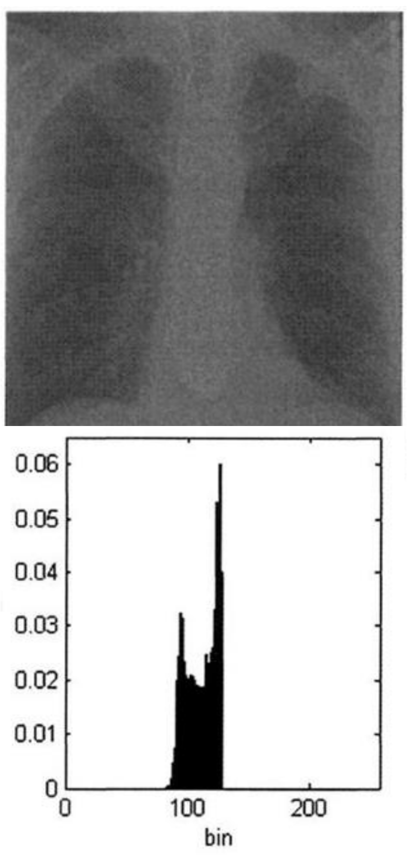
LAB # 04: <u>Transformation Operations</u>

<u>Lab Objective:</u>

The objective of this lab is to enhance contrast of an image using contrast stretching and histogram equalization.

<u>Lab Description:</u>

<u>Contrast stretching:</u> is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values. Normally (min, max) → (0, 255)

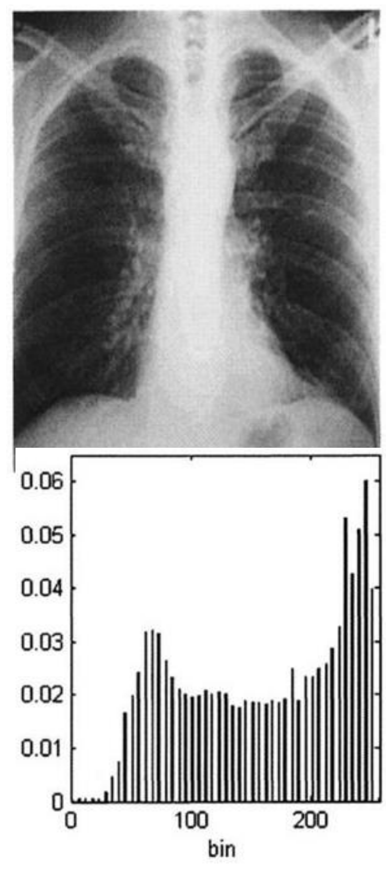


$$p = ((p-min)/ (max-min)) *255$$

Where:

p is pixel value at a certain pixel location

max, min is the max, min pixel value in the entire image



Instead of blindly computing the dynamic range using just the minimum and maximum pixel values, a more robust and adaptive technique is to use the **5th and 95th percentiles** of the input values when deriving the dynamic range of the input image.

<u>Histogram equalization:</u>

Histogram of an image shows the frequency of different intensities values present in the image. This gives a clear idea of what intensities dominate the image. **Histogram equalization** is a technique that uses this information to enhance the contrast using the probability of a certain pixel to occur.

Steps:

Suppose we have a 3-bit image (L = 8) of size 64x64

a) Calculate number of pixels per pixel value.

Pixel Value (r_k)	0	1	2	3	4	5	6	7
No of Pixels (n_k)	790	1023	850	656	329	245	122	81

b) Calculate probability density function PDF = n_k / size of the image

No of Pixels (n_k)	790	1023	850	656	329	245	122	81
PDF	0.19	0.25	0.21	0.16	0.08	0.06	0.03	0.02

c) Calculate cumulative density function CDF = sum of n_k from 0 - k

PDF	0.19	0.25	0.21	0.16	0.08	0.06	0.03	0.02
CDF	0.19	0.44	0.65	0.81	0.89	0.95	0.98	1

d) Calculate transformation function by multiplying CDF with (L – 1) and round of it.

CDF	0.19	0.44	0.65	0.81	0.89	0.95	0.98	1
TF	1.33	3.08	4.55	5.67	6.23	6.65	6.86	7
TF (s_k)	1	3	5	6	6	7	7	7

e) Replace original Pixel values with the s_k values

Pixel Value (r_k)	0	1	2	3	4	5	6	7
TF (s_k)	1	3	5	6	6	7	7	7

The Image obtained will be Histogram Equalized Image with high contrast.

Some Useful Commands:

Importing matplotlib: import matplotlib.pyplot as plt

1. To calculate the mean of 2D array using NumPy: my_mean = **numpy. mean (my_array)**
2. To calculate min (or max) of an array: **my_min = numpy.amin(my_array)**
3. To calculate the power of an array using NumPy: array_power = **numpy.power (my_array, power)**

4. To obtain percentile value. **percentile_array = numpy.percentile(my_array, percentile)**
5. To change data type of array. **my_array = my_array. astype(numpy. uint16)**
6. To plot a simple plot using matplottlib: **plt.plot(my_data)**
7. For label along x axis: **plt.xlabel ('Some cooked up data')**
8. For label along y axis: **plt.ylabel ('Some value')**
9. To show the graph: **plt.show()**

Lab Tasks:

1: Apply contrast stretching on the image of car provided by setting 5th and 95th percentiles of the input values to 0 and 255 respectively.

2: Now apply Histogram equalization on the same image.

i. Calculate the histogram of the image save it as Figure_1.jpg. (Don't use any built-in function of OpenCV or NumPy etc.)
ii. Calculate probability density function (PDF) from the histogram and save it as Figure_2.jpg. PDF = H/(R*C). Where H is the Histogram and R and C is the number of Rows and Columns of the image respectively.
iii. Calculate cumulative density function (CDF) and save it as Figure_3.jpg.
iv. Multiply the Cumulative PDF with 255 to find the transformation function then save it as Figure_4.jpg
v. From the transformation function, replace the gray levels of the image to create contrast enhanced (histogram equalized) image and save it as Figure_5.jpg
vi. Calculate the histogram of the output image save it as Figure_6.jpg.

<u>**Home Task:**</u>

We have SEM (scanning electron microscope) image of tungsten filament wrapped around a support. The filament in the center of the image and its support are quite clear and easyto study. There is another filament structure on the right , dark side of the image but it is almost imperceptible. Local enhancement by contrast manipulation is an ideal approach to such problems in which parts of an image may contain hidden features. You have to appply following techniques and compare their results. // Fig 3.27 (a,b,c)

i. Apply global histogram equalization technique on given image and save the results.
ii. Enhance the image by using local histogram statistics.

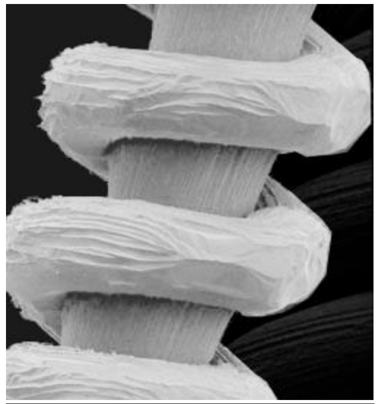
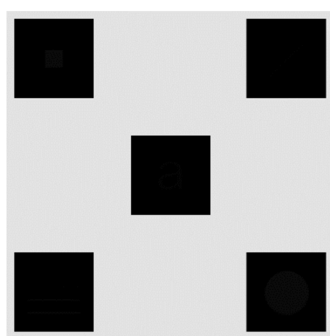


Fig:Tungsten Filament

Figure shows an 8 bit 512*512 image that at first glance appears to contain five black squares on a gray background. The image is slightly noisy but noise is imperceptible.

i. Apply global histogram equalization technique on the image.
ii. Apply local histogram equalization with a neighborhood of size 3*3.



Compare both histogram equalization techniques. The result of global histogram equalization shows the significant enhancement of noise, aside from noise it does not reveal any significant details from the original other than a very faint hint that top left and bottom right squares contain an object but from local histogram with neighborhood of size 3*3 we will see significant detail contained within dark squares.

//Figure reference 3.26 (a,b,c)

THINK!!

1. How is histogram equalization different from contrast stretching?
2. In the image shown below almost 90% pixels have pixel value 220 and the rest 10% are greater than this value. Which process is better for contrast enhancement of this image, Histogram equalization or contrast stretching? Explain.

220	220	235	220	240	220	220
220	220	220	230	220	255	220
220	220	220	220	250	220	245
220	220	220	220	220	220	220

3. If all the pixel values of an image are same, say 100 what will be the output of histogram equalization?