4. Histogram

Histogram

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

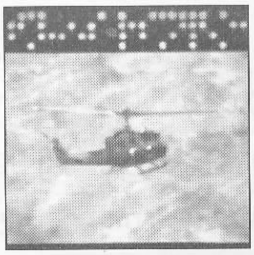
A histogram appears as a graph with "brightness" on the horizontal axis from 0 to 255 (for an 8-bit) intensity scale) and "number of pixels "on the vertical axis. For each colored image three histogram are computed, one for each component (RGB, HSL).The histogram gives us a convenient -easy -to -read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

1 Whether an image is basically 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.

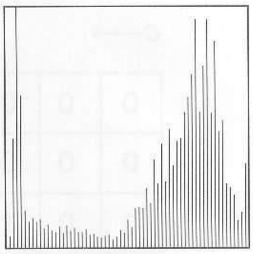
So the shape of histogram provide us with information about nature of the image or sub image if we considering an object within the image. For example:

1 Very narrow histogram implies a low-contrast image.
2 Histogram skewed 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 below.

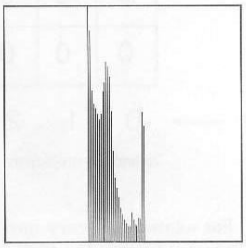


a. Object in contrast with background.



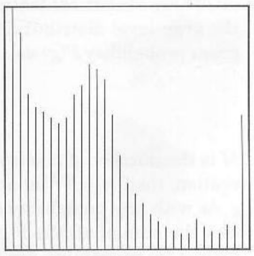
b. Histogram of (a) shows bimodal shape.

c. Low-contrast image.



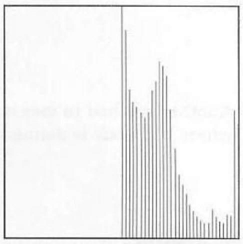
d. Histogram of (c) appears clustered.

e. High-contrast image.



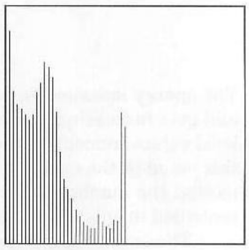
f. Histogram of (e) appears spread out.

g. Bright image.



h. Histogram of (g) appears shifted to the right.

i. Dark image.

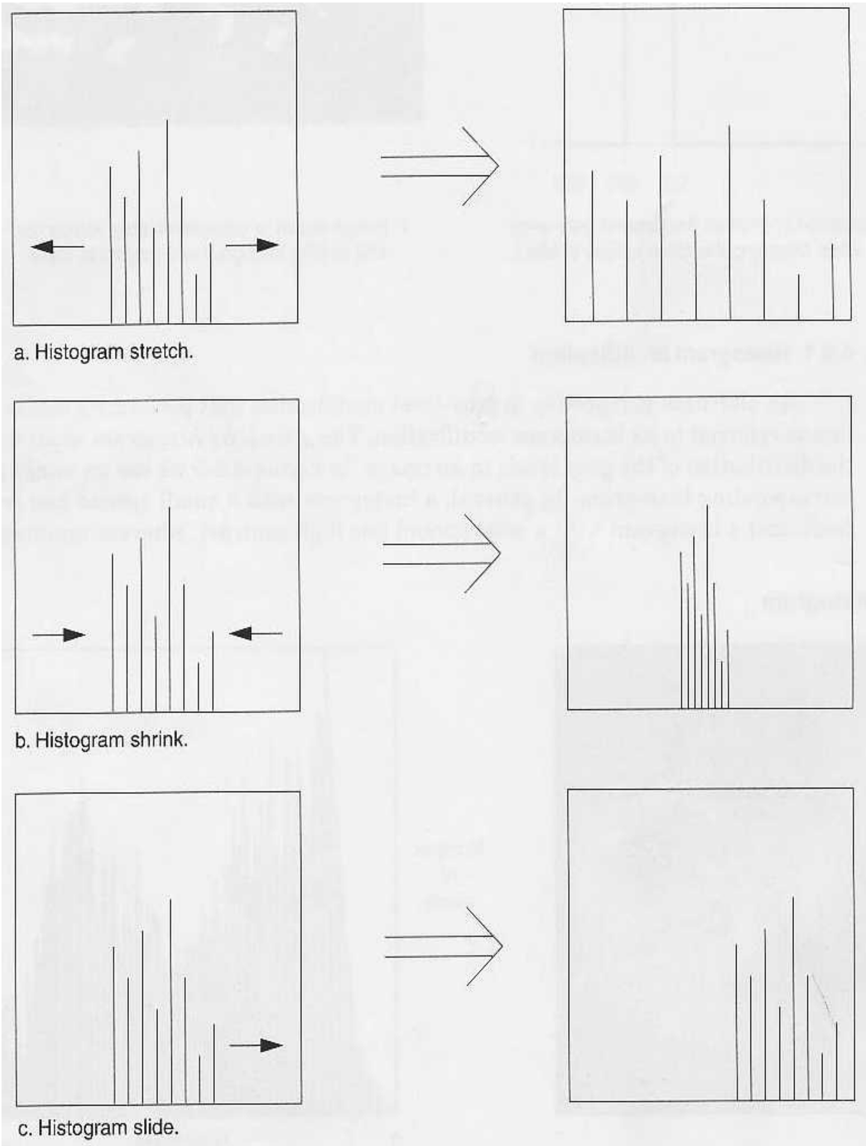


j. Histogram of (i) appears shifted to the left.

Different types of Histogram

Histogram Modifications

The gray level histogram of 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.



Histogram Modifications.

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

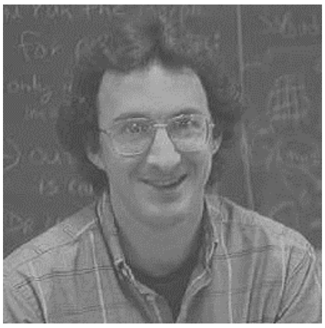
$$\text{Stretch (I (r, c))} = \left[\frac{I(r,c)-I(r,c)_{\min}}{I(r,c)_{\max}-I(r,c)_{\min}}\right][MAX\text{-}MIN] + MIN.$$

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

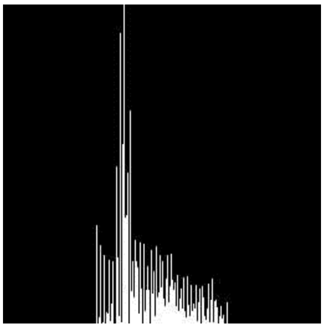
$I(r,c)_{min}$ is the smallest gray- level in the image I(r,c).

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 across the entire gray-level range which has the effect of increasing the contrast of a low contrast image (see figure below of histogram stretching).



Low-contrast image



Histogram of low-contrast image

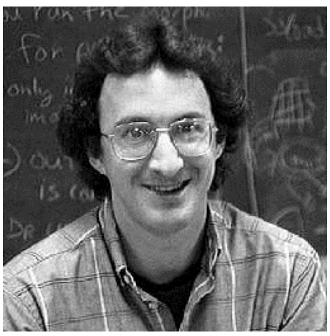
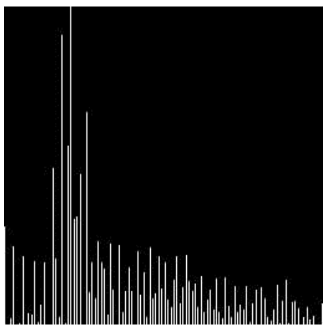


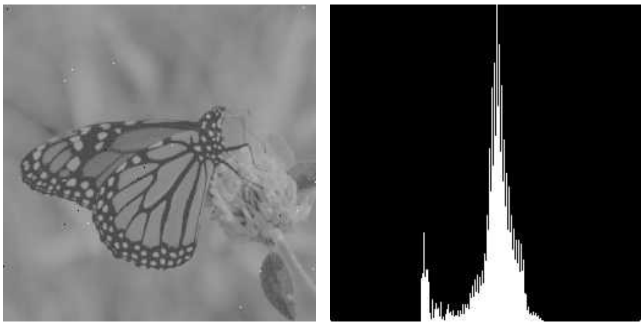
Image after histogram stretching



Histogram of image after stretching

Histogram Stretching.

In most of the pixel values in an image fall within small range, but a few outlines force the histogram to span the entire range, a pure histogram stretch will not improve the image. In this case it is useful to allow a small proceeding of the pixel values to be clipped at the low and high end of the range (for an 8-bit image this means truncating at 0 and 255). See figure below of stretched and clipped histogram.



Original Image   Histogram of the original image

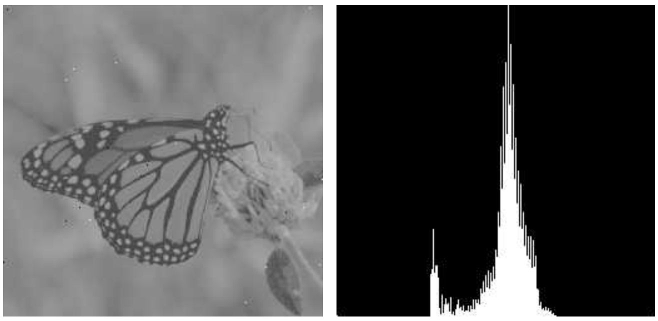


Image after histogram stretching without clipping   Histogram of the image

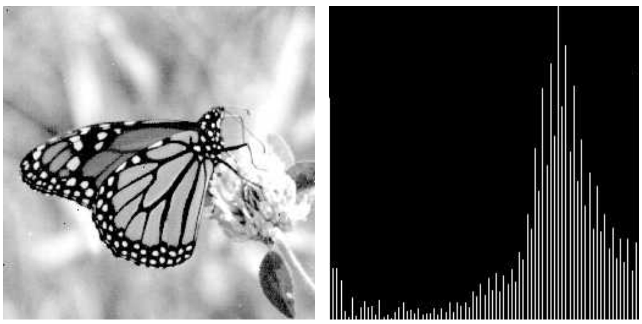


Image after histogram stretching with clipping 3% low and high value   Histogram of the image

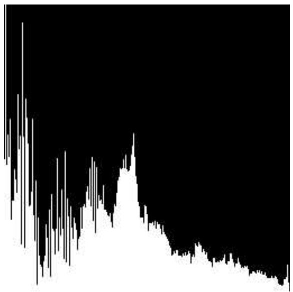
Histogram Stretching (Clipping).

- 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:

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

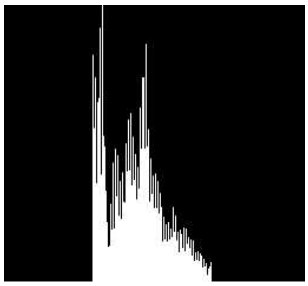
Shrink $_{max}$ and shrink $_{min}$ correspond to the maximum and minimum desired in the compressed histogram. In general, this process produces an image of reduced contrast and may not seem to be useful an image enhancement (see figure below of shrink histogram).

Original image



Histogram of original image

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



Histogram of the image

Histogram Shrinking.

- The histogram slide techniques can be used to make an image either darker or lighter but retain the relationship between gray-level values.

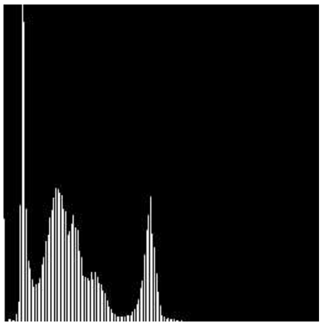
This can be a accomplished by simply adding or subtracting a fixed number for all the gray-level values, as follows:

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

Where OFFSET values is the amount to slide the histogram.

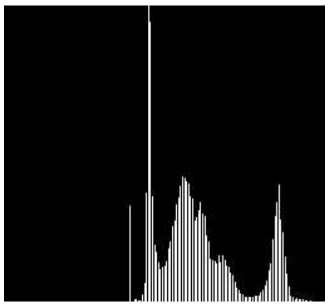
In this equation, a positive OFFSET value will increase the overall brightness; where as a negative OFFSET will create a darker image, figure below shows histogram sliding.

Original image



Histogram of original image

Image after positive-value histogram sliding



Histogram of image after sliding

Histogram Sliding.

Histogram Equalization

Is a popular technique for improving the appearance of a poor image. It's a function 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 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: Create 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+2=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.

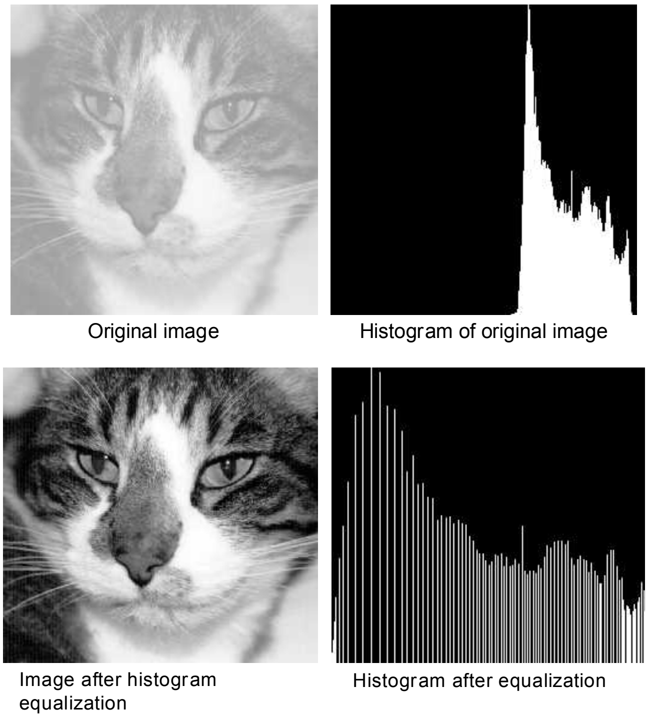
The first three steps:

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 below) 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.



Histogram Equalization.