Group- 02
Image Enhancement

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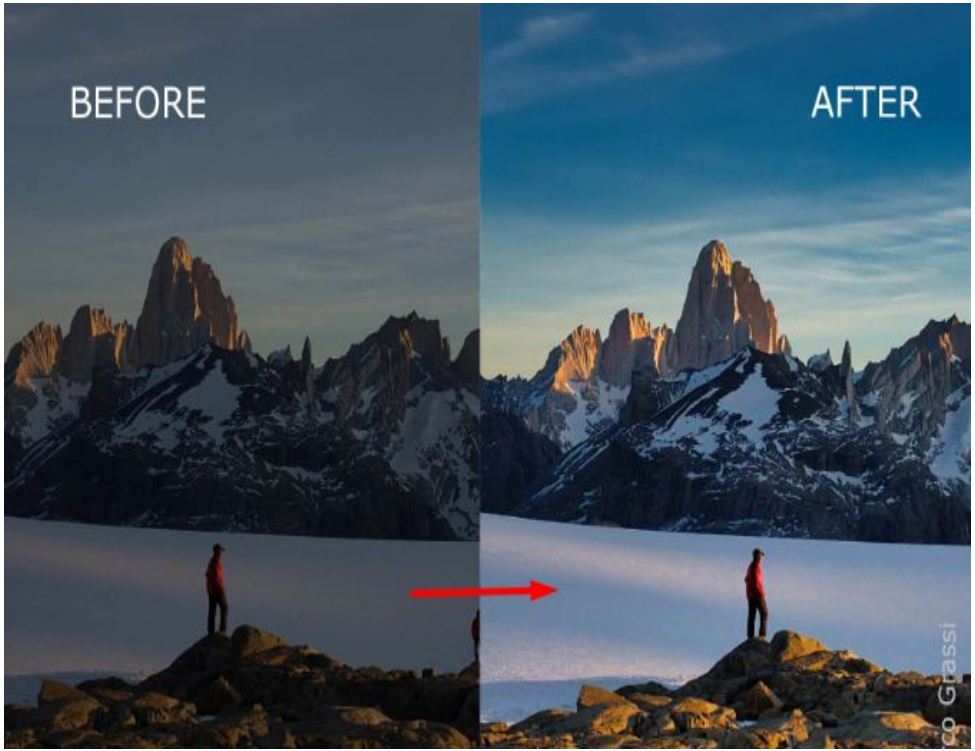
What is Image Enhancement ?

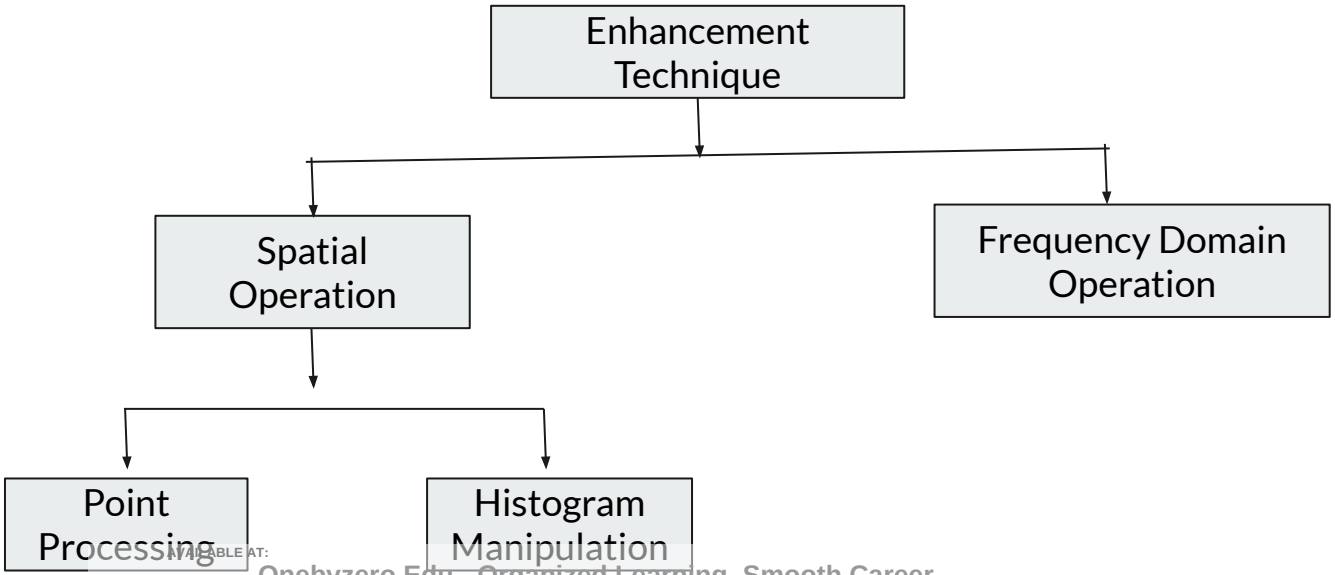
- Image Enhancement is the process that improves the quality of the image for a specific application.
- The idea behind this technique is to bring out details that are hidden of an image.



Why Image Enhancement?

- Fundamental Step of Digital Image processing
- Data Restoration
- It is Subjective
- Used in Machine Learning
- In Medical Sector

Image Enhancement Technique:



Spatial Operation & Frequency Domain Operation:

Spatial Operation: Spatial operations in image processing refer to techniques that manipulate the pixels of an image based on their spatial arrangement. These operations directly work on the pixel values, and are fundamental in enhancing, analyzing, and understanding images

Frequency Domain Operation: Frequency domain processing techniques are based on modifying the Fourier transform of an image.

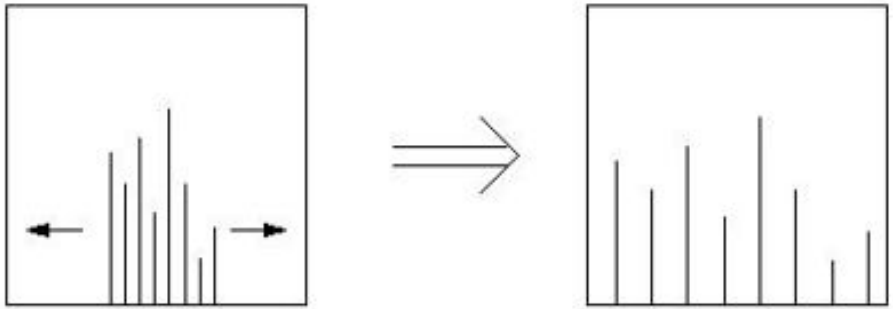
Histogram Modification:

works by considering histogram's shape and spread.

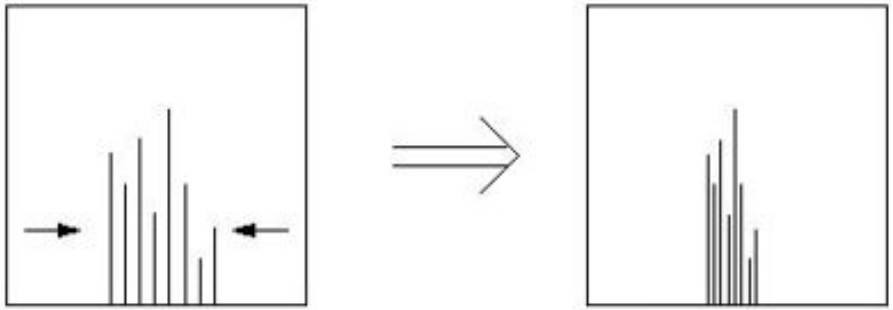
The histogram can be modified by a mapping function

shrink (compress): Compress image size, or decrease image contrast

Stretch (brightness/intensity):modify brightness



a) Histogram stretch



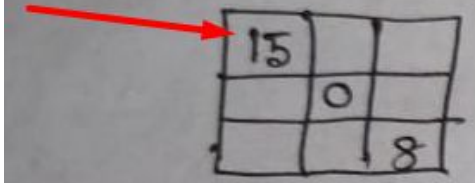
b) Histogram shrink

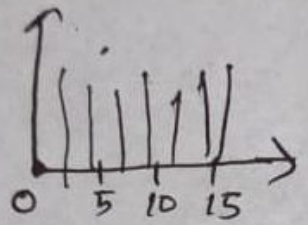
Histogram Shrinking :

Let's clear it by its law and its process:

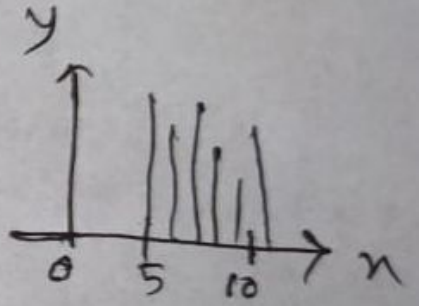
$$\text{Shrink }((r,c)) = \left[\frac{Shrink_{\max} - Shrink_{\min}}{I(r,c)_{\max} - I(r,c)_{\min}}\right] [\, I(r,c) - I(r,c)_{min}] + Shrink_{\,min}$$

lets an image pixel:





we want to shrink it into [5-12]



So,

$$\text{Shrink}((\text{inc})) = \left[\frac{12-5}{15-0}\right][15-0] + 5$$

$$= \frac{7}{\cancel{15}_{3}} \times \cancel{20}^{4} = \frac{28}{3}$$

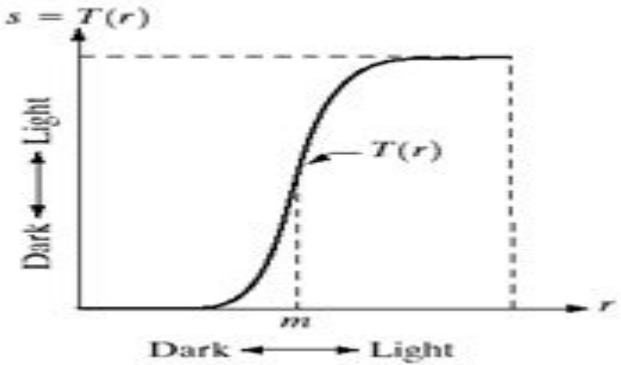
Image Enhancement technique

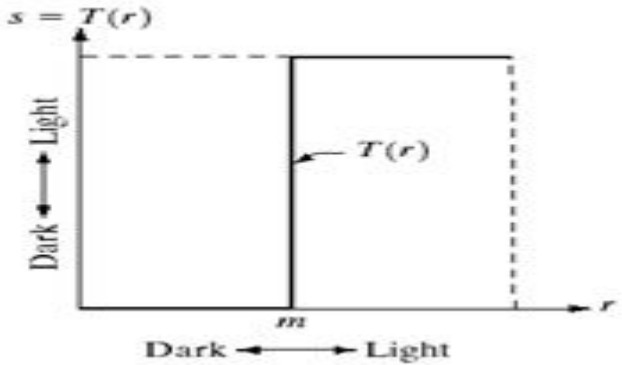
Image enhancement in spatial domain:

- Point processing: Change pixel intensity.

$$g(x)=T\,[\,F(x)]$$

Intensity Transformation





Contrast Stretching

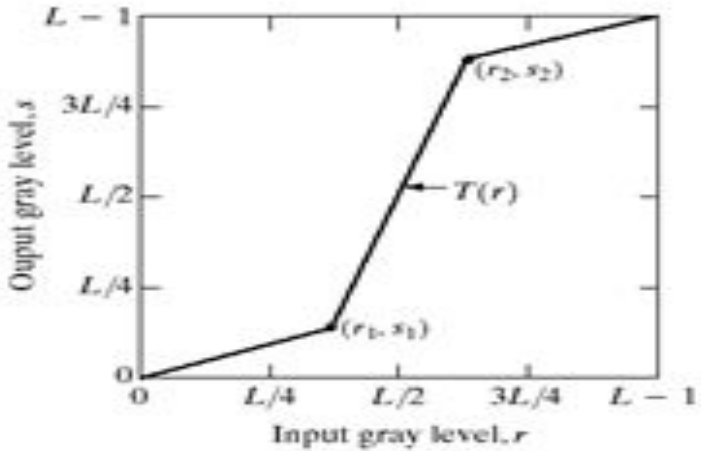
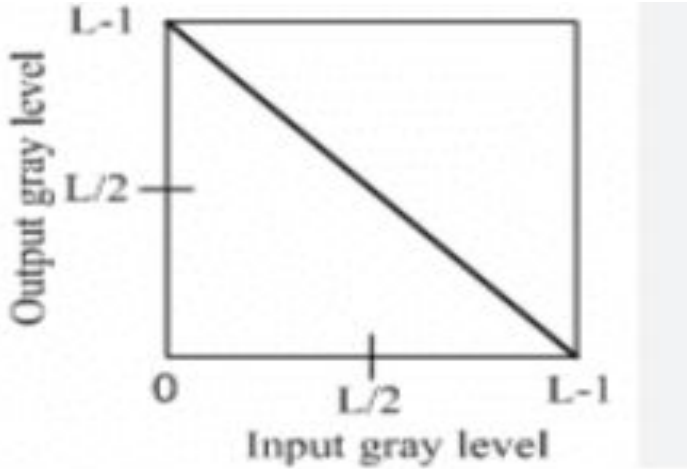
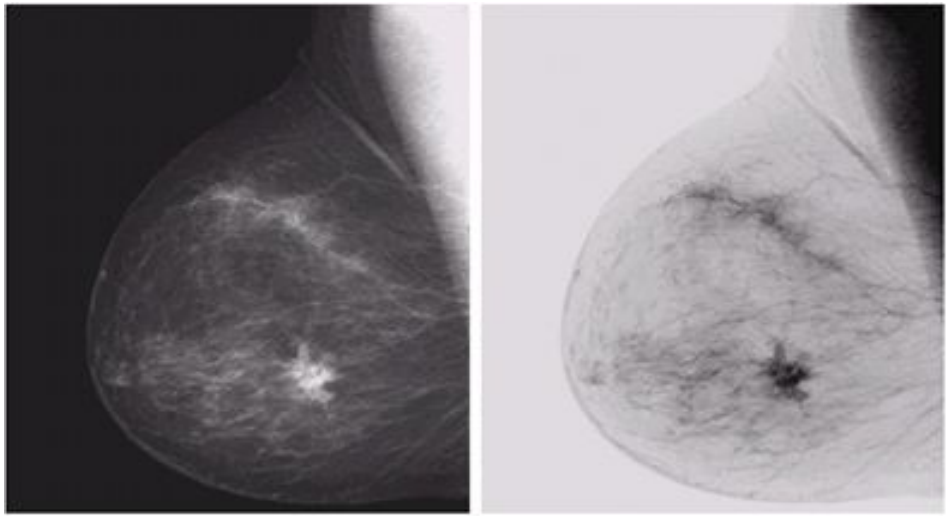


Image Negative

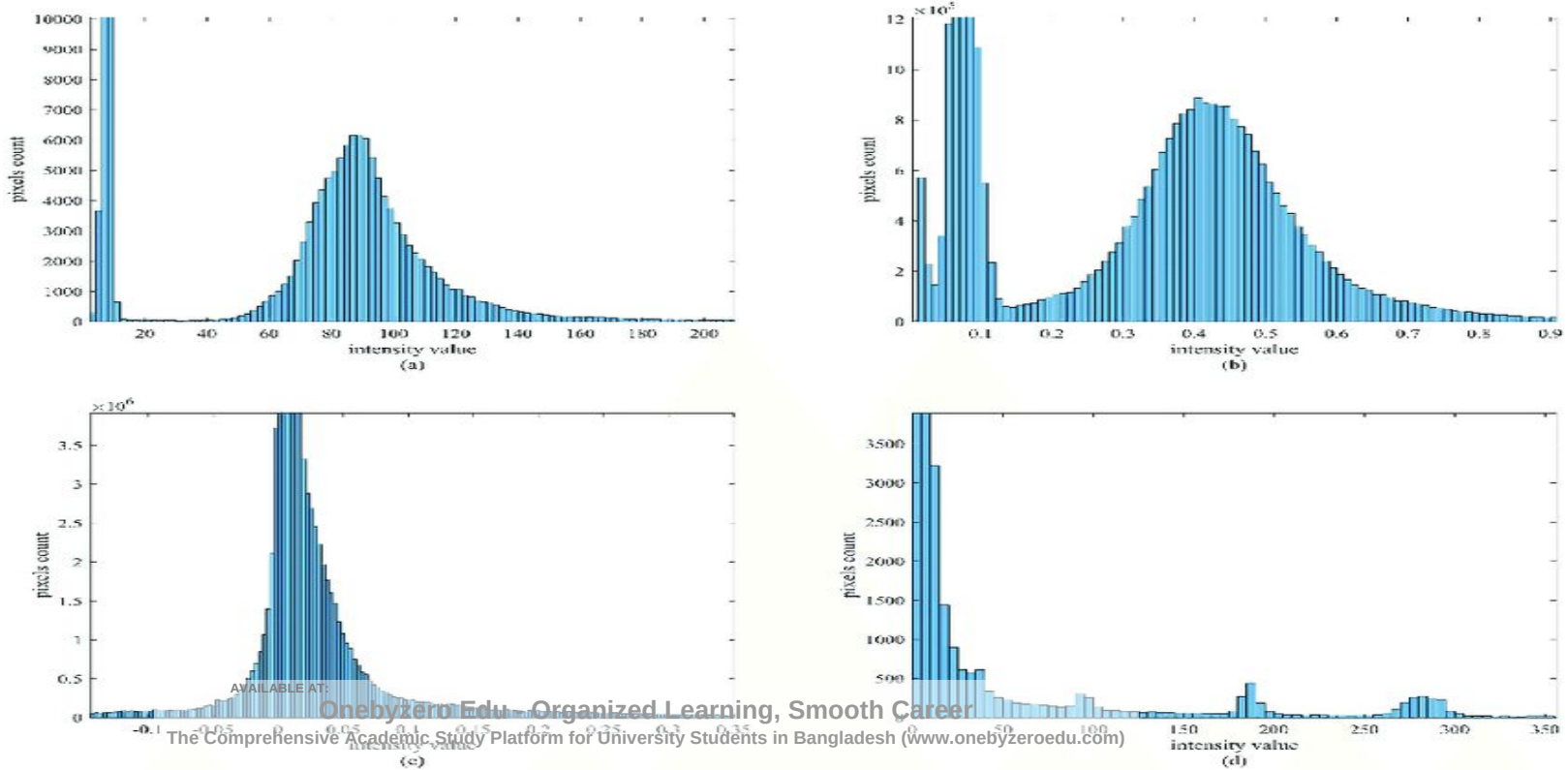




Histogram Introduction

The histogram of an image is typically displayed as a bar graph, where the x-axis represents the different pixel intensity values (ranging from 0 to 255 for an 8-bit grayscale image), and the y-axis represents the number or frequency of pixels having that particular intensity value.

How to represent of Histogram



Histogram Applications

1. In digital image processing, histograms are used for analyzing the distribution of pixel intensities in an image
2. It is used to analyze an image. Properties of an image can be predicted by the detailed study of the histogram.
3. It is used for image equalization. Gray level intensities are expanded along the x-axis to produce a high contrast image.
4. Histograms are used in thresholding as it improves the appearance of the image.
5. If we have input and output histogram of an image, we can determine which type of transformation is applied in the algorithm.

A Note About Grey Levels

So far when we have spoken about image grey level values we have said they are in the range [0, 255]

- Where 0 is black and 255 is white

There is no reason why we have to use this range

- The range [0,255] stems from display technologies

For many of the image processing operations in this lecture grey levels are assumed to be given in the range [0.0, 1.0]

Histogram Techniques

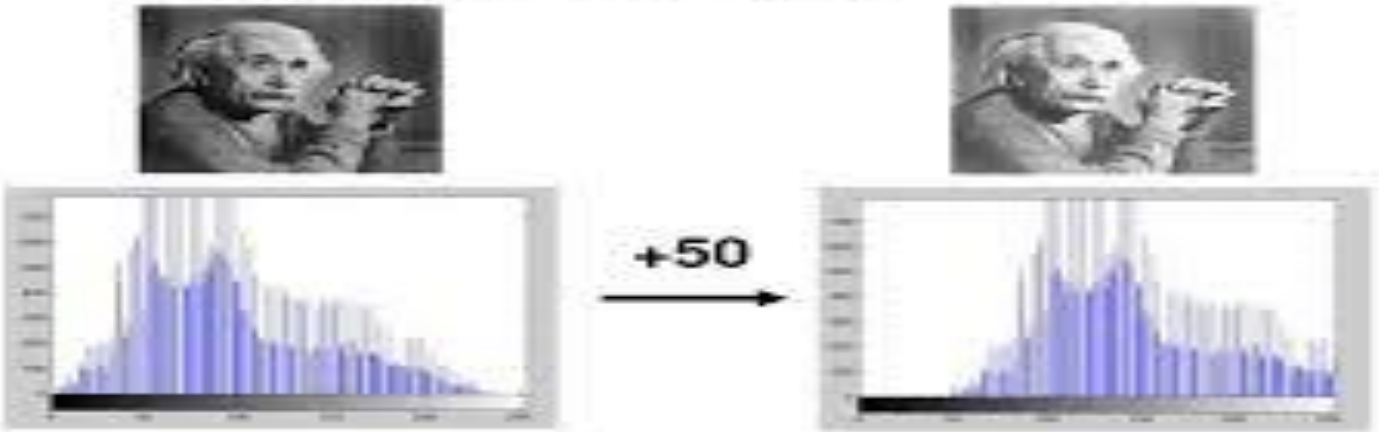
Histogram Sliding:

In Histogram sliding, the complete histogram is shifted towards rightwards or leftwards. When a histogram is shifted towards the right or left, clear changes are seen in the brightness of the image. The brightness of the image is defined by the intensity of light which is emitted by a particular light source.

Histogram Shading

Histogram sliding

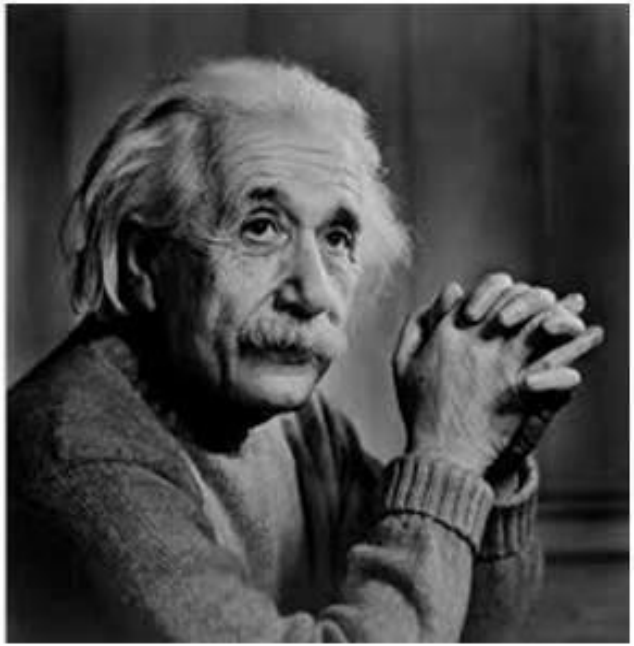
- Brightness is changed by shifting the histogram to left or right.

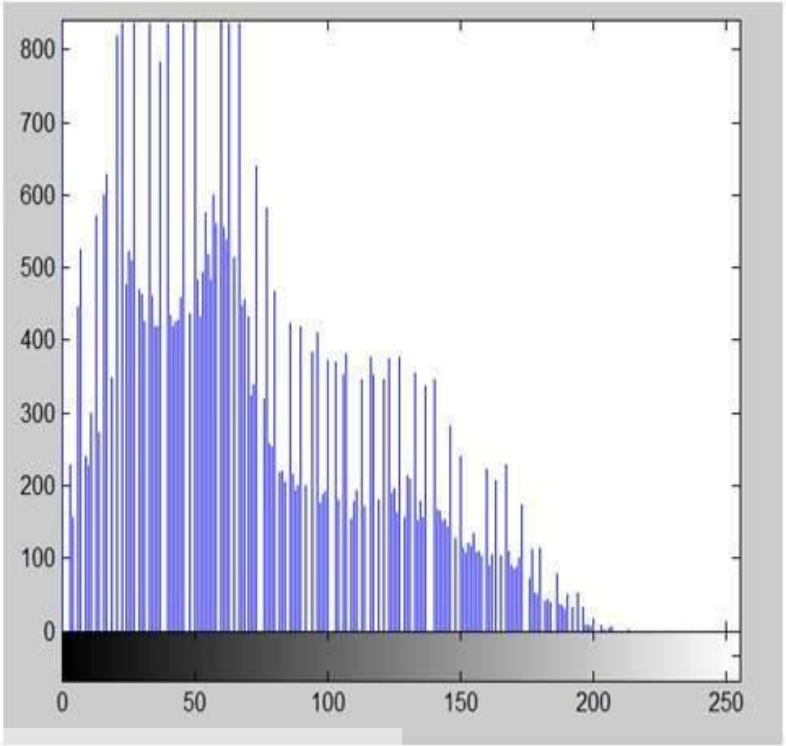


Histogram Stretching

In histogram stretching, contrast of an image is increased. The contrast of an image is defined between the maximum and minimum value of pixel intensity. If we want to increase the contrast of an image, histogram of that image will be fully stretched and covered the dynamic range of the histogram.

Histogram Stretching





Calculation of Histogram Stretching

The formula for stretching the histogram of the image to increase the contrast is

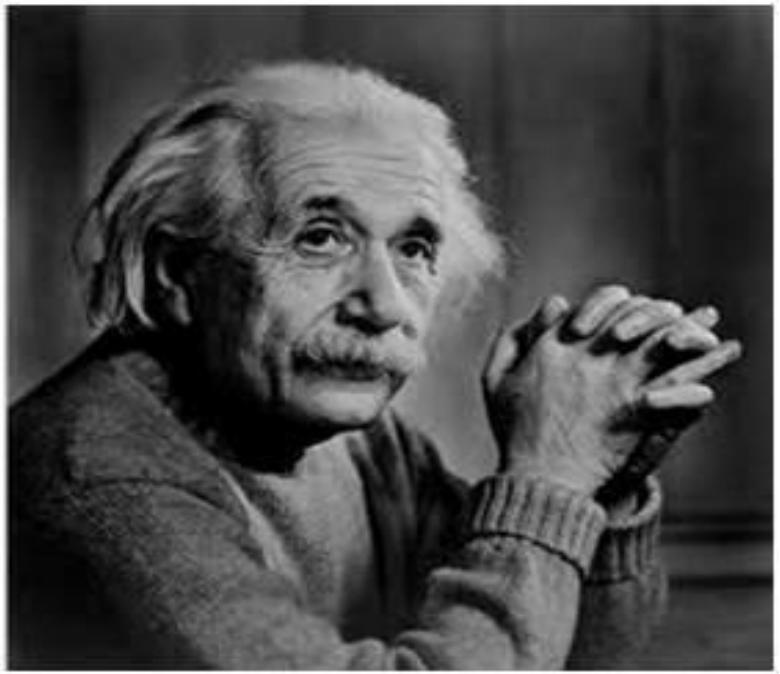
$$g(x,y) = \frac{f(x,y)-fmin}{fmax-fmin} * 2^{bpp}$$

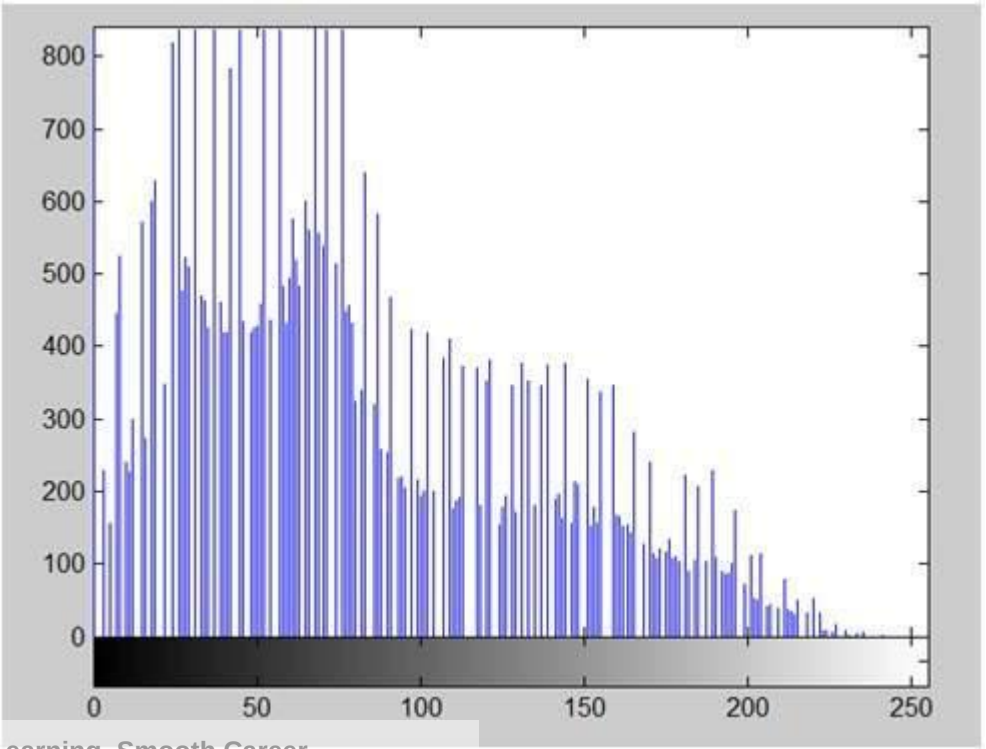
The formula requires finding the minimum and maximum pixel intensity multiply by levels of gray. In our case the image is 8bpp, so levels of gray are 256.

The minimum value is 0 and the maximum value is 225. So the formula in our case is

$$g(x,y) = \frac{f(x,y)-0}{225-0} * 255$$

Histogram Stretching

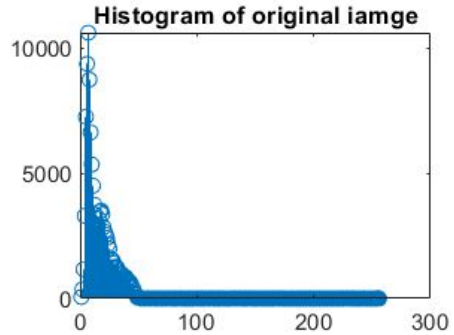


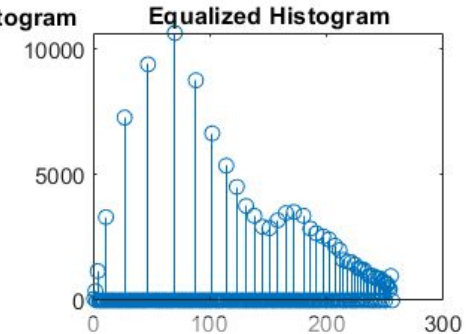


Histogram Equalization

Histogram equalization is an image processing technique used to enhance the contrast of an image. This method redistributes the intensity values of the pixels in the image so that the resulting histogram (a graphical representation of the distribution of pixel intensities) is more uniform. This can improve the visibility of features in an image, especially in cases where the original image has poor contrast.

Histogram Equalization





Advantages

1. It is simple and enhances contrasts of an image.
2. It offers an excellent enhancement of image contrast.
3. It is easy to implement.

Disadvantages

1. If there are gray values that are physically far apart from each other in the Image, then this method fails.
2. Computationally very slow, requires a high number of operations per pixel.
3. Requires a few more operations because it is necessary to create the cumulative histogram.

Steps involves in histogram equalization

1. Compute the Histogram
2. Compute the Probability Distribution Function(PDF)
3. Compute the Cumulative Distribution Function (CDF)
4. Normalize the CDF
5. Map the Intensity Values
6. Generate the Equalized Image

Steps

Compute Histogram

- Let I be the input image with gray levels ranging from 0 to L-1. (L=256 for 8 bit image)
- Compute Histogram H where H(i) is the number of pixels with gray level i

Steps

Compute the Probability Distribution Function(PDF):

- PDF(i) = nk(i)/N
- N = Total Number of Pixels

Steps

Compute the Cumulative Distribution Function (CDF):

- CDF(0) = PDF(0)
- CDF(i>0) = CDF(i-1)+PDF(i)

Histogram Equalization Process

1	2	1	1	1
2	5	3	5	2
2	5	5	5	2
2	5	3	5	2
1	1	1	2	1

Max Value: 5

L = 8 (Needs 3 bit to represent 5 and 2^3 = 8)

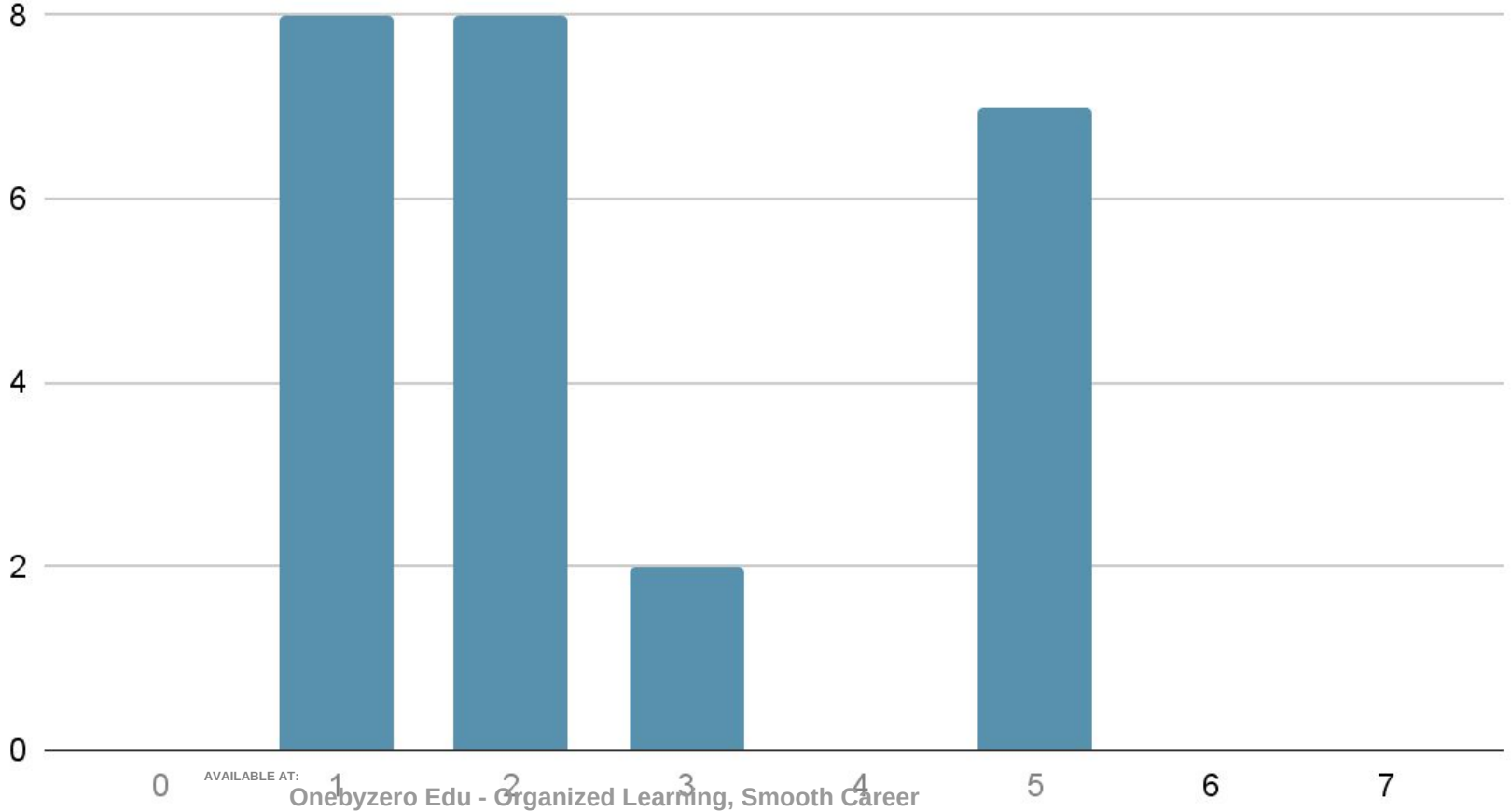
Gray Level Values will be from 0 to 7 (0 to L-1)

N = 25 (Number of Pixels)

Histogram Equalization Process

Gray Levels (rk)	0	1	2	3	4	5	6	7
Number of Pixels (nk)	0	8	8	2	0	7	0	0

Histogram



Histogram Equalization Process

Gray Scale (rk)	Number of pixels(nk)	PDF = nk/N	CDF	CDF * (L-1)	Histogram Equalization Level
0	0	0	0	0	0
1	8	0.32	0.32	2.24	2
2	8	0.32	0.64	4.48	4
3	2	0.08	0.72	5.04	5
4	0	0	0.72	5.04	5
5	7	0.28	1.00	7	7
6	0	0	1.00	7	7
7	0	0	1.00	7	7

Histogram Equalization Process

Gray Levels (rk)	0	1	2	3	4	5	6	7
Number of Pixels (nk)	0	0	8	0	8	2	0	7

Histogram Equalization Process

2	4	2	2	2
4	7	5	7	4
4	7	7	7	4
4	7	5	7	4
2	2	2	4	2

This is the final Image After Enhancement

Histogram Specification

– histogram matching or histogram specification is the transformation of an image so that its histogram matches a specified histogram

Perform the Histogram Specification

Original Image

Gray level	0	1	2	3	4	5	6	7
No. of Pixels	8	10	10	2	12	16	4	2

Desired Image

Gray level	0	1	2	3	4	5	6	7
No. of Pixels	0	0	0	0	20	20	16	8

Histogram Equalization (Input Image)

Gray level(r_k)	No. of Pixels(n_k)	PDF(n_k/N) $P_r(r_k)$	CDF	(L-1)*CDF	H_k
0	8	0.13	0.13	0.91	1
1	10	0.16	0.29	2.03	2
2	10	0.16	0.45	3.15	3
3	2	0.03	0.48	3.36	3
4	12	0.18	0.66	4.62	5
5	16	0.25	0.91	6.37	6
6	4	0.06	0.97	6.79	7
7	2	0.03	1.0	7	7
	64	1			

Histogram Equalization (Target Image)

Gray level(r_k)	No. of Pixels(n_k)	PDF(n_k/N) $P_r(r_k)$	CDF	(L-1)*CDF	S_k
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	20	0.31	0.31	2.17	2
5	20	0.31	0.62	4.34	4
6	16	0.25	0.87	6.09	6
7	8	0.13	1.0	7	7
	64	1			

Mapping

Gray Scale	H	S	Map
0	1	0	4
1	2	0	4
2	3	0	5
3	3	0	5
4	5	2	6
5	6	4	6
6	7	6	7
7	7	7	7

Modified Image

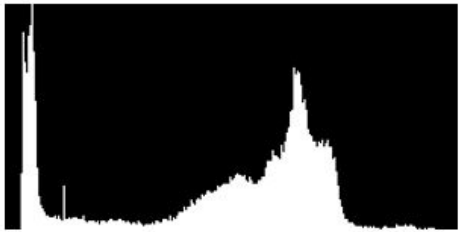
Gray level	0	1	2	3	4	5	6	7
No. of Pixels	0	0	0	0	18	12	28	6

Histogram Specification Examples

Original image

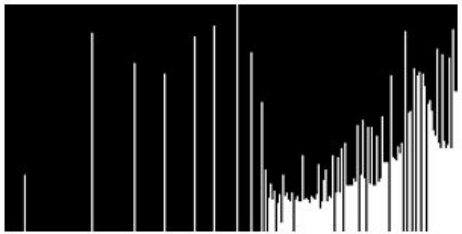
Histogram of original image

Histogram Specification Examples (contd)



Original histogram

Specified histogram, *exp(0.015*x)*

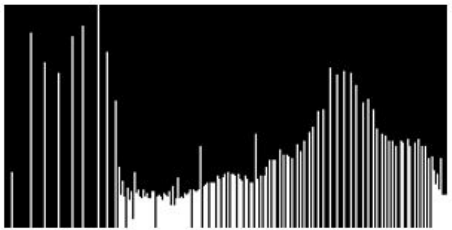


Output image and its histogram

Histogram Specification Examples (contd)

Original histogram

Specified histogram, *log(0.5*x+2)*



Output image and its histogram

Image Averaging

- A digital image processing technique that is often employed to enhance video images that have been corrupted by random noise
- Remove blurring of an image
- Allow noise reduction

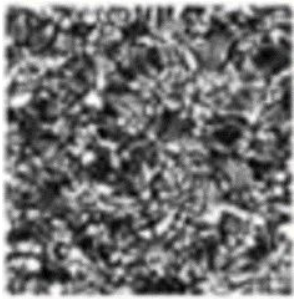
Image Averaging(Cont.)

➢ Working process:

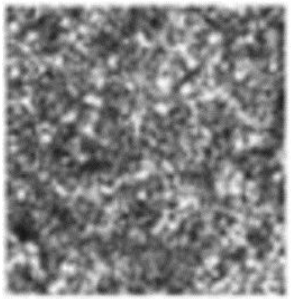
- Image averaging algorithms operates by computing an average (i.e. arithmetic mean) of the intensity values for each pixel position in a set of captured images from the same scene or view-field.
- In the averaging process, the signal component of the image remains the same, but the noise component differs from one image frame to another (as each image has a stable signal component and random noise component).
- When the averaged image is computed, the image signal component has a stronger influence over the summation than does the noise component.

Image Averaging(Cont.)

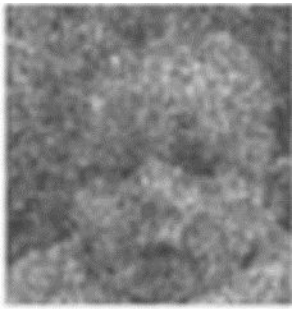
1



5



50



100

500

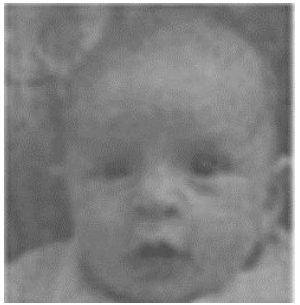


Image Averaging(Cont.)

➢ **Formula:**

$$A(N, x, y) = \frac{1}{N} * \sum_{i=1}^{N} l\,(i, x, y)$$

Here,

A(N, x, y) = Average intensity value

N = No of image frame

(x, y) = co-ordinates

l(i, x, y) = sum taken from the pixel intensity value of the ith frame from the N set of image frames

Image Subtraction

- Also called pixel subtraction or difference imaging.
- An image processing technique whereby the digital numeric value of one pixel or whole image is subtracted from another image
- The result of the subtraction of individual pixels between two images forms another image

Image Subtraction(Cont.)

- **Example:** Let f1(x, y) & f2(x, y) be two 4*4 images. Now, find image difference, g(x, y) using image subtraction method.

100	150	200	100
70	90	255	160
150	100	200	175
150	200	45	70

f1

10	12	12	10
16	0	105	60
50	40	120	100
90	20	05	35

f2

Solution: g(x, y) = f1(x, y) - f2(x, y)

=

90	138	188	90
54	90	150	100
100	60	80	75
60	180	40	35

Image Subtraction(Cont.)

➢ **Need of image subtraction:**

1. Leveling the uneven section of an image, that is, subtraction helps to change an uneven image into a more even-structured image.
2. Detecting changes between two images.

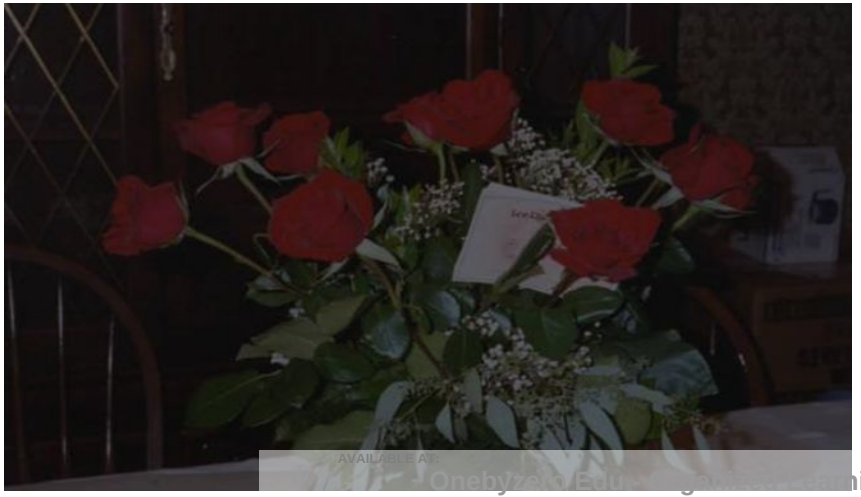
➢ **Example**:Medical Imaging..

Color Image Enhancement

- **Histogram Equalization on Individual Color Channels method applies** histogram equalization separately to each color channel (Red, Green, and Blue)
- For color images, the process more complex compared to grayscale images for avoiding color distortions

Color Image Enhancement(Cont.)

A)Original poor contrast image



B)Histogram equalization based on the red color band

Color Image Enhancement(Cont.)

C)Histogram equalization based on the green color band

D) Histogram equalization based on the blue color band

Color Image Enhancement(Cont.)

In this case the red band gives the best results. This will depend on the image and the desired result..

Thank You All !!!