جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

قسم الامن السيبراني

Department of Cyber Security

Subject:

Image Processing

Class:

Third

Lecturer:

Asst. Prof. Dr. Ali Kadhum Al-Quraby

Lecture: (7)

Image Histogram

Image 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**. 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.

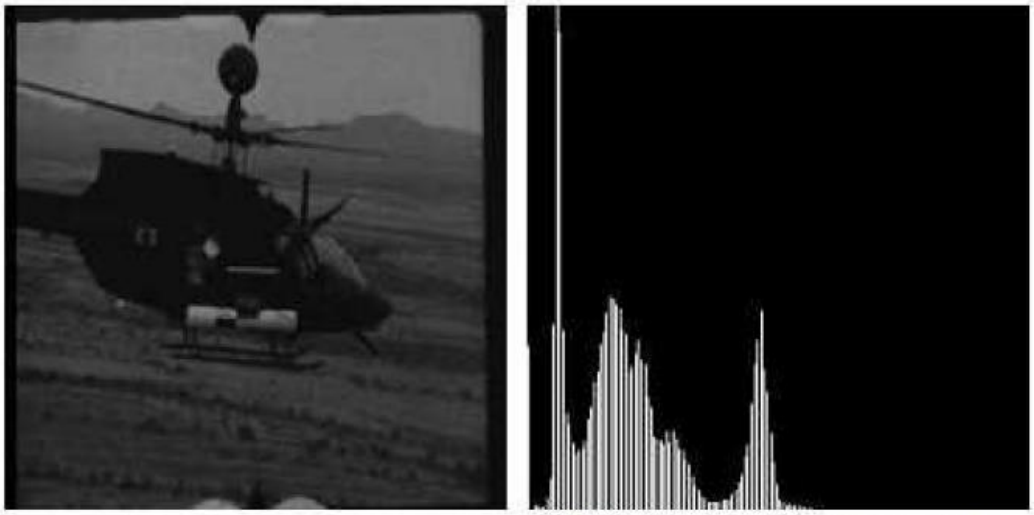
Contrast: can be defined as the difference between maximum and minimum pixel intensity in an image.

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**

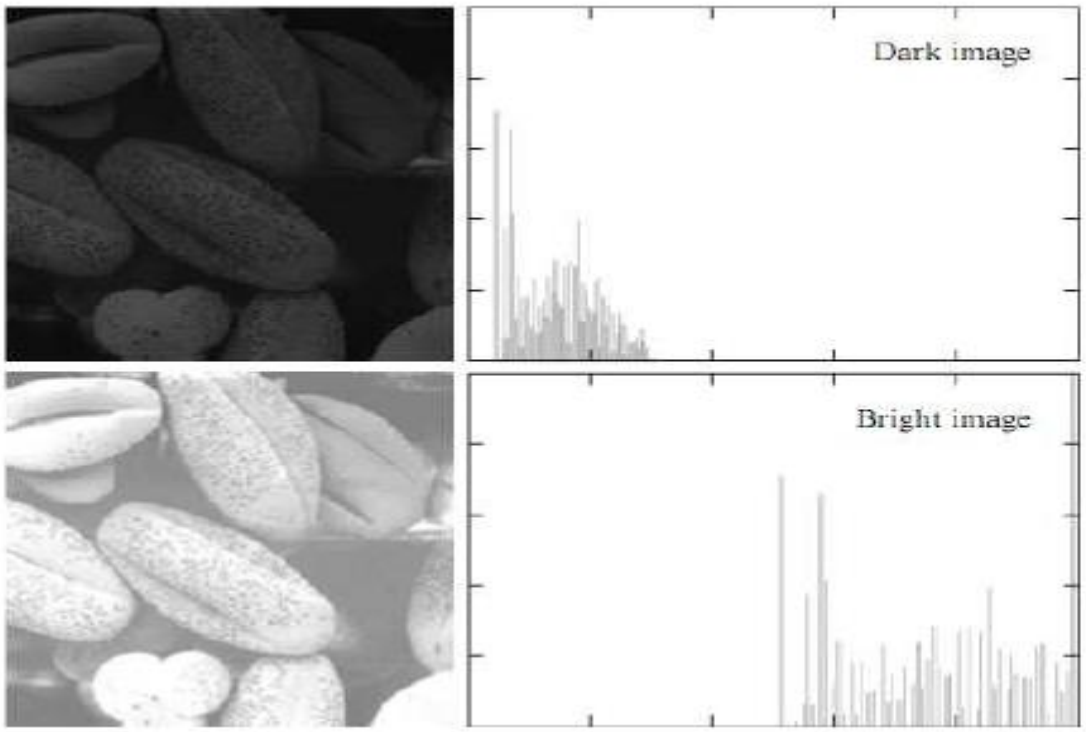
2. Histogram skewed (مائل) to word the high end implies a **bright image**

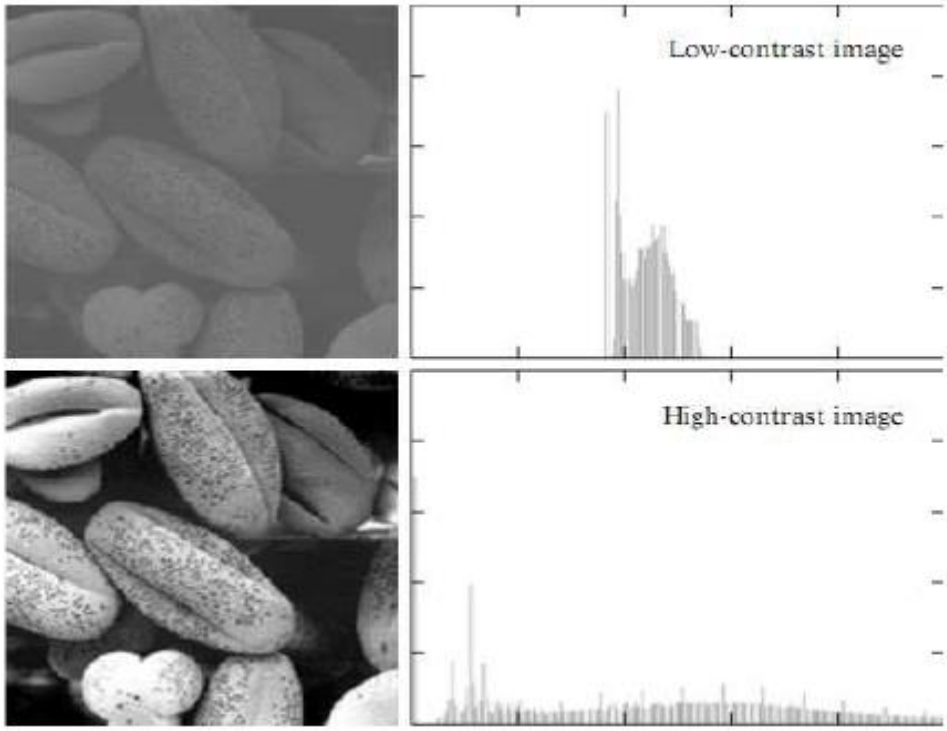
Histogram with two major peaks , called bimodal, implies an object that is in contrast with the background

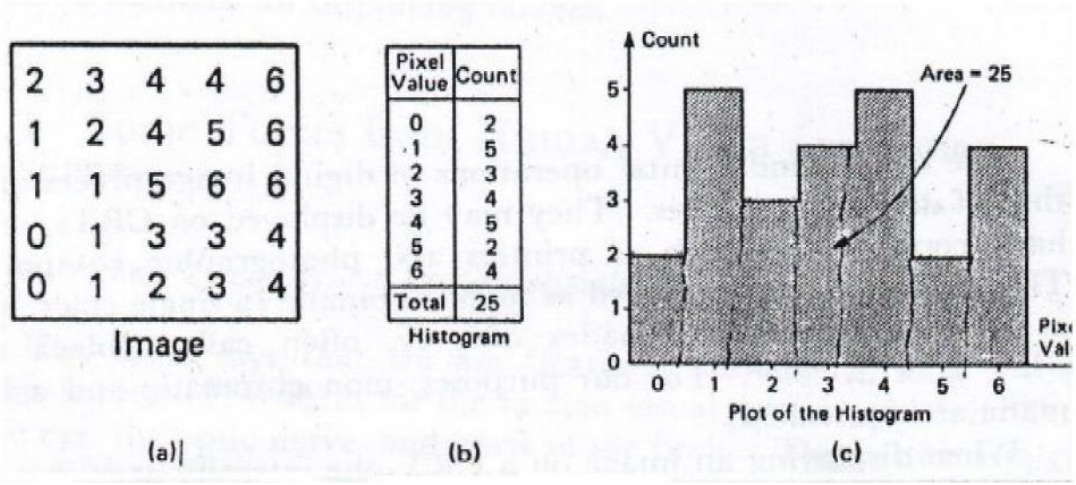


Original image Histogram of original image

Figure(1) histogram of image







Histogram Modifications

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 modified by mapping functions, which will stretch, shrink (compress), or slide the histogram. Figure below illustrates a graphical representation of histogram stretch, shrink and slide.

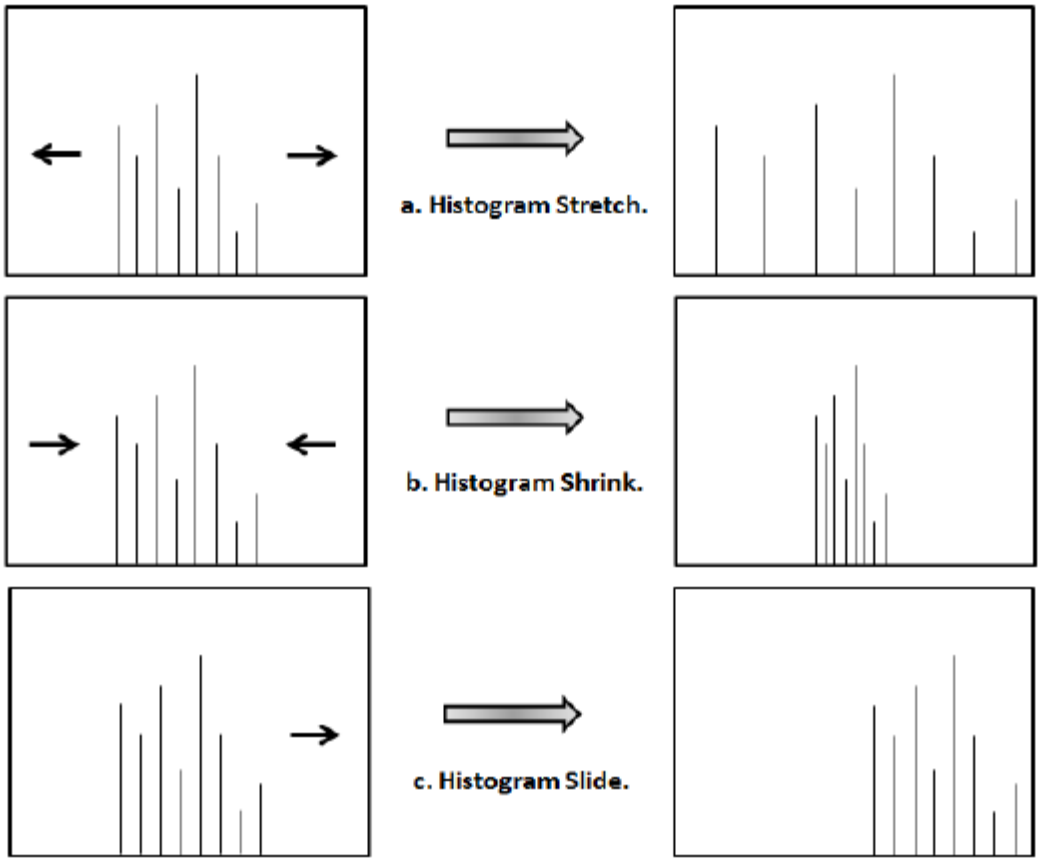


Figure 3.4: Histogram Modifications

Histogram Stretch

The mapping function for **histogram stretch** can be found by the following equation:

$$\text{Stretch (I (r, c))} = \left[\frac{I(r,c) - I(r,c)_{\min}}{I(r,c)_{\max} - I(r,c)_{\min}} \right] [MAX\text{-}MIN] + MIN.$$

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

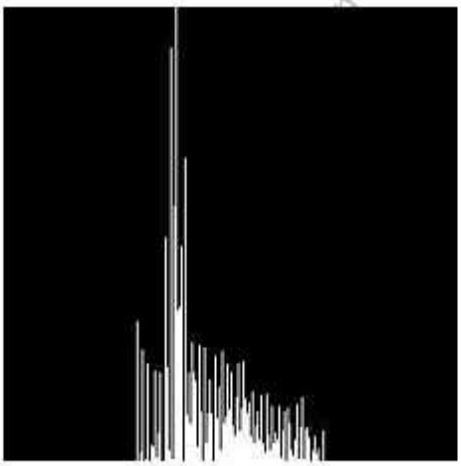
I(r,c) min is the smallest gray- level in the image I(r,c).

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 (8-2) 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.

Low-contrast image



Histogram of low-contrast image

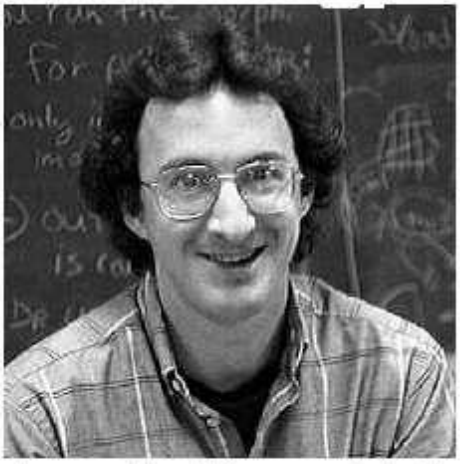
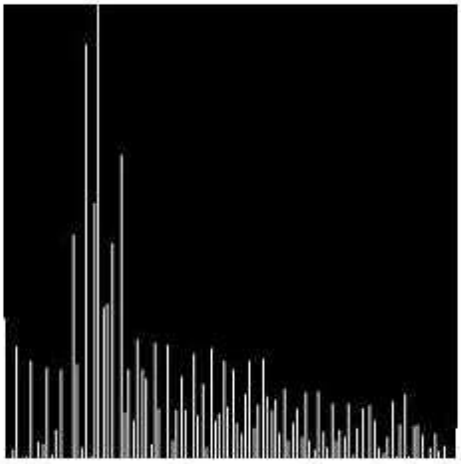


Image after histogram stretching



Histogram of image after stretching

Example: Apply histogram stretching for the following sub image :

$$\begin{matrix} 7 & 12 & 8 \\ 20 & 9 & 6 \\ 10 & 15 & 1 \end{matrix}$$

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

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

Histogram Shrink

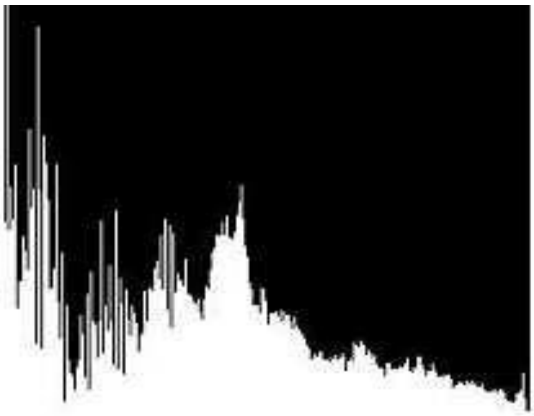
The opposite of a histogram stretch is a histogram shrink, which will decrease image contrast by compressing the gray levels. The mapping function for a **histogram shrinking** can be found by the following equation:

$$Shrink(f(x,y)) = \left[\frac{shrink_{max} - shrink_{min}}{f(x,y)_{max} - f(x,y)_{min}}\right][f(x,y) - f(x,y)_{min}] + shrink_{min}$$

$shrink_{max}$ and $shrink_{min}$ correspond to the maximum and minimum desired in the compressed histogram. In general, this process produces an image of reduced

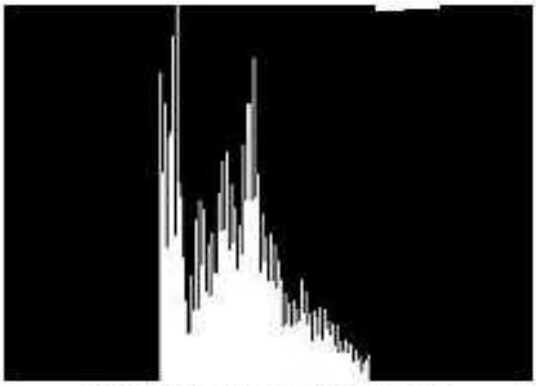
contrast and may not seem to be useful an image enhancement (see figure (8-3) of shrink histogram).

Original image



Histogram of original image

Image after histogram shrink to the range [75, 175]



Histogram of the image

Histogram Sliding

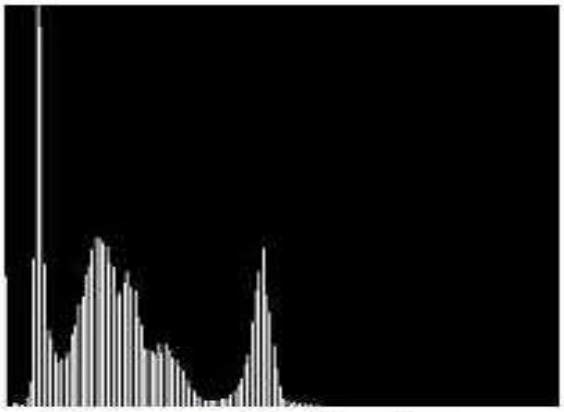
The histogram slide techniques can be used to make an image either darker or lighter but retain the relationship between gray-level values. This can be a accomplished by simply adding or subtracting a fixed number for all the gray-level values, as follows:

$$\text{Slide } (I(r,c)) = I(r,c) + \text{OFFSET}.$$

Where OFFSET values is the amount to slide the histogram.

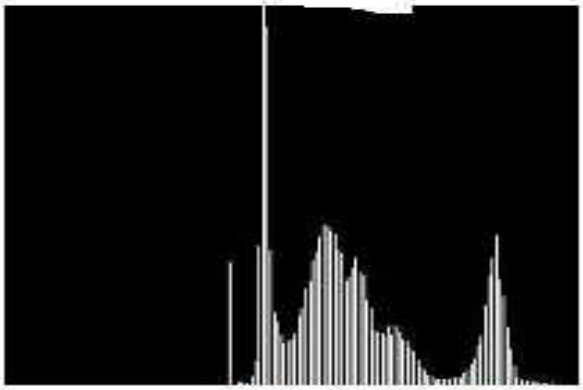
In this equation, a positive OFFSET value will increase the overall brightness; where as a negative OFFSET will create a darker image, figure (8-4) shows histogram sliding.

Original image



Histogram of original image

Image after positive-value histogram sliding



Histogram of image after sliding

Image Histogram Questions— MCQs

Image Histogram Fundamentals

1. What does the **histogram of an image** plot on its horizontal and vertical axes?
2. For an 8-bit intensity scale, what is the range of values typically represented on the horizontal (brightness) axis of a histogram?
3. What is the definition of **Contrast** in an image?
4. What information does a histogram provide regarding the concentration of pixels?
5. What two general characteristics of an image can be immediately determined by looking at its histogram?

Interpreting Histogram Shapes

6. What characteristic does a **very narrow histogram** imply about the contrast of an image?
7. What does a histogram that is **skewed toward the high end** imply about the image's overall brightness?
8. What characteristic does a **bimodal** histogram (one with two major peaks) imply about an object within the image?
9. In the graphical representation of a dark image's histogram, where on the horizontal axis would most of the pixels be concentrated?
10. In the graphical representation of a bright image's histogram, where on the horizontal axis would most of the pixels be concentrated?

Histogram Modification Fundamentals

11. What is the definition of the gray level histogram of an image?
12. By what means can the histogram be modified?
13. What three actions can mapping functions perform on a histogram?
14. How many pixels are there in the example image shown on page 3, corresponding to the total count (Area) of the histogram?

Histogram Stretch (Contrast Enhancement)

15. What is the primary **effect** of performing a histogram stretch on a low-contrast image?
16. Write the full equation for **Histogram Stretch** (i.e., Stretch(I(r,c))).
17. In the histogram stretch equation, what do **MAX** and **MIN** represent for an 8-bit image?
18. What specific condition regarding pixel intensities can cause the histogram stretching algorithm to fail?
19. In the example calculation, an input pixel value of I(r,c)=7 maps to what stretched value, given I(r,c)min=1 and I(r,c)max=20?

Histogram Shrink

20. What is the purpose of **Histogram Shrink**, and what is its effect on image contrast?
21. What do the terms shrinkmax and shrinkmin represent in the histogram shrink equation?
22. Does histogram shrinking generally produce an image of reduced or increased contrast?

Histogram Slide

23. What two overall changes can the **histogram slide** technique be used to make to an image, while retaining the relationship between gray-level values?
24. Write the simple equation used to perform a **Histogram Slide** (i.e., Slide(I(r,c))).
25. In the histogram slide equation, what effect will a **negative OFFSET** value have on the image?