CS 663 Assignment 1 Report Part 2

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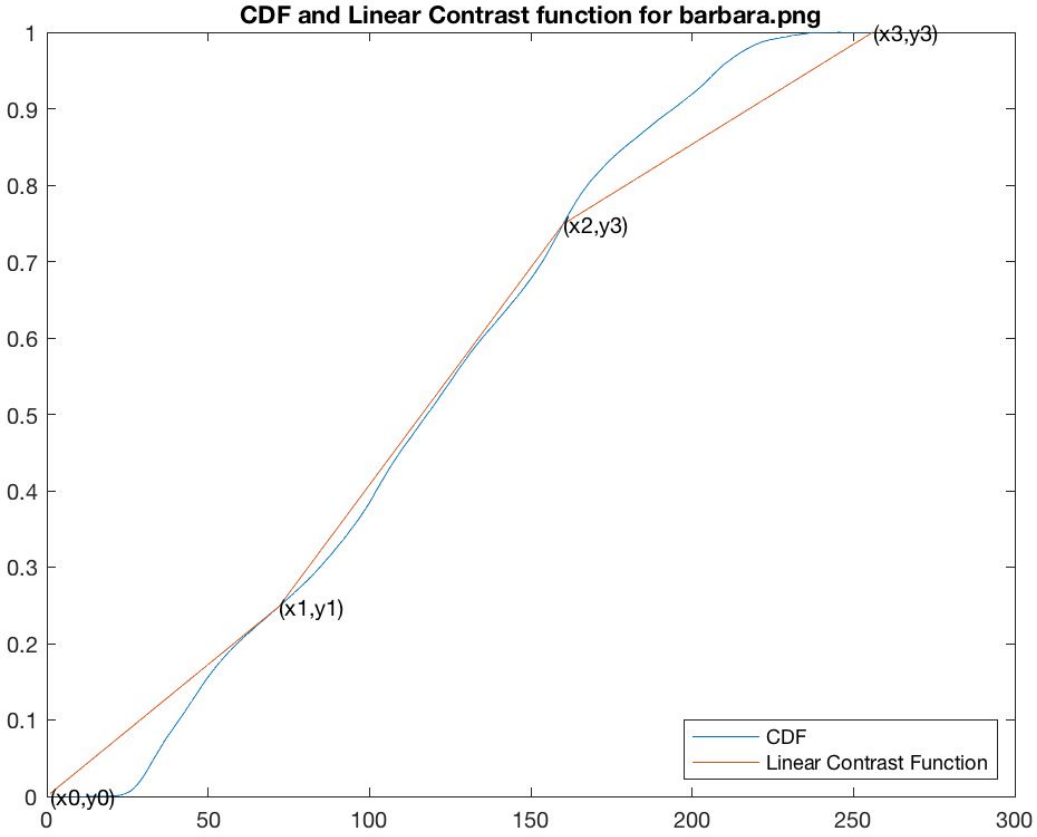
Question 2 - Image Enhancements

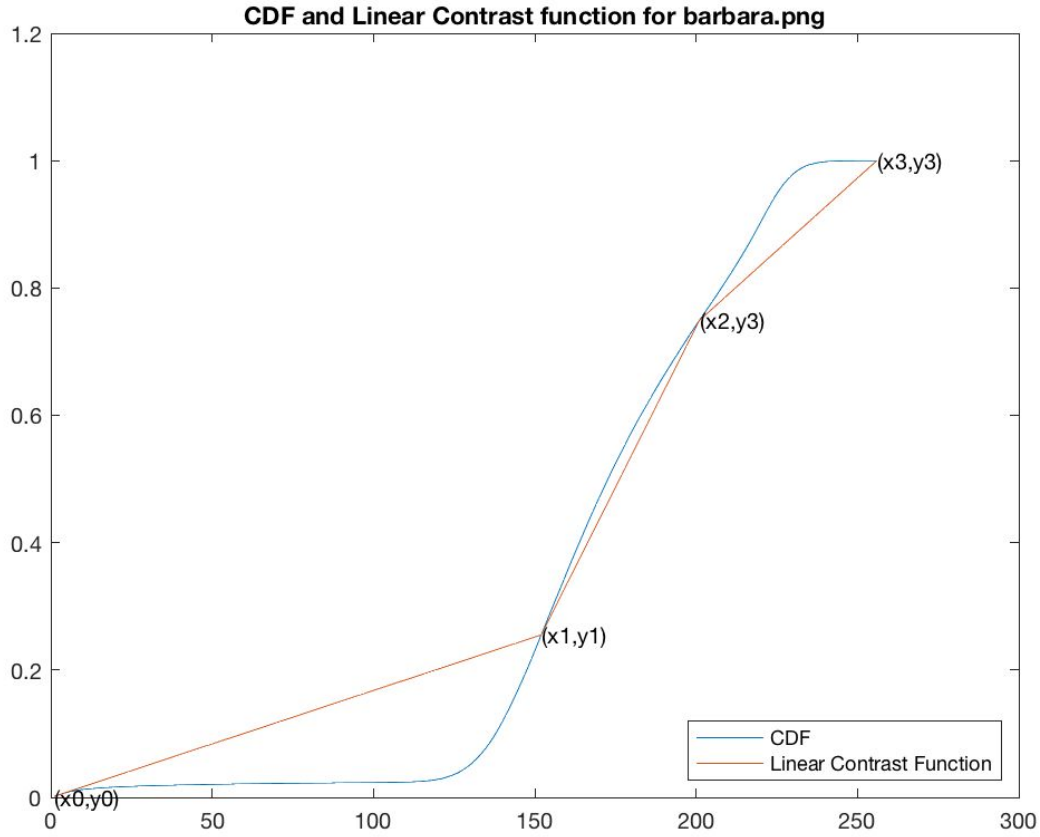
A. Linear Contrast Stretching

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:

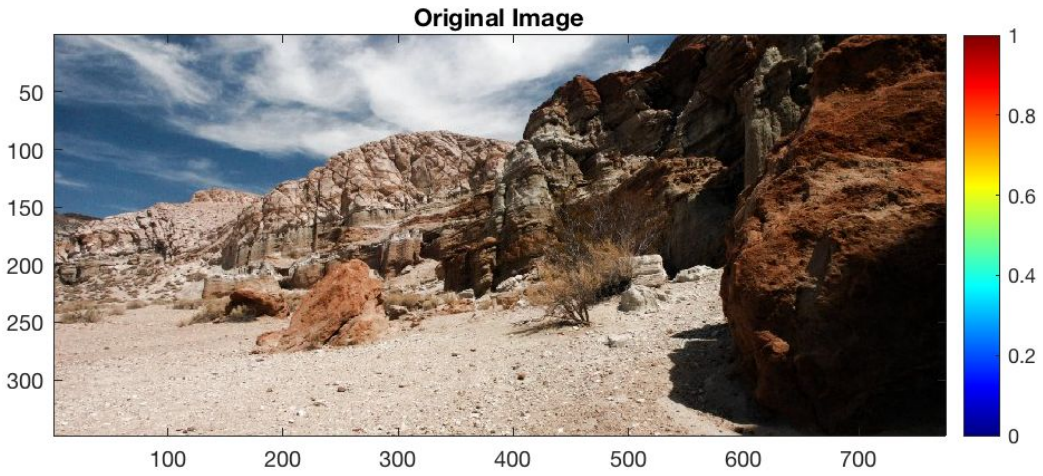
1. For a single channel image, Calculate its CDF
2. (x0, y0) = (1,0)
3. Find x1 such that y1 ≃ 0.25
4. Find x2 such that y1 ≃ 0.75
5. (x3, y3) = (256,1)
6. Define map_1 as a straight line between (x0,y0) and (x1,y1)
7. Define map_2 as a straight line between (x1,y1) and (x2,y2)
8. Define map_3 as a straight line between (x2,y2) and (x3,y3)
9. Concatenate map_1, map_2 and map_3 to get final linear mapping


CDF and Linear Contrast function for barbara.png
(x3,y3)
(x2,y3)
(x1,y1)
(x0,y0)
CDF
Linear Contrast Function
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300

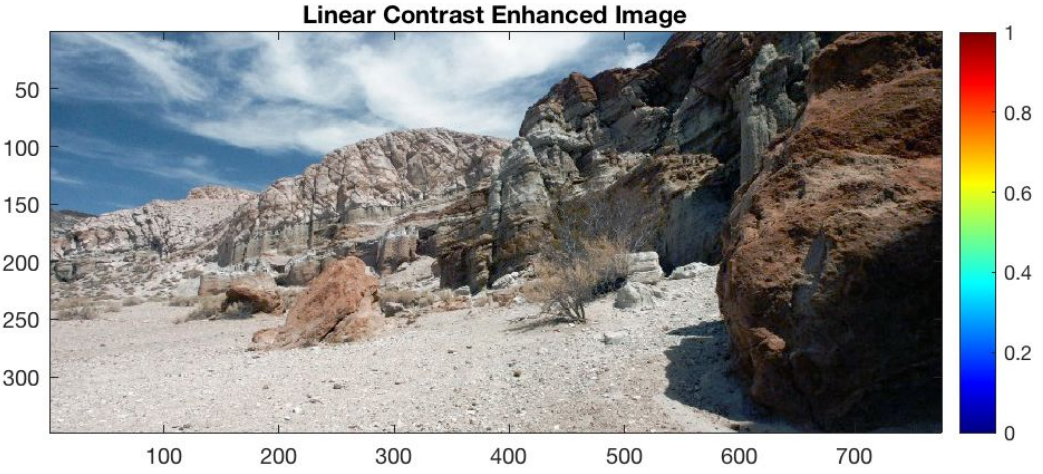

CDF and Linear Contrast function for barbara.png
(x3,y3)
(x2,y3)
(x1,y1)
(x0,y0)
CDF
Linear Contrast Function
0
0.2
0.4
0.6
0.8
1
1.2
0
50
100
150
200
250
300

Pixel info: (X, Y) Intensity

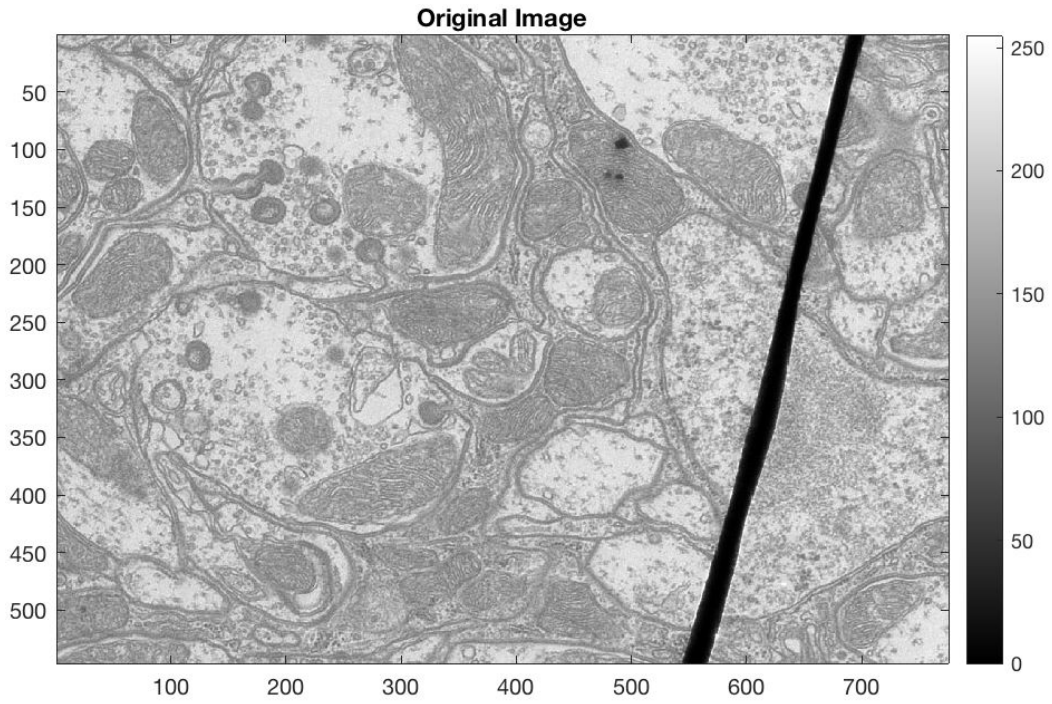
Pixel info: (X, Y) Intensity



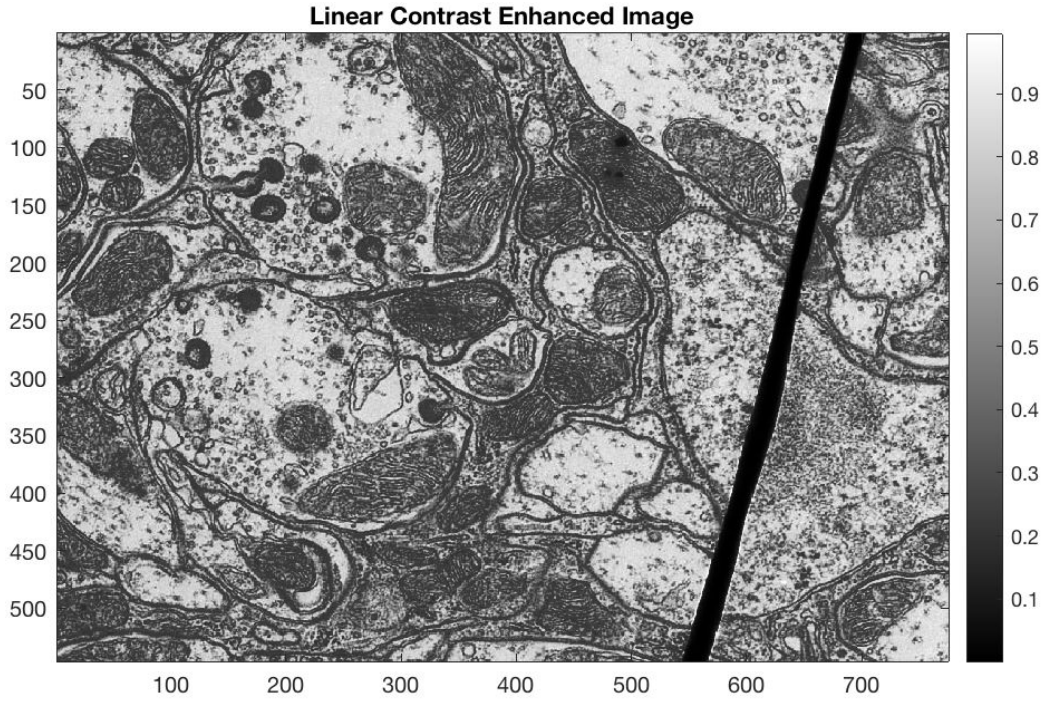
Pixel info: (X, Y) [R G B]



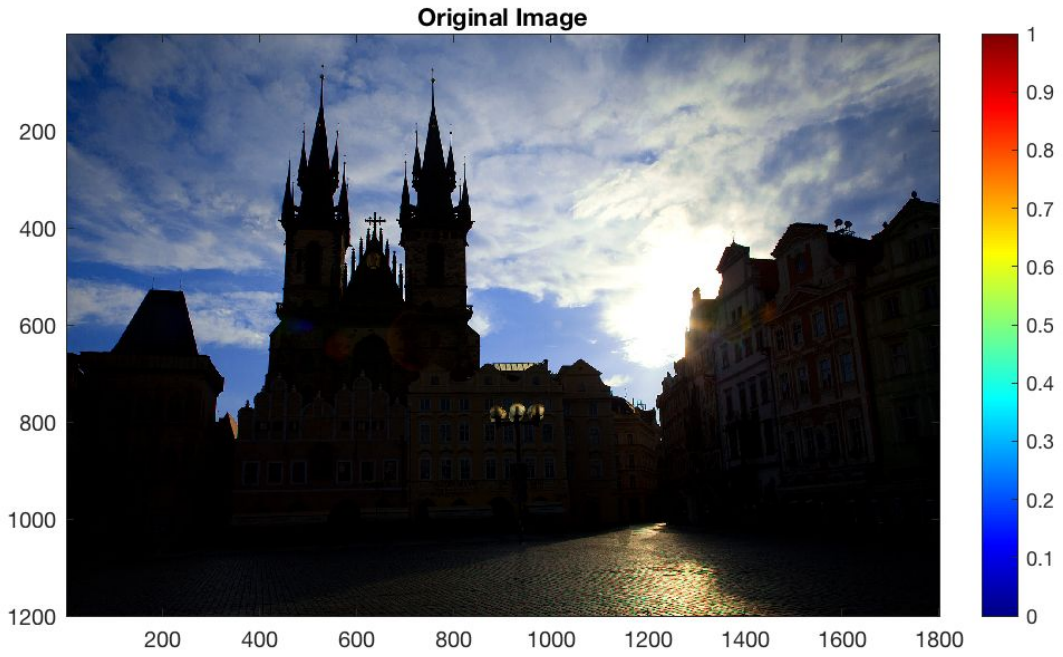
Pixel info: (X, Y) [R G B]

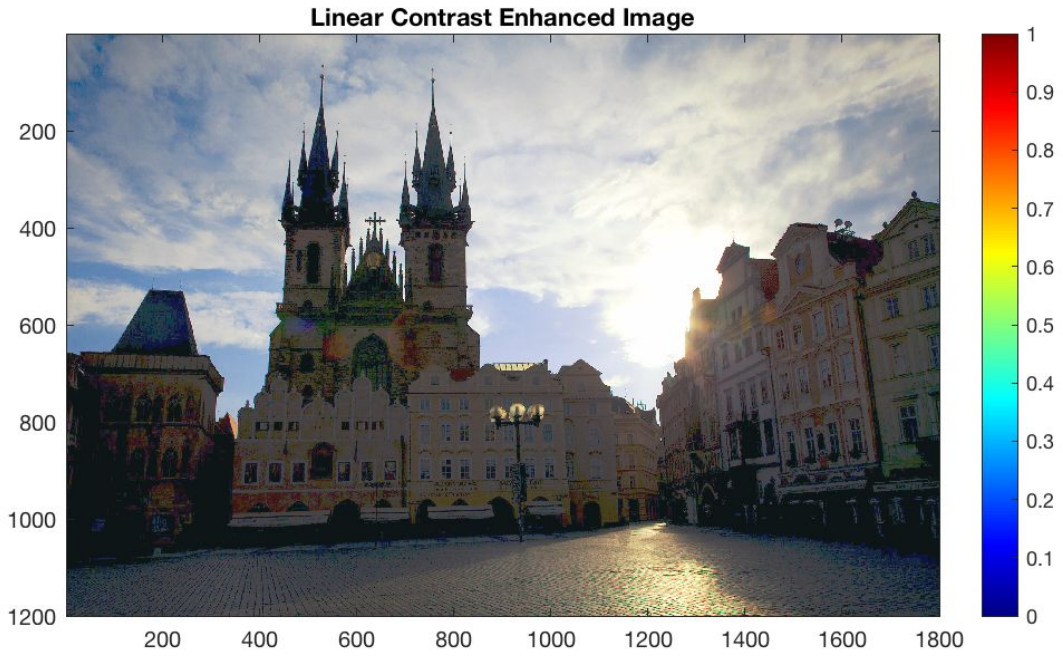


Pixel info: (X, Y) Pixel Value



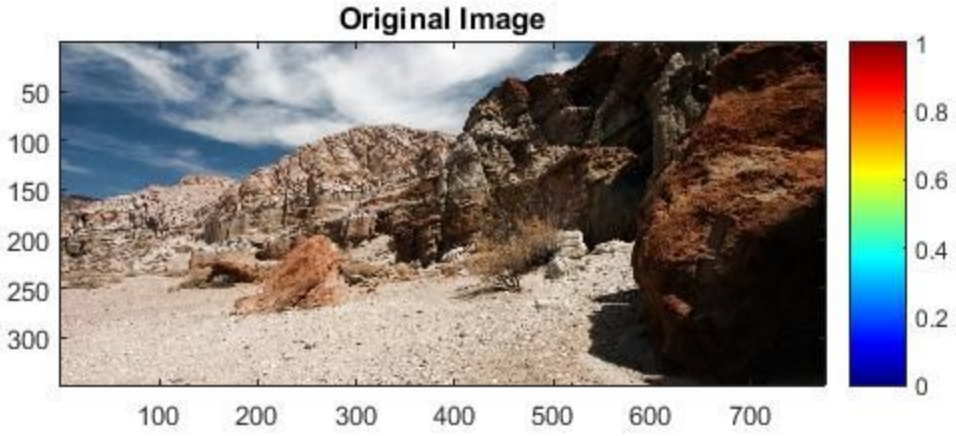
Pixel info: (X, Y) Intensity


Original Image
200
400
600
800
1000
1200
200
400
600
800
1000
1200
1400
1600
1800
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pixel info: (X, Y) [R G B]


Linear Contrast Enhanced Image
200
400
600
800
1000
1200
200
400
600
800
1000
1200
1400
1600
1800
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Pixel info: (X, Y) [R G B]

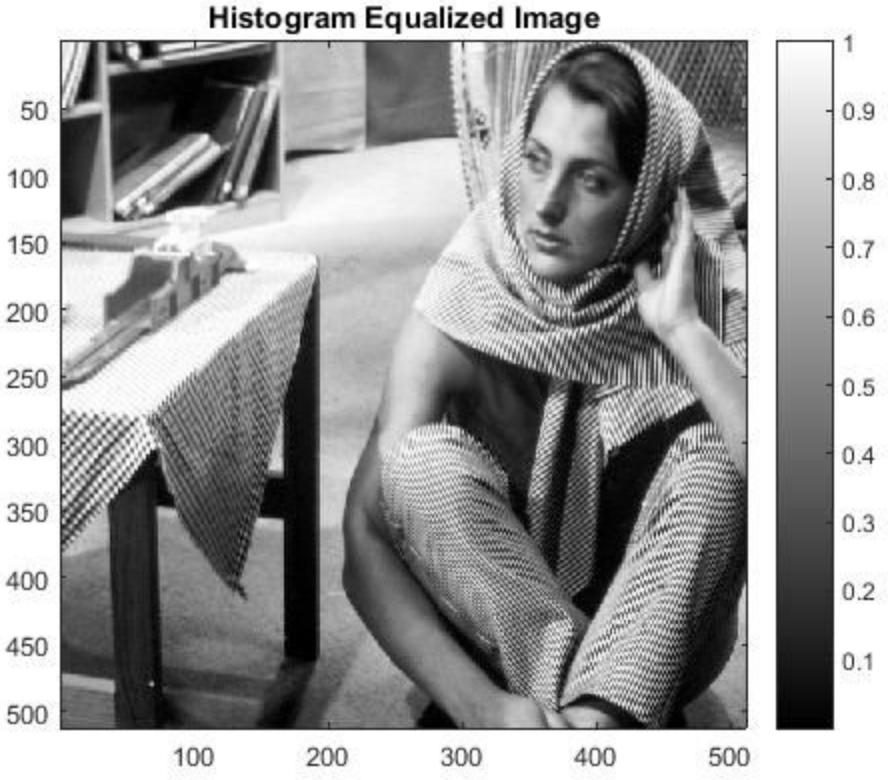
B. Histogram Equalization

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

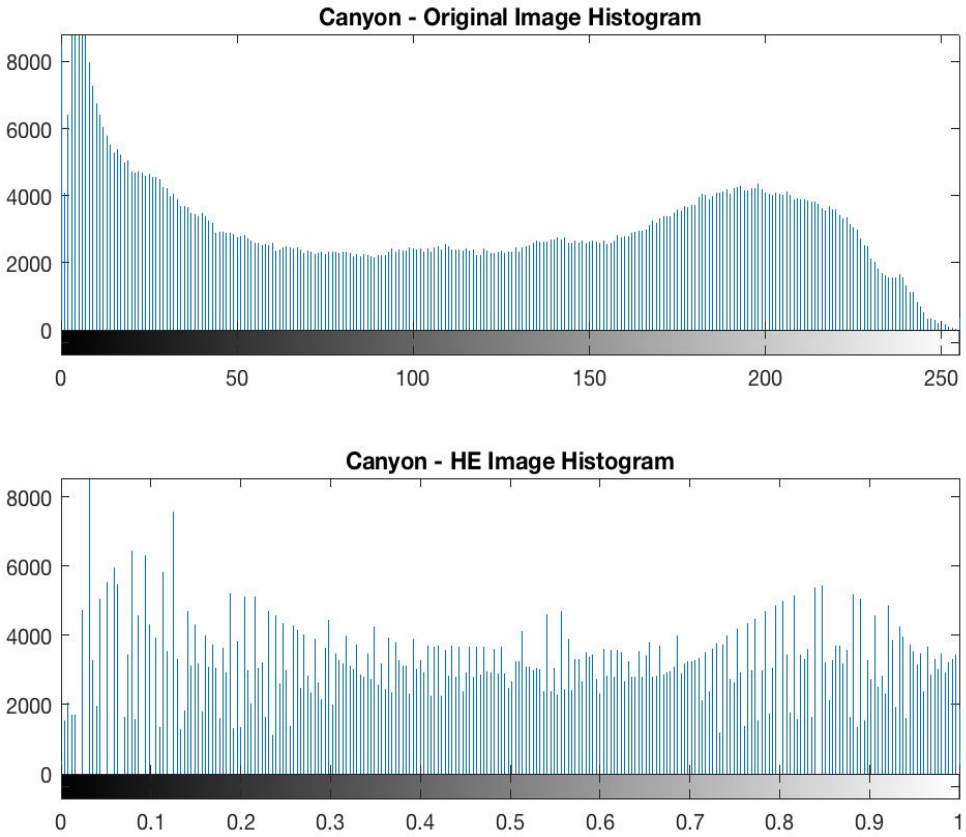



Histogram Equalized Image
200
400
600
800
1000
1200
200
400
600
800
1000
1200
1400
1600
1800
1
0.8
0.6
0.4
0.2
0
Original Image
200
400
600
800
1000
1200
200
400
600
800
1000
1200
1400
1600
1800
1
0.8
0.6
0.4
0.2
0


Original Image
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
200
150
100
50


Histogram Equalized Image
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

Analysis in Canyon Image

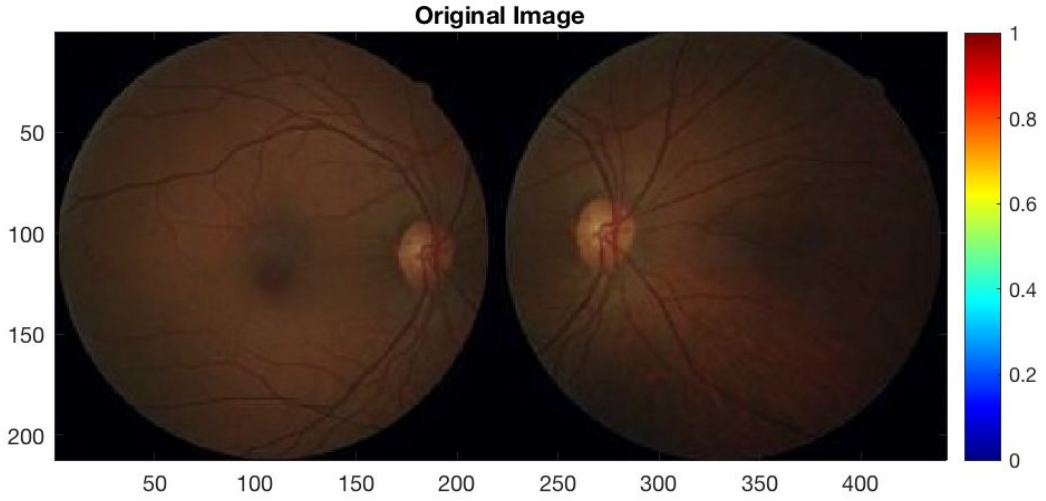


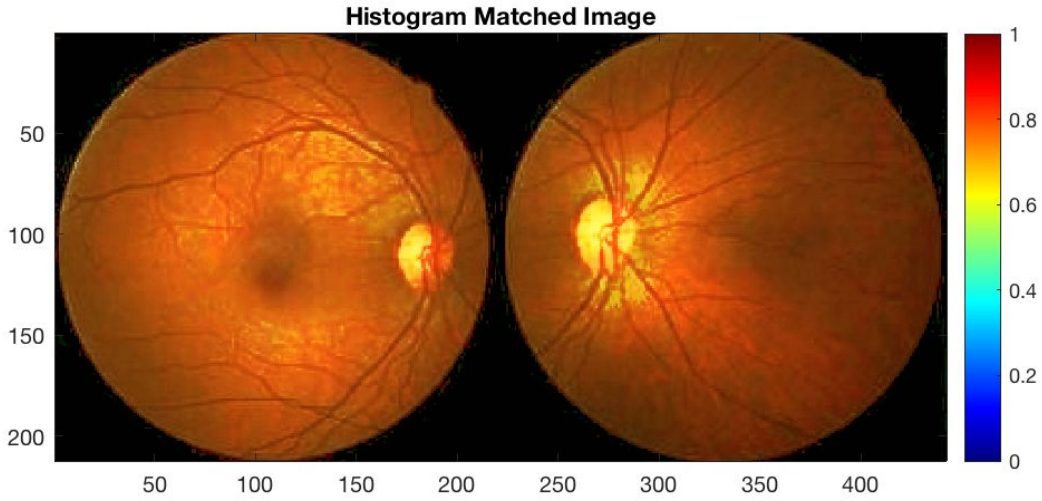
The above comparison of the histogram (of red channel) between the original image of the canyon (above) and Histogram Equalized Image shows that why Histogram Equalization doesn't have a significant impact on canyon image. The histogram in the original image itself is relatively well distributed over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

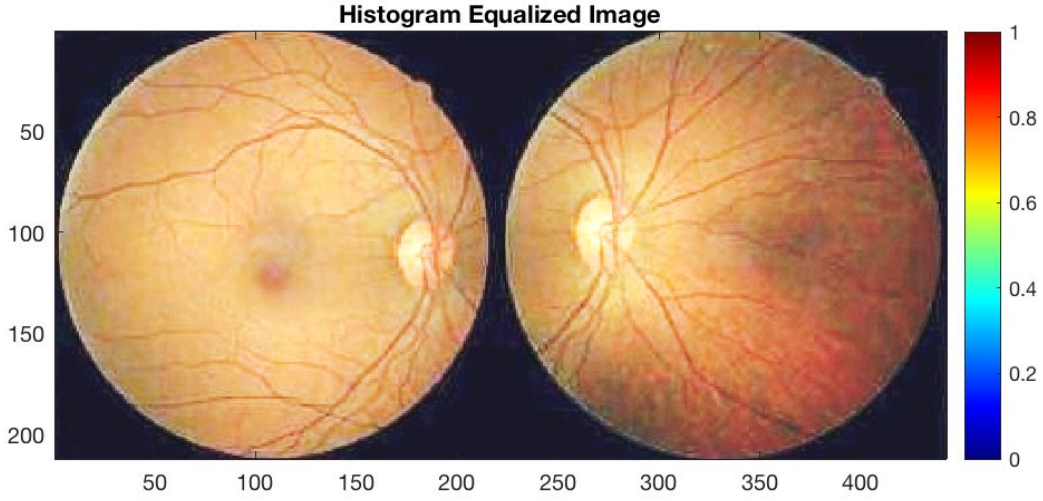
C. Histogram Matching

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
50
100
150
200
50
100
150
200
250
300
350
400
1
0.8
0.6
0.4
0.2
0


Histogram Equalized Image
50
100
150
200
50
100
150
200
250
300
350
400
1
0.8
0.6
0.4
0.2
0

D. Adaptive Histogram Equalization

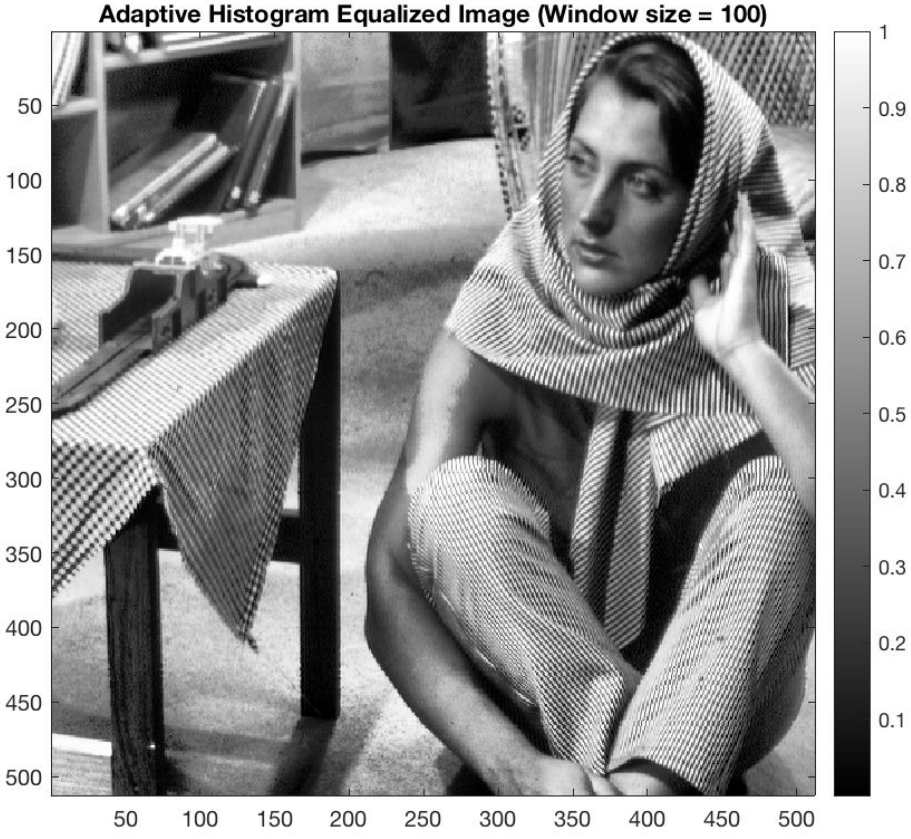
The ideal window choice after fine tuning was chosen as 100. Output images of AHE have better contrast that output images of HE in case of TEM.png. The performance is similar in case of canyon.png while AHE performance is worse in case of barbara.png
(Window size W means that window was constructed with 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)x(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))

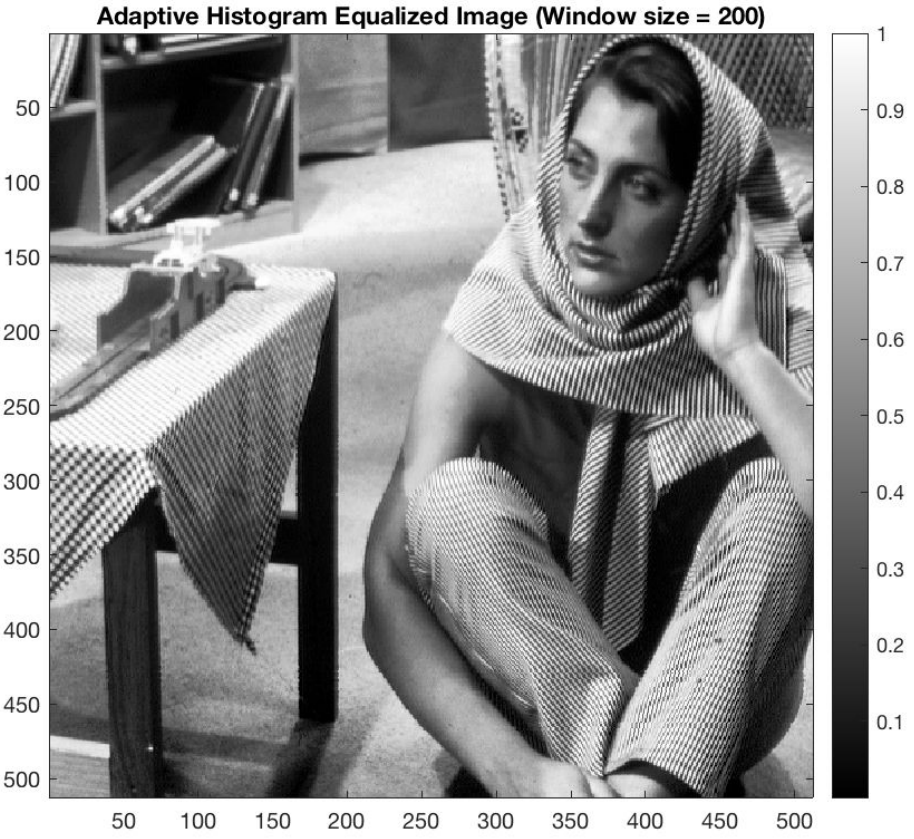
The low contrast in case of small window size can be easily seen.

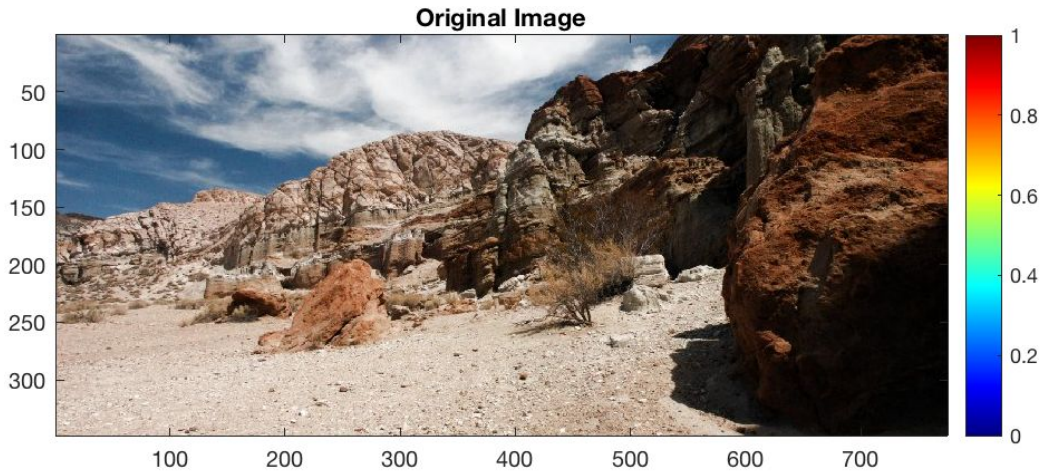
Noise amplification can also be noticed for large window size. In barbara.png and canyon.png, the noise is evident on the face of the lady and plant at the bottom of the canyon. In TEM.png, the patterns become less subtle due to noise amplification.

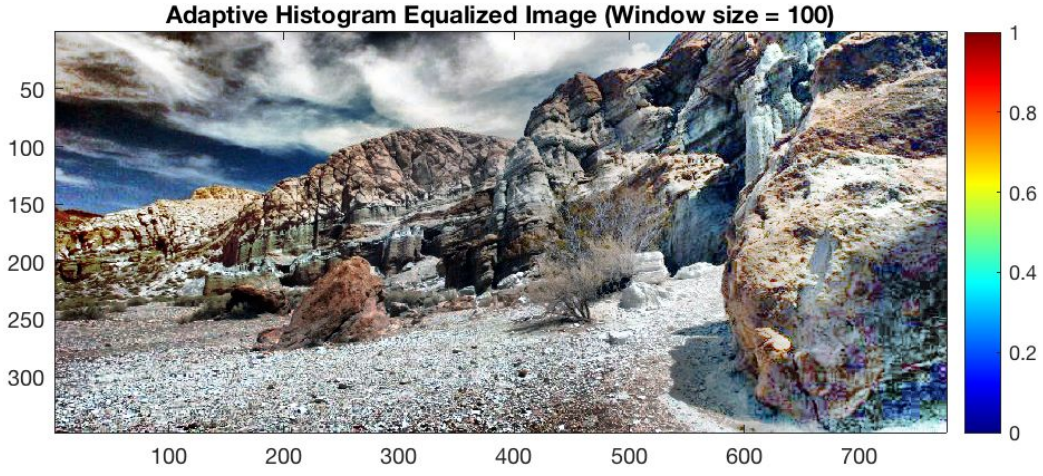

Original Image
50
100
150
200
250
300
350
400
450
500
200
150
100
50

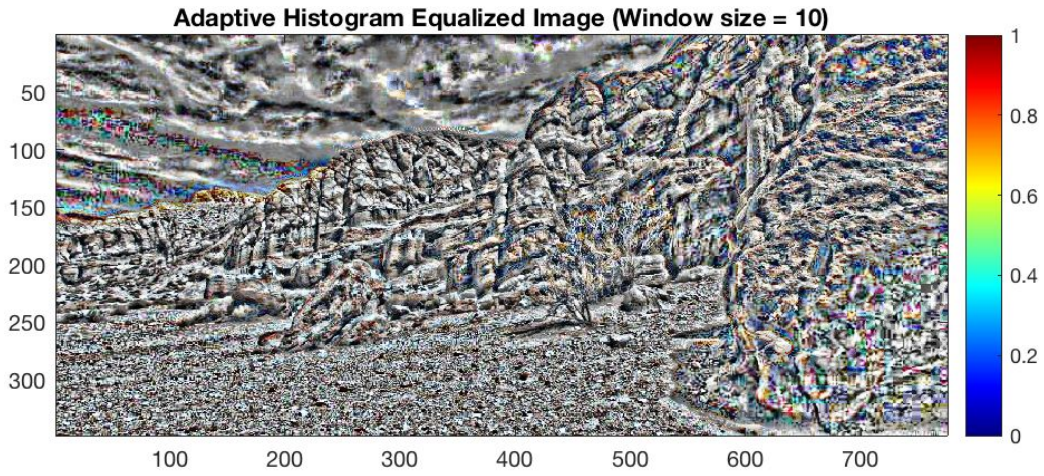

Adaptive Histogram Equalized Image (Window size = 100)
50
100
150
200
250
300
350
400
450
500
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

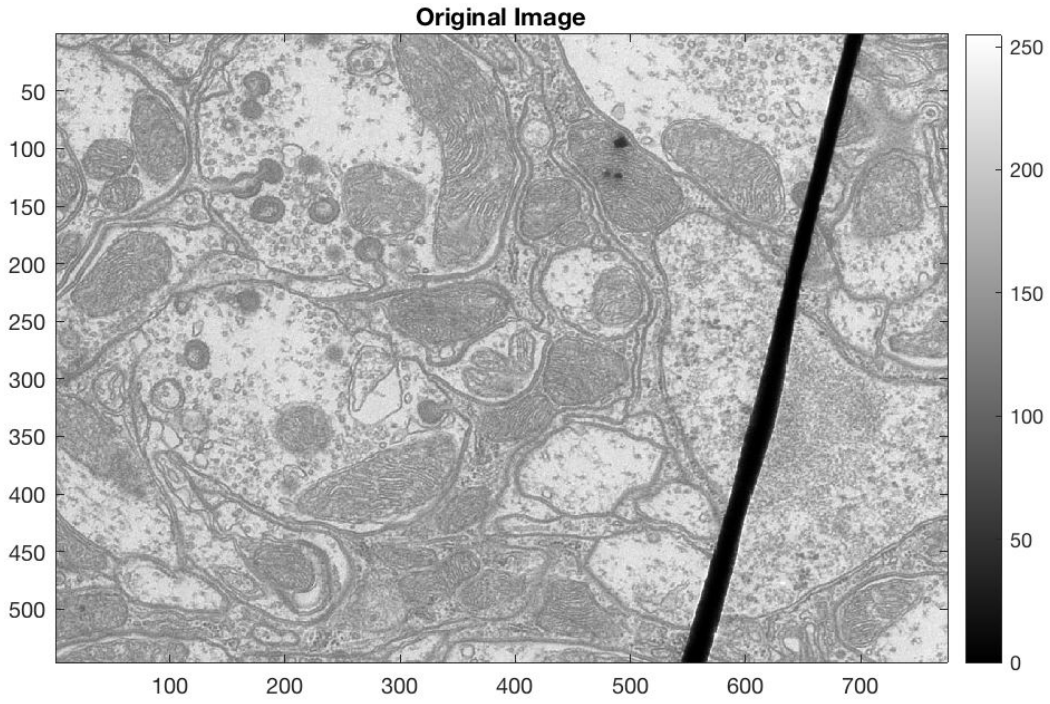

Adaptive Histogram Equalized Image (Window size = 10)
50
100
150
200
250
300
350
400
450
500
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

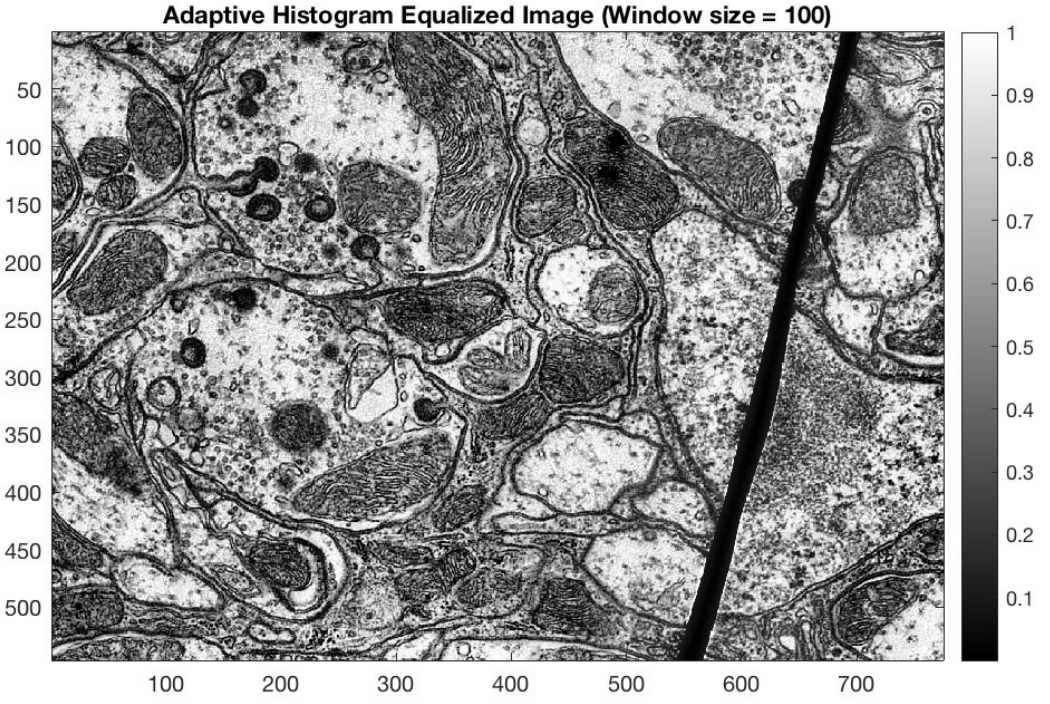

Adaptive Histogram Equalized Image (Window size = 200)
50
100
150
200
250
300
350
400
450
500
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

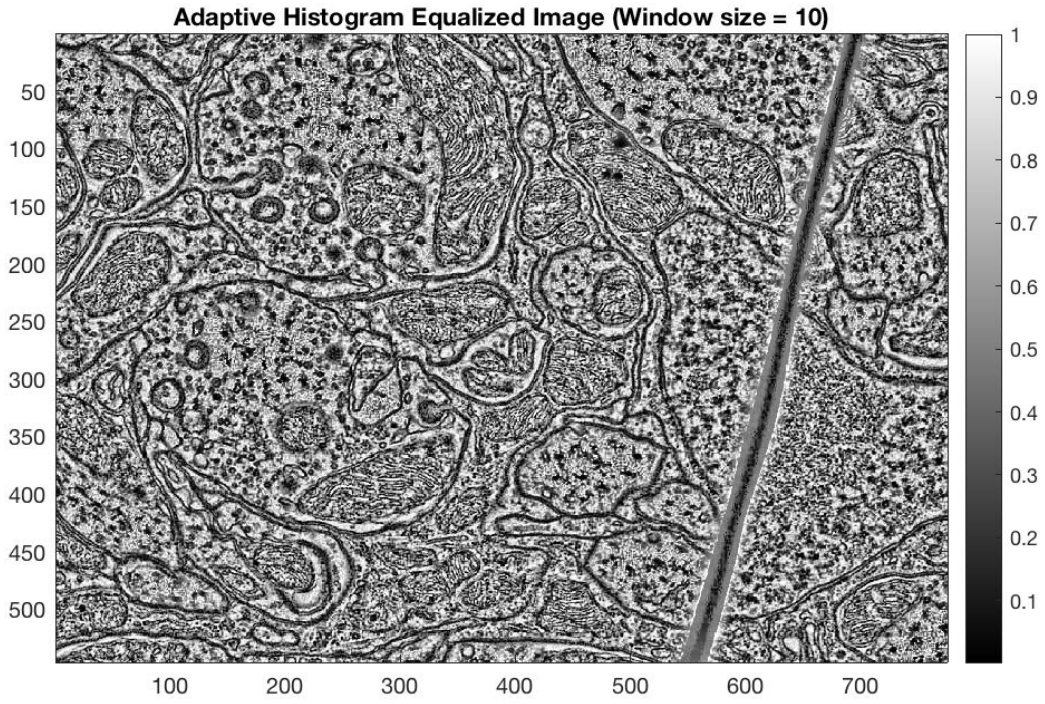

Original Image
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0

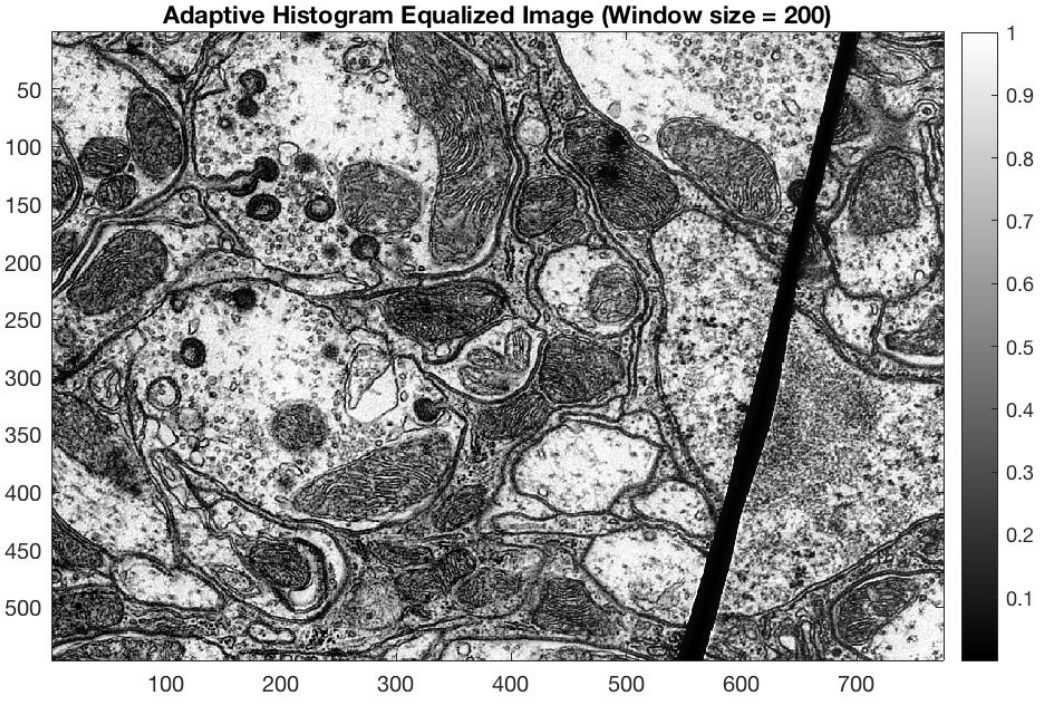

Adaptive Histogram Equalized Image (Window size = 100)
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0


Adaptive Histogram Equalized Image (Window size = 10)
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0
Adaptive Histogram Equalized Image (Window size = 200)
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0


Original Image
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
250
200
150
100
50
0


Adaptive Histogram Equalized Image (Window size = 100)
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

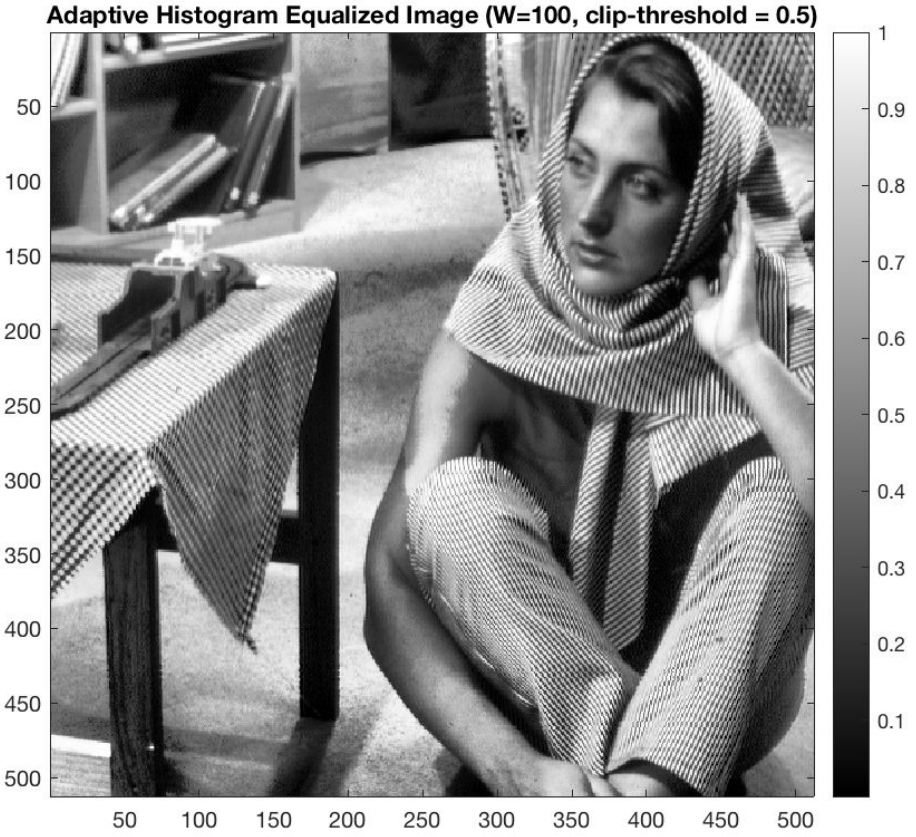

Adaptive Histogram Equalized Image (Window size = 10)
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Adaptive Histogram Equalized Image (Window size = 200)
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

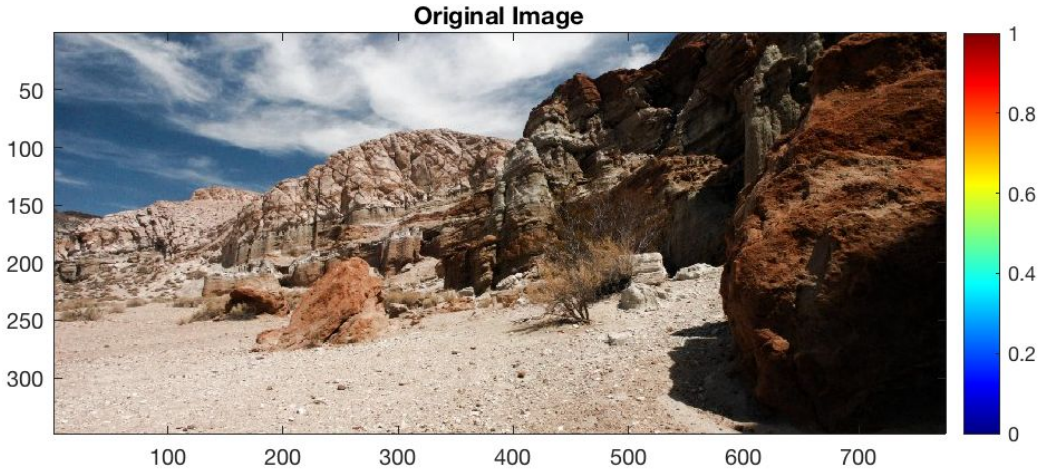
E. Contrast-Limited Adaptive Histogram Equalization

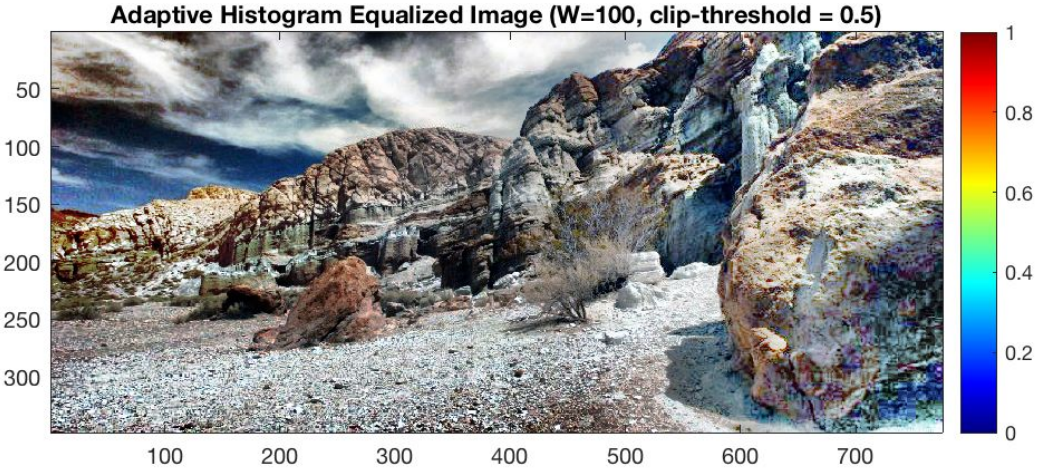
The clipping threshold was taken as 0.5 and window size as in AHE is taken as 100.

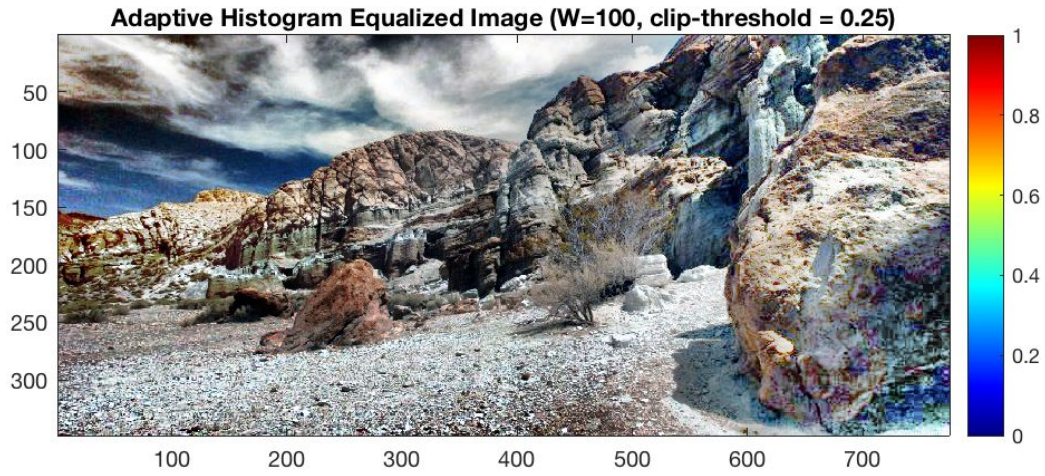

Original Image
50
100
150
200
250
300
350
400
450
500
50
100
150
200
250
300
350
400
450
500
200
150
100
50

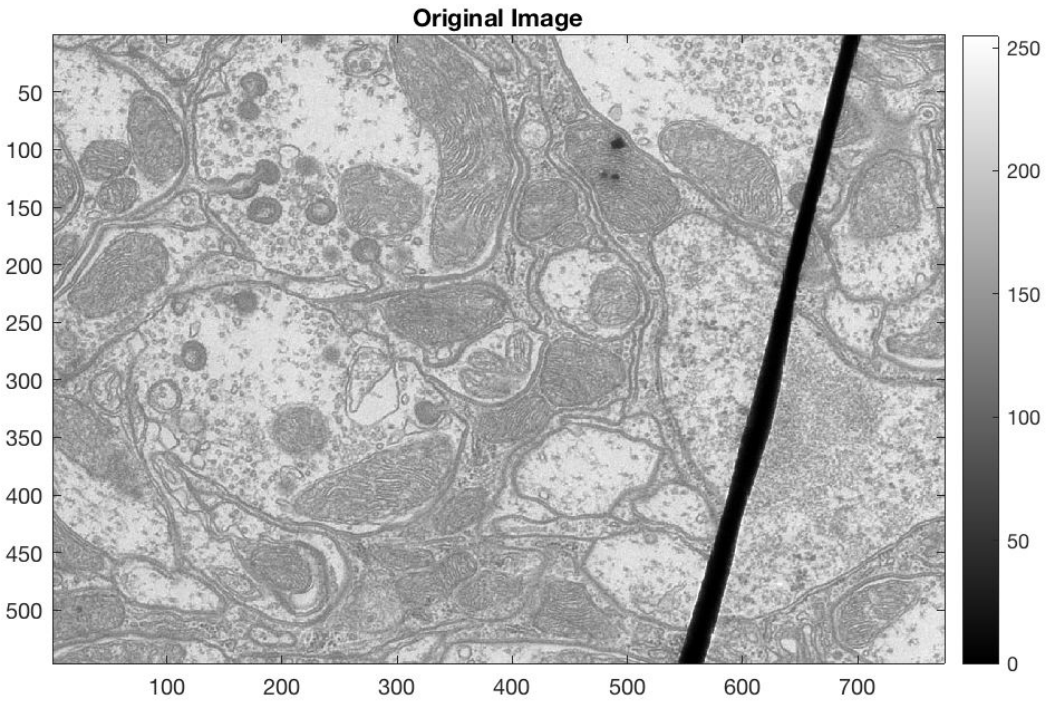

Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.5)
50
100
150
200
250
300
350
400
450
500
50
100
150
200
250
300
350
400
450
500
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

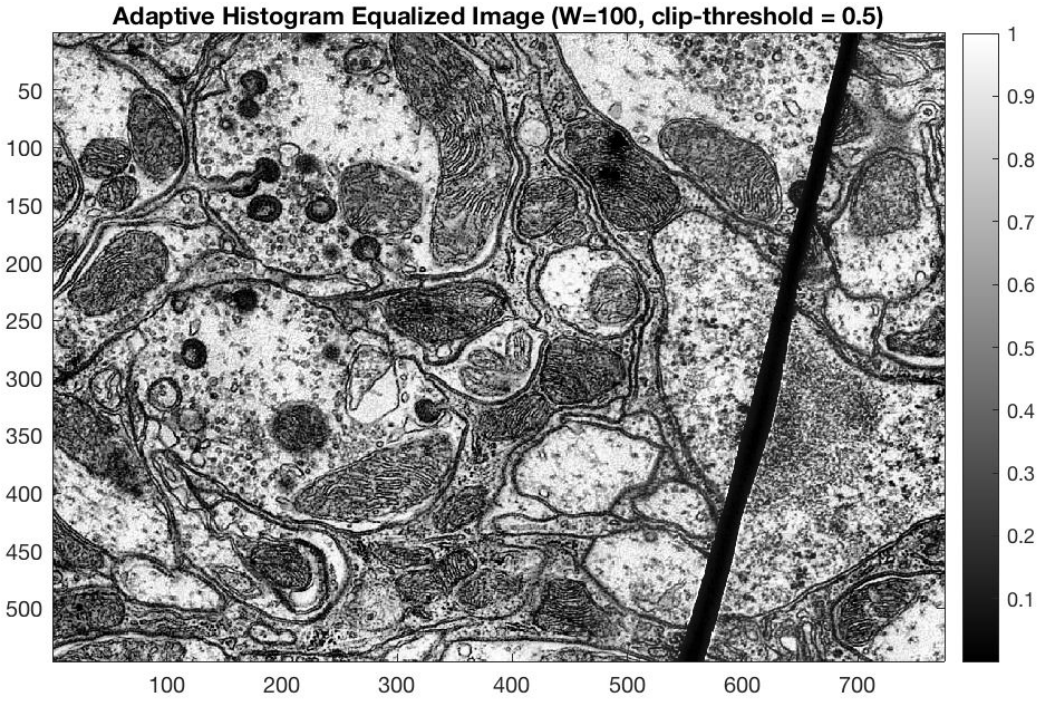

Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.25)
50
100
150
200
250
300
350
400
450
500
50
100
150
200
250
300
350
400
450
500
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

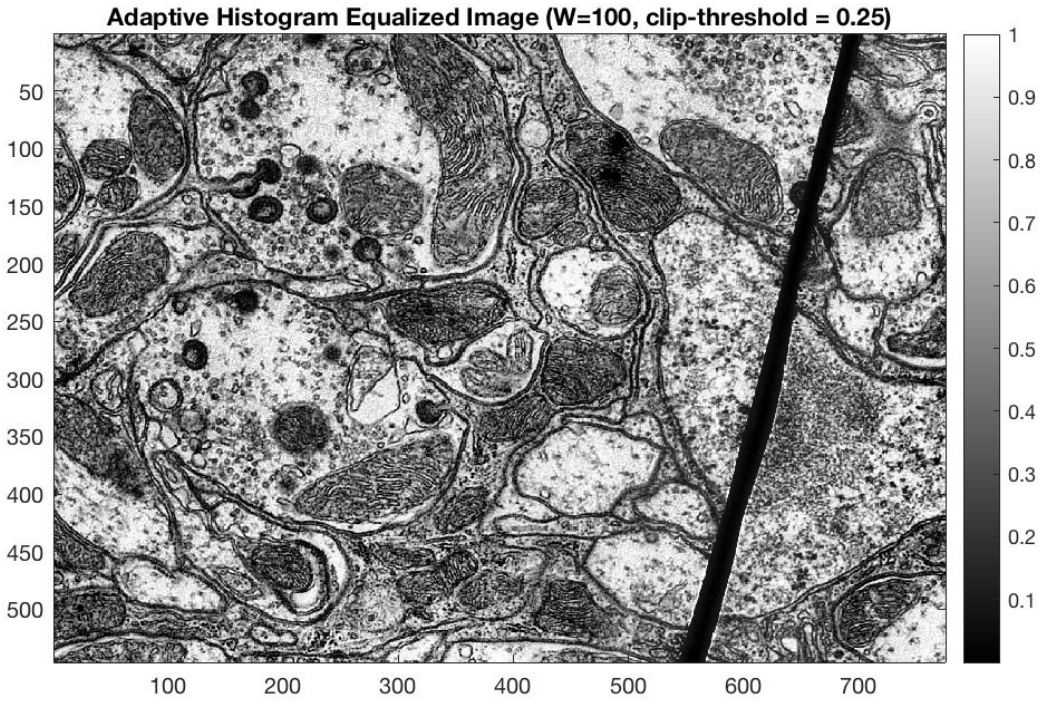

Original Image
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0


Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.5)
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0


Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.25)
50
100
150
200
250
300
100
200
300
400
500
600
700
1
0.8
0.6
0.4
0.2
0


Original Image
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
250
200
150
100
50
0


Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.5)
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Adaptive Histogram Equalized Image (W=100, clip-threshold = 0.25)
50
100
150
200
250
300
350
400
450
500
100
200
300
400
500
600
700
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1