Chapter Three

Histogram

3.1 Histogram

The histogram of an image is a plot of the gray _levels values versus the number of pixels at that value.

A histogram appears as a graph with "brightness" on the horizontal axis from 0 to 255 (for an 8-bit) intensity scale) and "number of pixels "on the vertical axis. For each colored image three histogram are computed, one for each component (RGB, HSL).The histogram gives us a convenient -easy -to -read representation of the concentration of pixels versus brightness of an image, using this graph we able to see immediately:

1. Whether an image is dark or light, and high or low contrast.
2. Give us our first clues about what contrast enhancement would be appropriately applied to make the image more subjectively pleasing to an observer, or easier to interpret by succeeding image analysis operations.

Brightness: is a relative term. Brightness can be defined as intensity of light emit by a particular light source.

Contrast: can be defined as the difference between maximum and minimum pixel intensity in an image.

So the shape of histogram provide us with information about nature of the image or sub image if we considering an object within the image. For example:

1. Very narrow histogram implies a **low-contrast image**
2. Histogram skewed (مائل) to word the high end implies a **bright image**

3. Histogram with two major peaks , called bimodal, implies an object that is in **contrast with the background**

Examples of the different types of histograms are shown in figure (3-1).

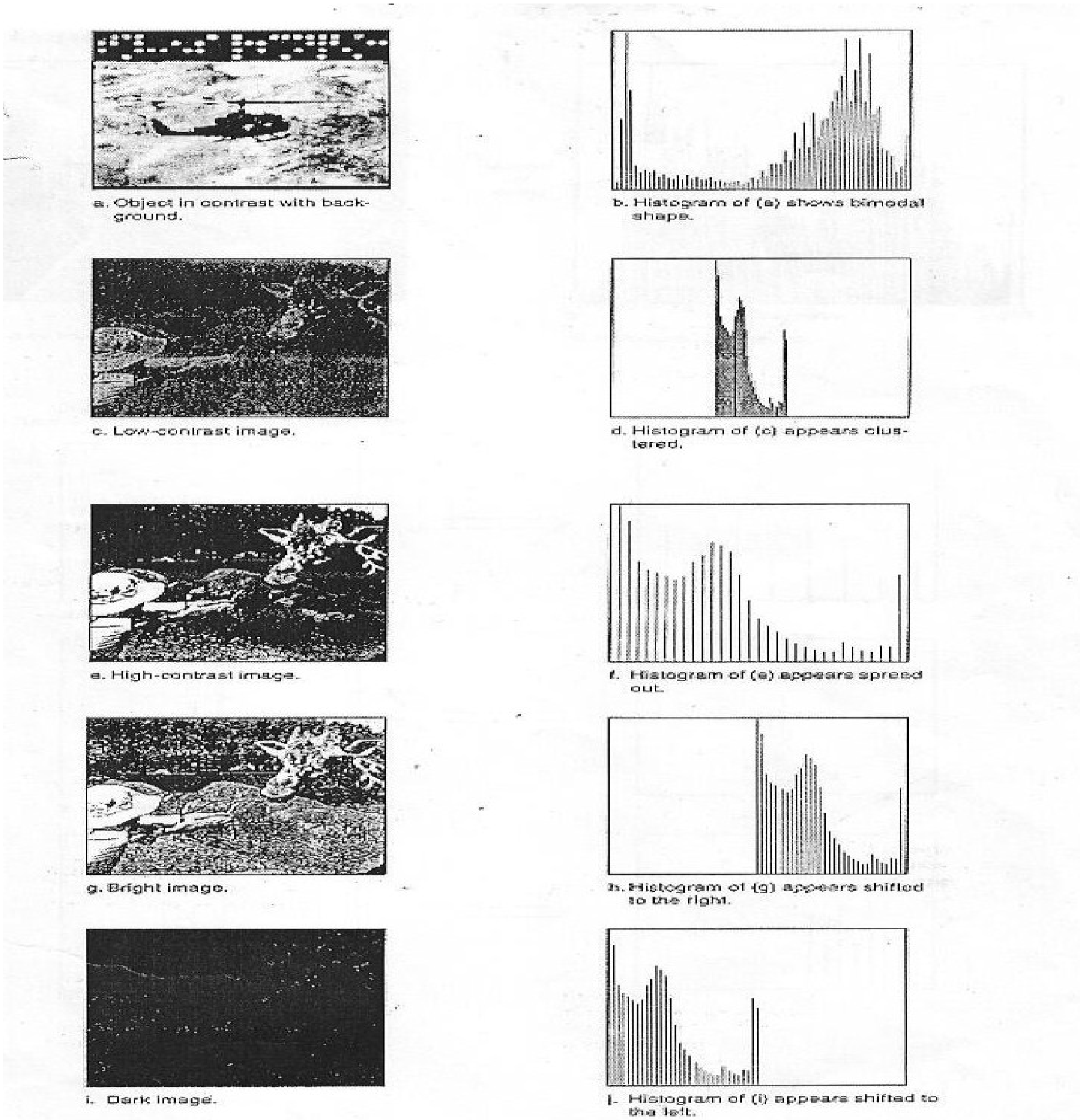


Figure (3-1): Histogram Types

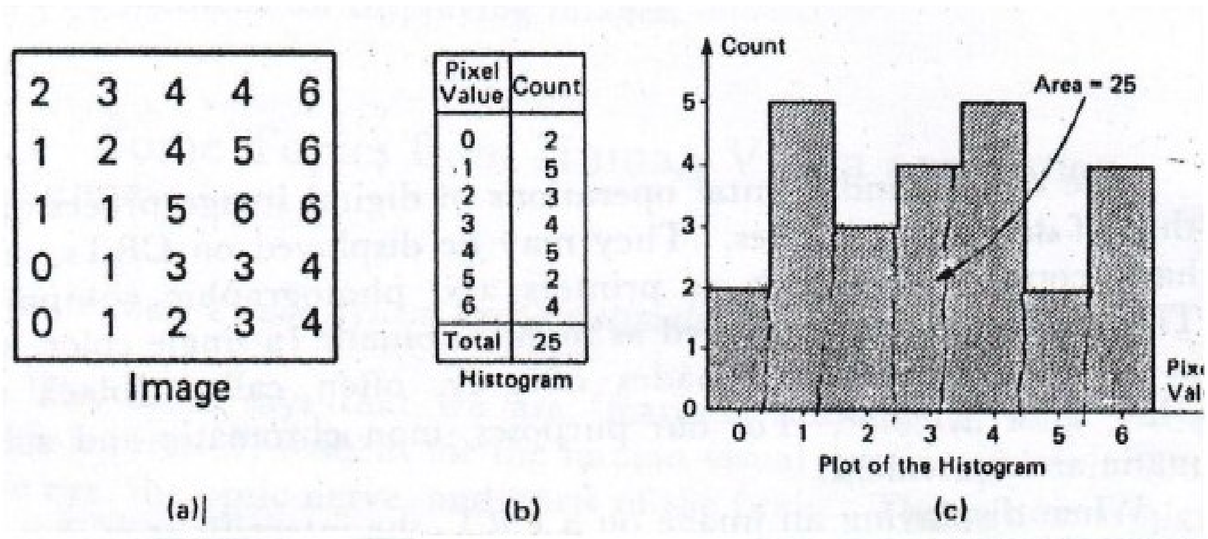


Figure (3-2): Sub image and its Histogram

3.2 Histogram Modification

The gray level histogram of an image is the distribution of the gray level in an image is the distribution of the gray level in an image. The histogram can be Enhanced or modified by mapping functions, which will stretch, shrink (compress), or slide the histogram. Figure (3-3) illustrates a graphical representation of histogram stretch, shrink and slide.

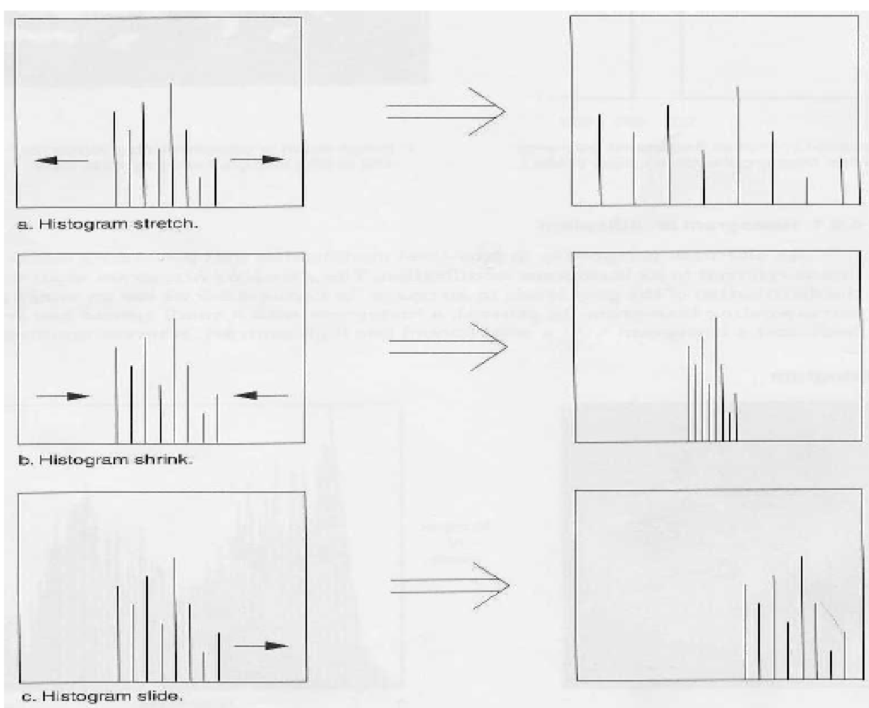


Figure (3-3): Histogram Modifications

3.2.1 Histogram stretching

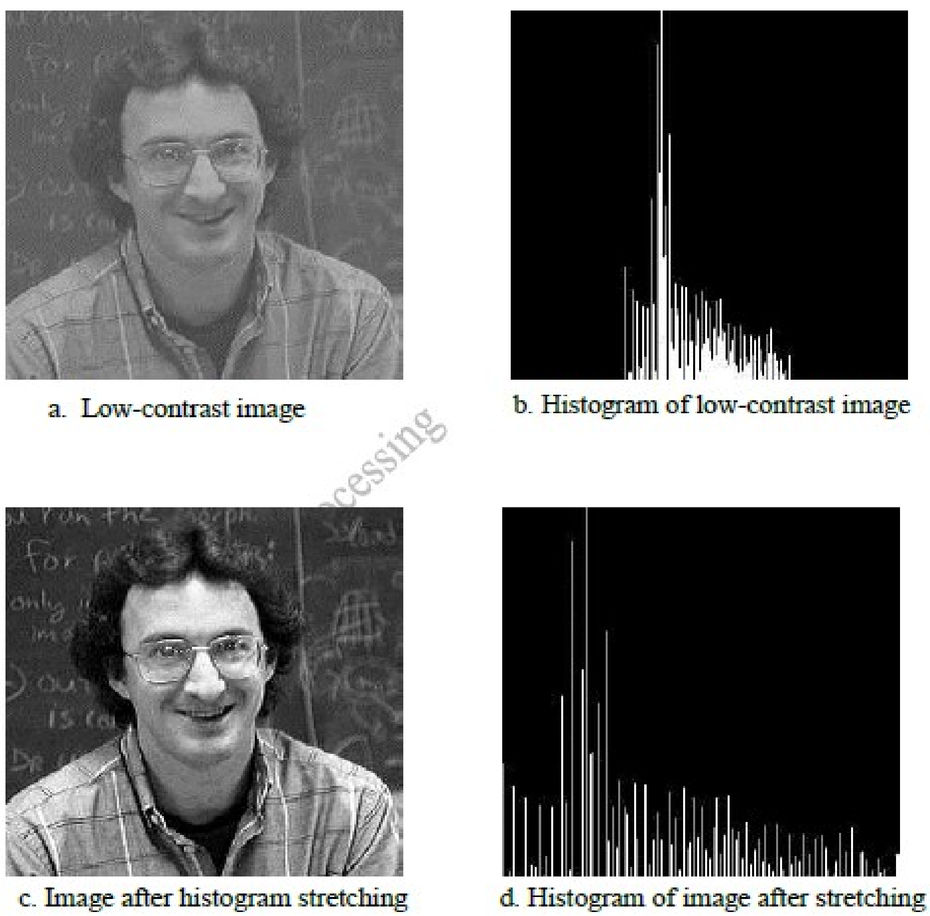
We can seen that contrast can be increased using histogram stretching. The mapping function for histogram stretch can be found by the following equation:

$$St(r,c) = \left[\frac{I(r,c) - I(r,c)_{min}}{I(r,c)_{max} - I(r,c)_{min}}\right] (Max - Min) + Min$$

Where, $I(r,c)_{max}$ is the largest gray- level in the image I(r,c).

$I(r,c)_{min}$ is the smallest gray- level in the image I(r,c).

MAX and MIN correspond to the maximum and minimum gray –level values possible (for an 8-bit image these are 255 and 0). This equation will take an image and stretch the histogram a cross the entire gray-level range which has the effect of increasing the contrast of a low contrast image (see figure (3-4) of histogram stretching).



a. Low-contrast image

b. Histogram of low-contrast image

c. Image after histogram stretching

d. Histogram of image after stretching

Figure (3-4): Histogram Stretching

Failing of histogram stretching

As we have discussed , that the algorithm fails on some cases. Those cases include images with when there is pixel intensity 0 and 255 are present in the image Because when pixel intensities 0 and 255 are present in an image, then in that case they become the minimum and maximum pixel intensity which ruins the formula like this.

Example: Apply histogram stretching for the following sub image :

7	12	8
20	9	6
10	15	1

Solution:

$$St(r,c) = \left[\frac{I(r,c) - I(r,c)_{min}}{I(r,c)_{max} - I(r,c)_{min}}\right](Max - Min) + Min$$

I(r,c)min = 1 ; I(r,c)max = 20 ; Max =255 ; Min =0

I(0,0) = [7-1 / 20-1] * [255 – 0] + 0 = 80.5
I(0,1) = [12-1 / 20-1] * [255 – 0] + 0 = 147.6
I(0,2) = [8-1 / 20-1] * [255 – 0] + 0 = 93.9
I(1,0) = [20-1 / 20-1] * [255 – 0] + 0 = 255
I(1,1) = [9-1 / 20-1] * [255 – 0] = 107.3
I(1,2) = [6-1 / 20-1] * [255 – 0] + 0 = 67.1
I(2,0) = [10-1 / 20-1] * [255 – 0] + 0 = 120.7
I(2,1) = [15-1 / 20-1] * [255 – 0] + 0 = 187.8
I(2,1) = [1-1 / 20-1] * [255 – 0] + 0 = 0

$$St = \begin{matrix} 80.5 & 147 & 93 \\ 25.5 & 107.3 & 67.1 \\ 120.7 & 187.8 & 0 \end{matrix}$$

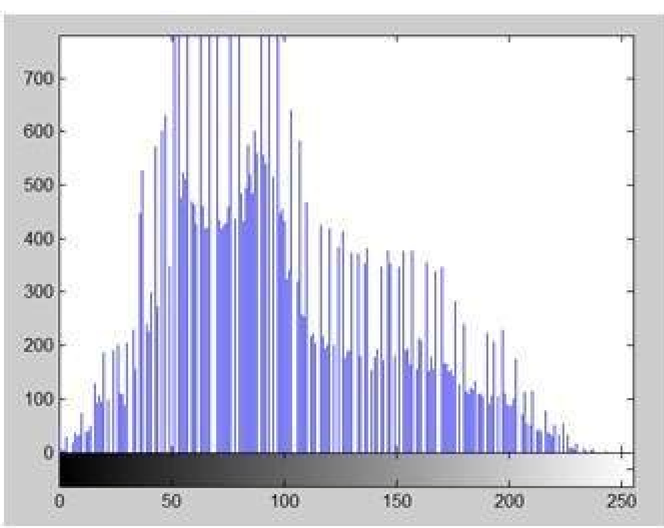
3.2.2 Histogram Sliding

The histogram slide techniques can be used to make an image either darker or lighter but retain the relationship between gray-level values. **In histogram sliding, we just simply shift a complete histogram rightwards or leftwards**. Due to shifting or sliding of histogram towards right or left, a clear change can be seen in the image. This can be a accomplished by simply adding or subtracting a fixed number for all the gray-level values, as follows:

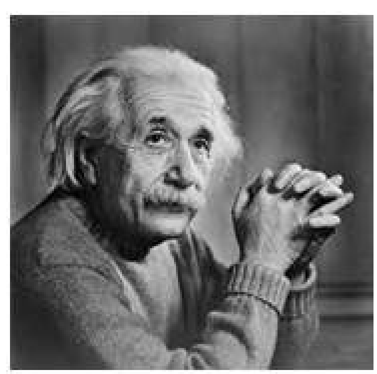
Sd (r,c) = I (r,c)+ OFFSET.

Where OFFSET values is the amount to slide the histogram. In this equation, a positive OFFSET value will increase the overall brightness; whereas a negative OFFSET will create a darker image, figure (3-5) shows histogram sliding. For example, increasing brightness using histogram sliding:

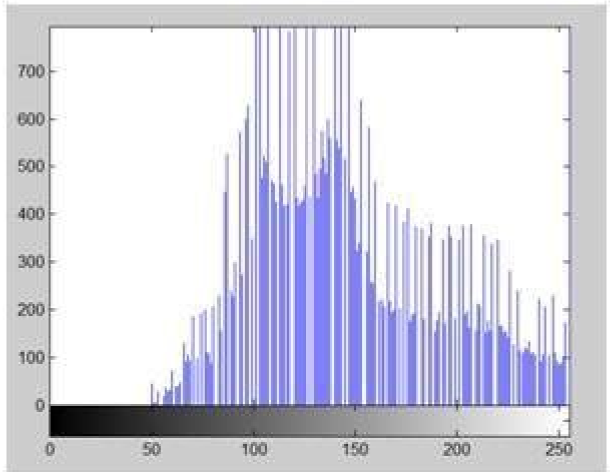
In order to bright it, we will slide its histogram towards right, or towards whiter portion. In order to do we need to add at least a value of 50 to this image.



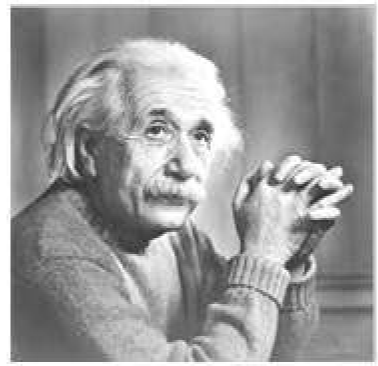
a) Histogram original image



b) original image



c) Histogram after slidig



d) image after sliding

Figure (3-5): Histogram Sliding

Conclusion

As we can clearly see from the new histogram that all the pixels values has been shifted towards right and its effect can be seen in the new image.

3.2.3 Histogram Equalization

Is a popular technique used for improving the appearance of a poor image. It's a function is similar to that of a histogram stretch but often provides more visually pleasing results across a wide range of images. Histogram equalization is a technique where the histogram of the resultant image is as flat as possible (with histogram stretching the overall shape of the histogram remains the same).

The results in a histogram with a mountain grouped closely together to "spreading or flatting histogram makes the dark pixels appear darker and the light pixels appear lighter (the key word is "appear" the dark pixels in a photograph cannot by any darker. If, however, the pixels that are only slightly lighter become much lighter, then the dark pixels will appear darker).

The histogram equalization process for digital images consists of four steps:

1. Find the running sum of the histogram values
2. Normalize the values from step1 by dividing by total number of pixels.
3. Multiply the values from step2 by the maximum gray level value and round.
4. Map the gray-level values to the results from step 3, using a one-to-one correspondence. The following example will help to clarify this process.

Example:-

We have an image with 3 bit /pixel, so the possible range of values is 0 to 7. We have an image with the following histogram:

Gray-level value	0	1	2	3	4	5	6	7
No of Pixel Histogram value	10	8	9	2	14	1	5	2

Step 1: Great a running sum of histogram values. This means that the first values is 10, the second is 10+8=18, next is 10+8+9=27, and soon. Here we get 10,18,29,43,44,49,51.

Step 2: Normalize by dividing by total number of pixels. The total number of pixels is 10+8+9+2+14+1+5+0=51.

Step 3 : Multiply these values by the maximum gray – level values in this case 7 , and then round the result to the closet integer. After this is done we obtain 1,2,4,4,6,6,7,7.

Step 4 : Map the original values to the results from step3 by a one –to-one correspondence.

The first three steps are:

Gray-level	0	1	2	3	4	5	6	7
No. of Pixel	10	8	9	2	14	1	5	2
Run Sum	10	18	27	29	43	44	49	51
Normalized	10/51	18/51	27/51	29/51	43/51	44/51	49/51	51/51
Multiply by 7	1	2	4	4	6	6	7	7

The fourth step:

Old	0	1	2	3	4	5	6	7
New	1	2	4	4	6	6	7	7

All pixel in the original image with gray level 0 are set to 1, values of 1 are set to 2, 2 set to 4, 3 set to 4, and so on (see figure (3-6) histogram. equalization, you can see the original histogram and the resulting histogram equalized histogram. Although the result is not flat, it is closer to being flat than the original.

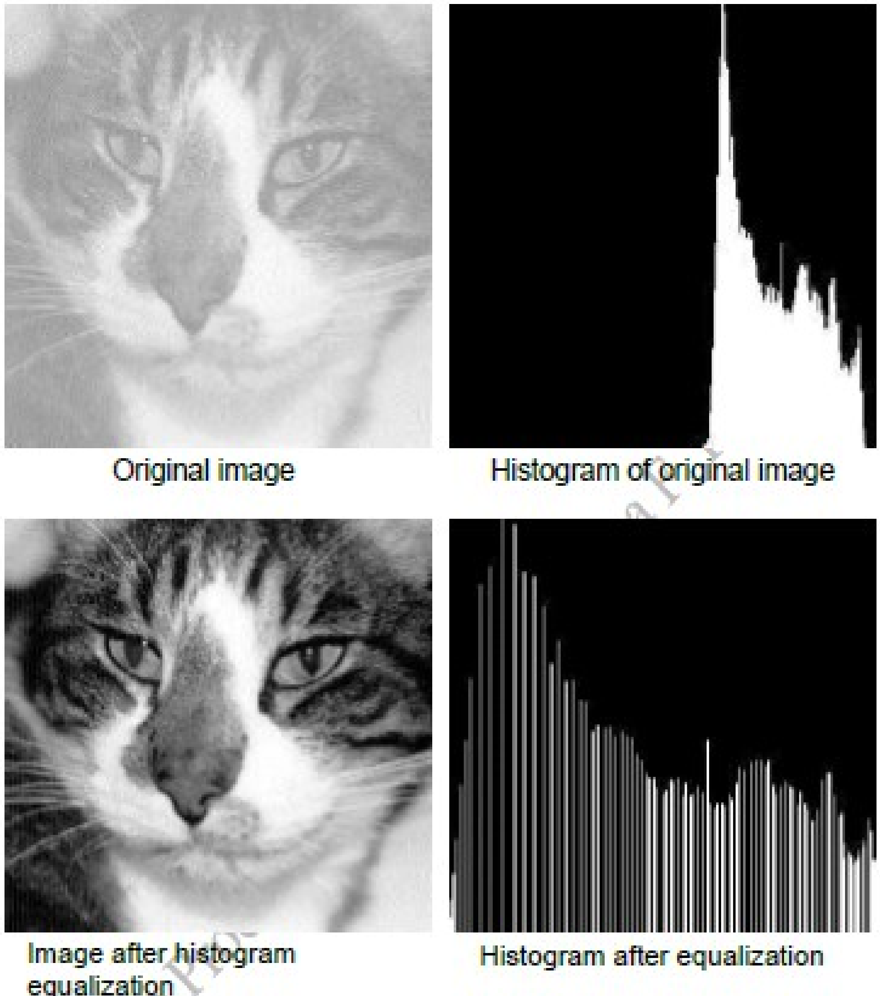


Figure (3-6): Histogram Sliding

<u>H.W:</u> Apply histogram equalization technique for the following (3-bit) sub image?

$$\begin{pmatrix} 0 & 3 & 1 & 4 & 0 & 4 & 1 & 0 & 5 \\ 2 & 0 & 4 & 1 & 1 & 2 & 4 & 4 & 7 \\ 0 & 4 & 0 & 4 & 4 & 1 & 2 & 6 & 7 \\ 5 & 2 & 4 & 0 & 4 & 7 & 6 & 6 & 5 \\ 2 & 0 & 2 & 4 & 0 & 4 & 2 & 2 & 6 \\ 0 & 1 & 1 & 0 & 2 & 0 & 3 & 1 & 6 \end{pmatrix}$$