CS 663 : Digital Image Processing : Assignment 1

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Question 2

(a) **Foreground Mask**

The foreground mask has been constructed by using the following method:

1. Threshold the image at intensity value $= 4$
2. Apply **median filter** *twice* on the thresholded image

(a) Original Image (b) Foreground Mask (c) Masked Image

Figure 1: Implementation of Foreground Mask on Image (7) [`statue.png`]

(b) **Linear Contrast Stretching**

Formula used for the linear stretching function:

$$i_{new} = (i_{old} - c)\left(\frac{b-a}{d-c}\right) + a$$

where:

$$a = min(Extended\,Intensity\,Values) = 0$$

$$b = max(Extended\,Intensity\,Values) = 255$$

$$c = min(Actual\,Intensity\,Values)$$

$$d = max(Actual\,Intensity\,Values)$$

In Image (1):

(a) Original Image

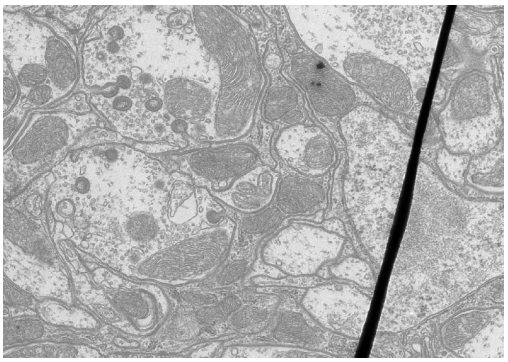
(b) Contrast-Enhanced Image

Figure 2: Linear Contrast Stretching applied to Image (1) [`barbara.png`]

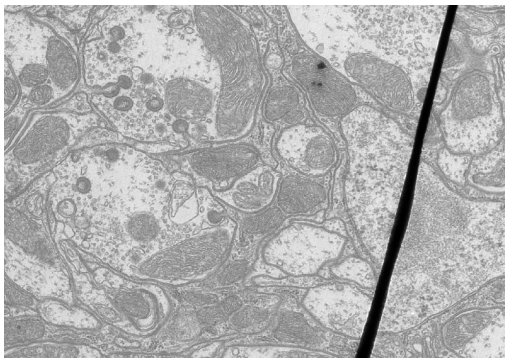
In Image (2):

- $min(Actual\ Intensity\ Values) = 0\ [In\ all\ the\ channels]$
- $max(Actual\ Intensity\ Values) = 255\ [In\ all\ the\ channels]$

[Here, ranges of actual & linearly stretched intensity values are the same. Thus, Linear Contrast Stretching will result in the same image.]



(a) Original Image

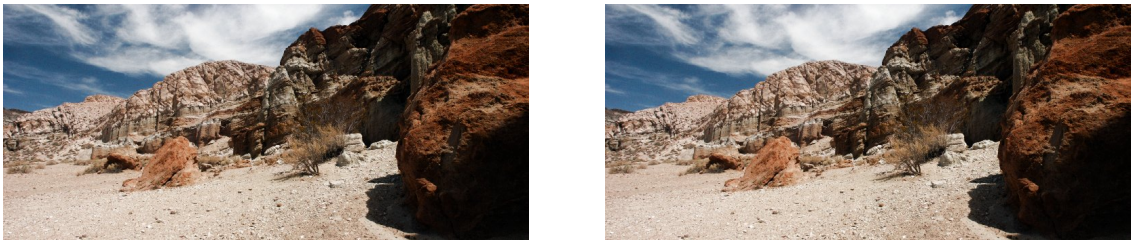


(b) Contrast-Enhanced Image

Figure 3: Linear Contrast Stretching applied to Image (2) [`TEM.png`]

In Image (3):

[Here too, ranges of actual & linearly stretched intensity values in all channels are the nearly same. Thus, there is hardly any change detected]



(a) Original Image (b) Contrast-Enhanced Image

Figure 4: Linear Contrast Stretching applied to Image (3) [`canyon.png`]

In Image (5):

- $min(Actual\ Intensity\ Values) = 0\ [In\ all\ the\ channels]$
- $max(Actual\ Intensity\ Values) = 255\ [In\ all\ the\ channels]$

[Here, ranges of actual & linearly stretched intensity values are the same. Thus, Linear Contrast Stretching will result in the same image. We can conclude that Linear Contrast Stretching is not effective in this case due to the initial actual range and desired (extended) range of the image being the same.]

(a) Original Image (b) Contrast-Enhanced Image

Figure 5: Linear Contrast Stretching applied to Image (5) [`church.png`]

In Image (6):

- $min(Actual\ Intensity\ Values) = 6$
- $max(Actual\ Intensity\ Values) = 226$

(a) Original Image

(b) Contrast-Enhanced Image

Figure 6: Linear Contrast Stretching applied to Image (6) [`chestXray.png`]

In Image (7):

(a) Original Image

(b) Contrast-Enhanced Image

Figure 7: Linear Contrast Stretching applied to masked Image (7) [`statue.png`]

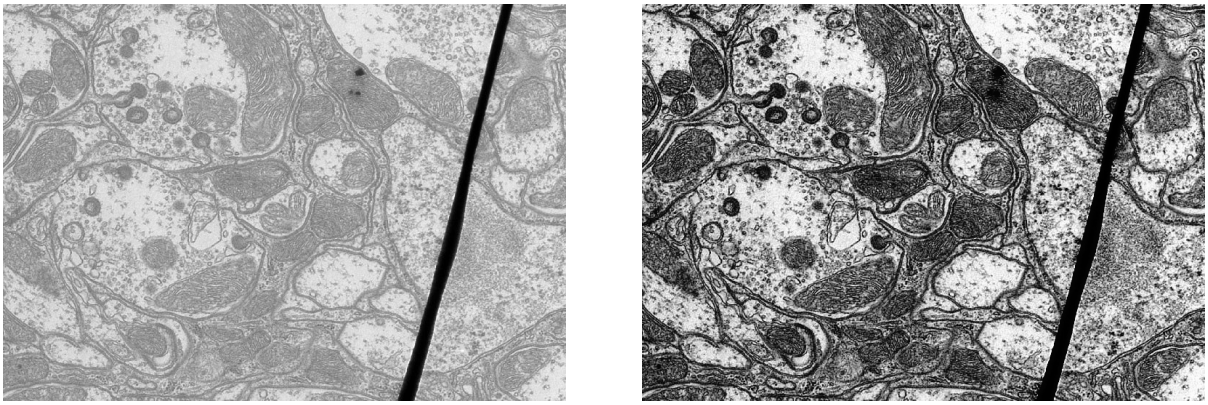
(c) **Histogram Equalization (HE)**

In Image (1):

(a) Original Image (b) Contrast-Enhanced Image

Figure 8: Histogram Equalization applied to Image (1) [`barbara.png`]

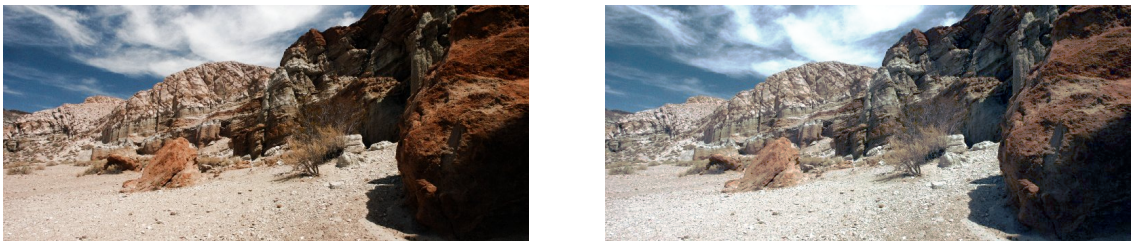
In Image (2):



(a) Original Image (b) Contrast-Enhanced Image

Figure 9: Histogram Equalization applied to Image (2) [`TEM.png`]

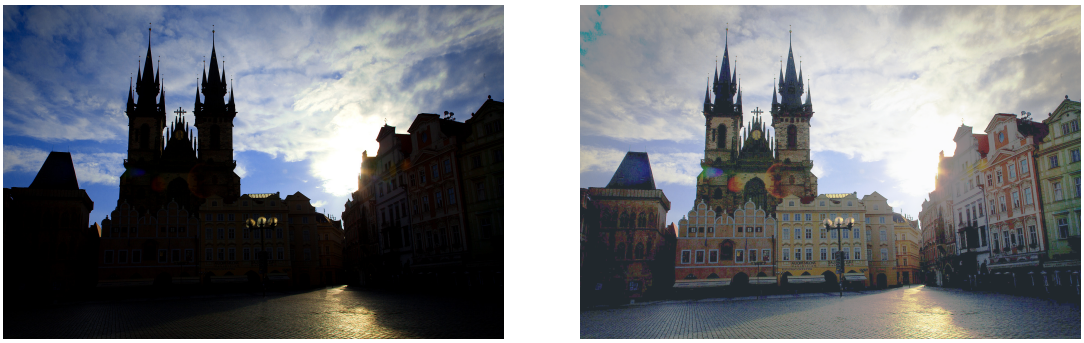
In Image (3):



(a) Original Image (b) Contrast-Enhanced Image

Figure 10: Histogram Equalization applied to Image (3) [`canyon.png`]

In Image (5):



(a) Original Image (b) Contrast-Enhanced Image

Figure 11: Histogram Equalization applied to Image (5) [`church.png`]

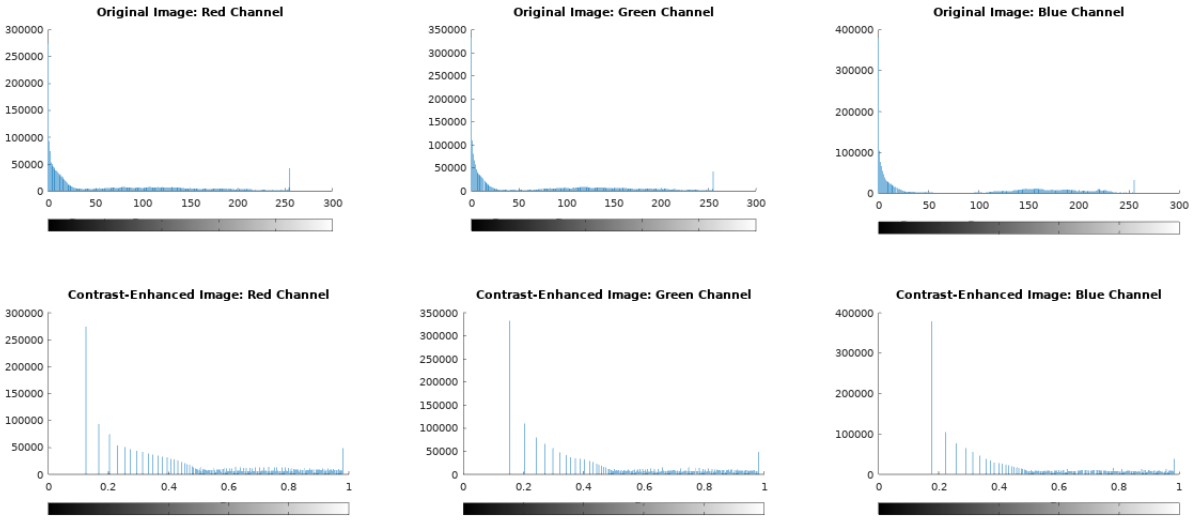
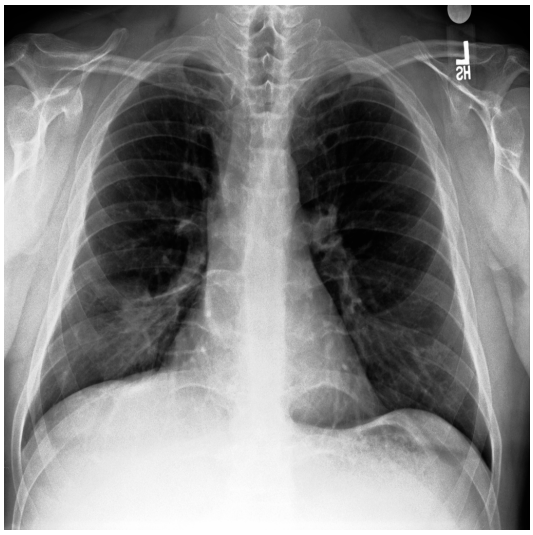


Figure 12: Channel-wise changes in histograms after applying HE to image (5)

[Histograms of original image (5) show the concentration of low value intensities as well as the spread of intensities over the entire range. By using HE, we are able to distribute intensities more uniformly over the range by using the CDF to transform the image. This helps to enhance the contrast so as to view details which were otherwise hidden due to low intensities. Hence, we will prefer Histogram Equalization for enhancing image (5).]

In Image (6):

(a) Original Image



(b) Contrast-Enhanced Image

Figure 13: Histogram Equalization applied to Image (6) [`chestXray.png`]

In Image (7):

(a) Original Image

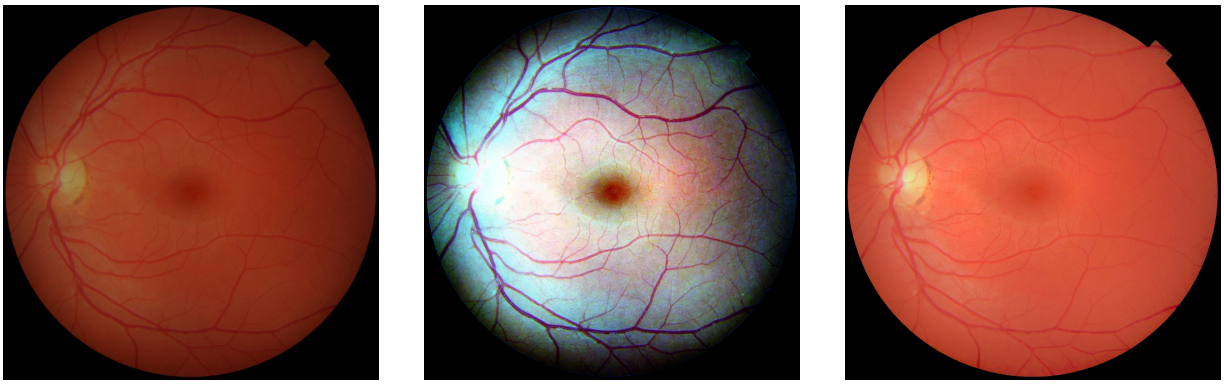
(b) Contrast-Enhanced Image

Figure 14: Histogram Equalization applied to masked Image (7) [`statue.png`]

(d) **Histogram Matching (HM)**

(a) Original Image (b) Reference Image (c) Histogram Matched Image

Figure 15: Histogram Matching applied to Image (4) [`retina.png`]



(a) Original Image (b) Histogram Equalized Image (c) Histogram Matched Image

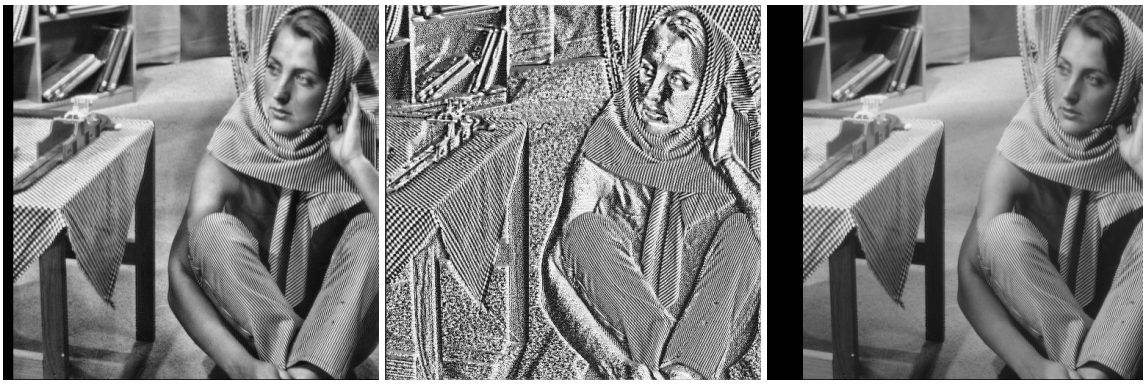
Figure 16: Comparison of Histogram Equalization & Histogram Matching applied to masked Image (4) [`retina.png`]

As seen clearly, the unmasked region of the original image is mostly red (blue & green intensities are very sparsely distributed according to the histogram if the channels). Thus, on applying Histogram Equalization, the blue & green intensities also get spread over the entire intensity range, similar to the red color, resulting in the image shown in (b). This is not something that we desire.

(e) **Contrast-Limited Adaptive Histogram Equalization (CLAHE)**

In Image (1):

Figure 17: Original Image



(a) Window Size = 30 (b) Window Size = 5 (c) Window Size = 100

Figure 18: CLAHE applied to Image (1) `[barbara.png]` for a tuned threshold & different window sizes

(a) Tuned Threshold (b) Tuned Threshold Halved

Figure 19: CLAHE applied to Image (1) `[barbara.png]` for window size = 30 & different thresholds

In Image (2):

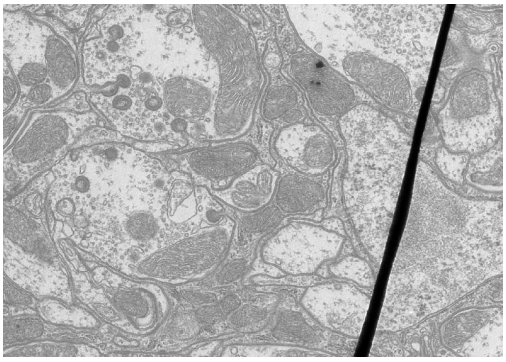
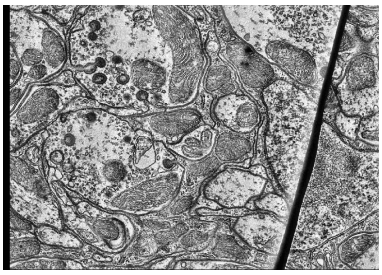
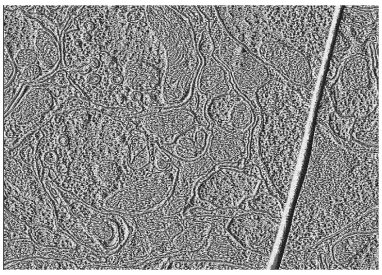


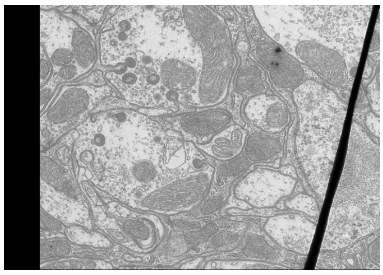
Figure 20: Original Image



(a) Window Size = 30

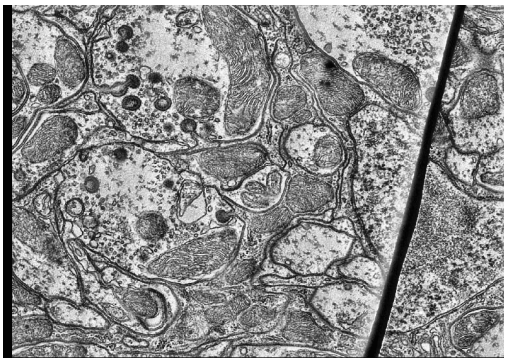


(b) Window Size = 5

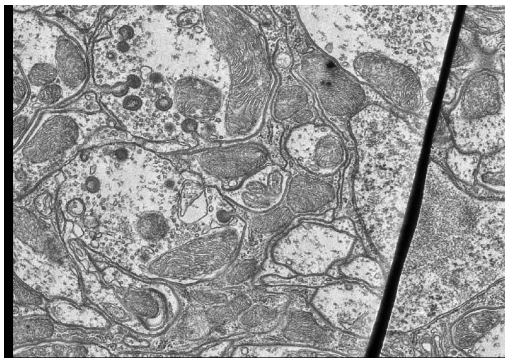


(c) Window Size = 100

Figure 21: CLAHE applied to Image (2) `[TEM.png]` for a tuned threshold & different window sizes



(a) Tuned Threshold

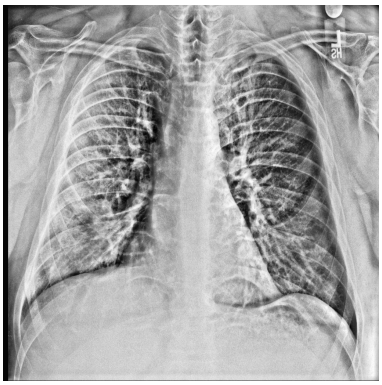


(b) Tuned Threshold Halved

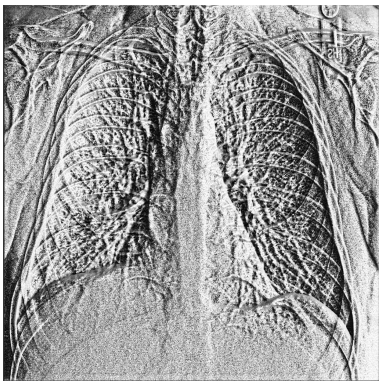
Figure 22: CLAHE applied to Image (2) `[TEM.png]` for window size = 30 & different thresholds

In Image (6):

Figure 23: Original Image



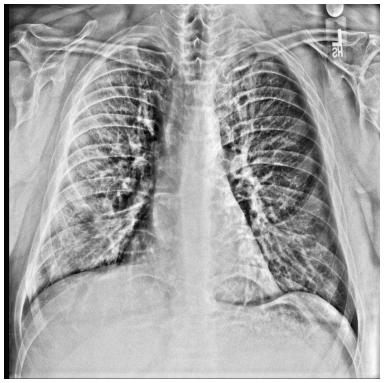
(a) Window Size = 30



(b) Window Size = 5

(c) Window Size = 100

Figure 24: CLAHE applied to Image (6) `[chestXray.png]` for a tuned threshold & different window sizes



(a) Tuned Threshold

(b) Tuned Threshold Halved

Figure 25: CLAHE applied to `[chestXray.png]` for window size = 30 & different thresholds

From the above, it is evident that:

- Larger window size results in extremely low contrast improvement
- Very small window size results in excessive amplification of noise
- Halving the tuned threshold parameter reduces the contrast improvement, but helps remove the noise