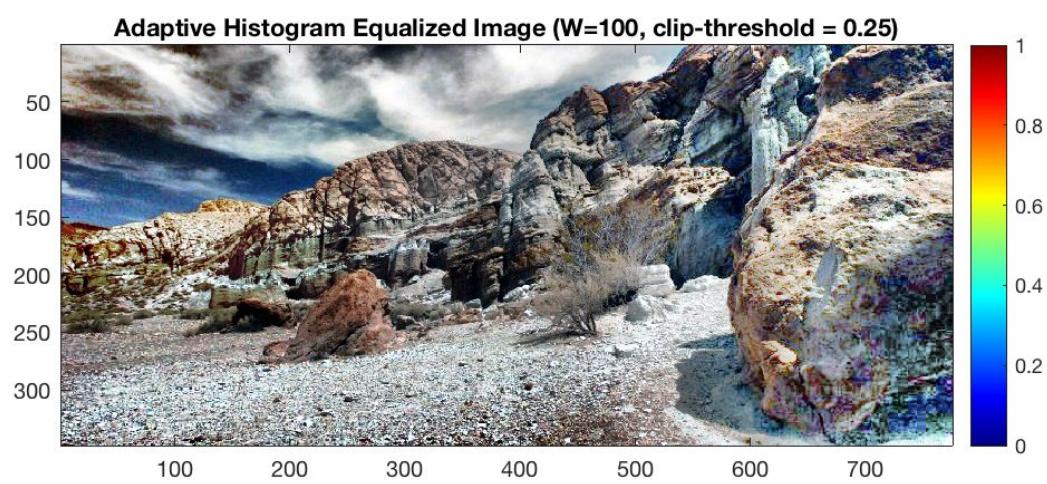
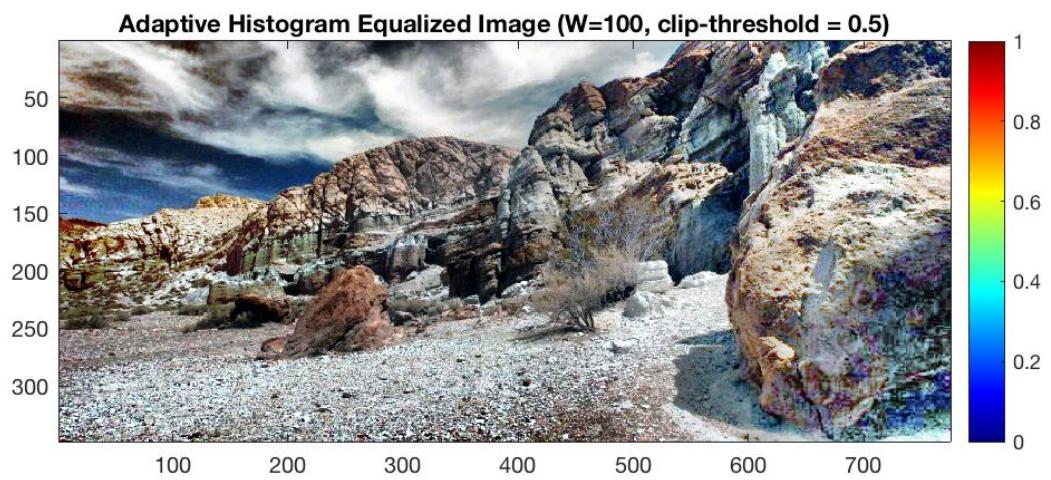


**Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.25)**

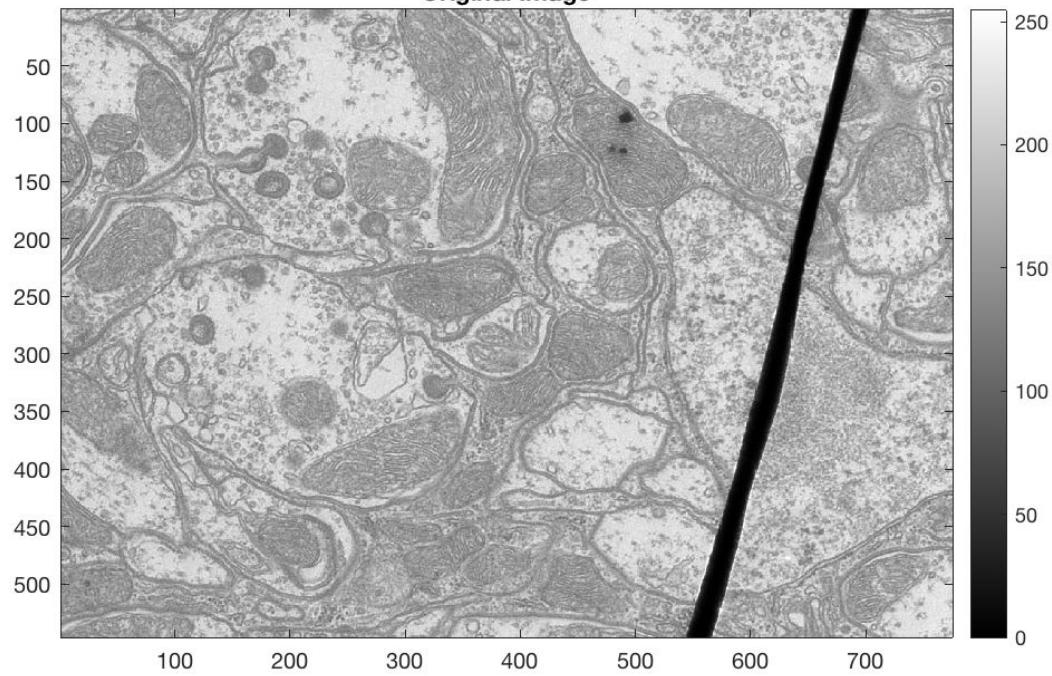


**Original Image**

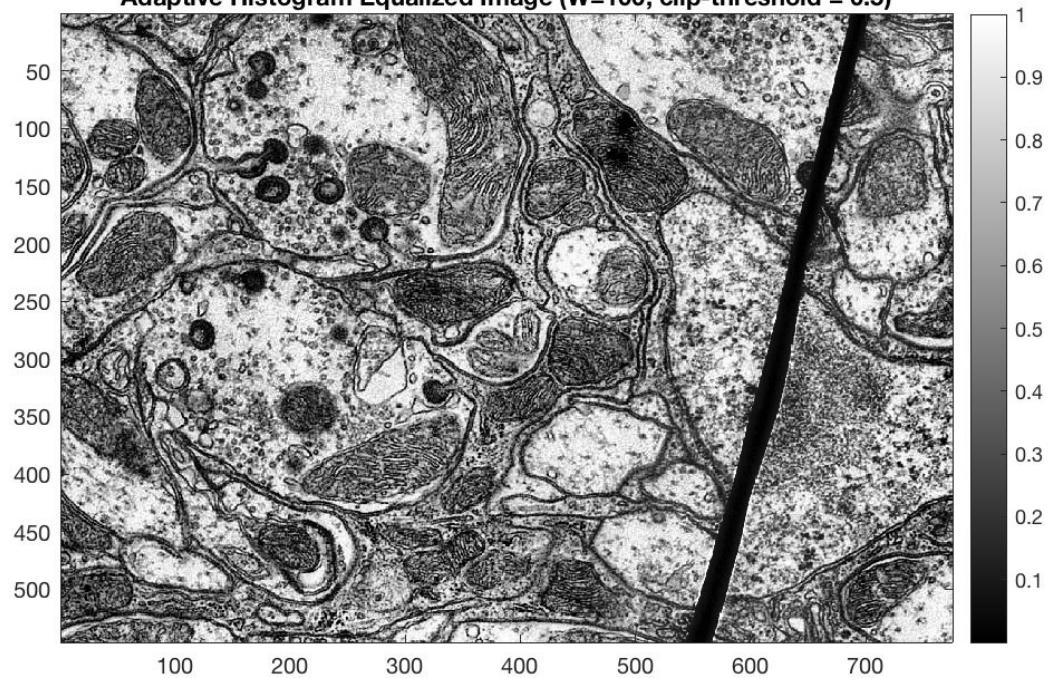




**Original Image**



**Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.5)**



**Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.25)**

