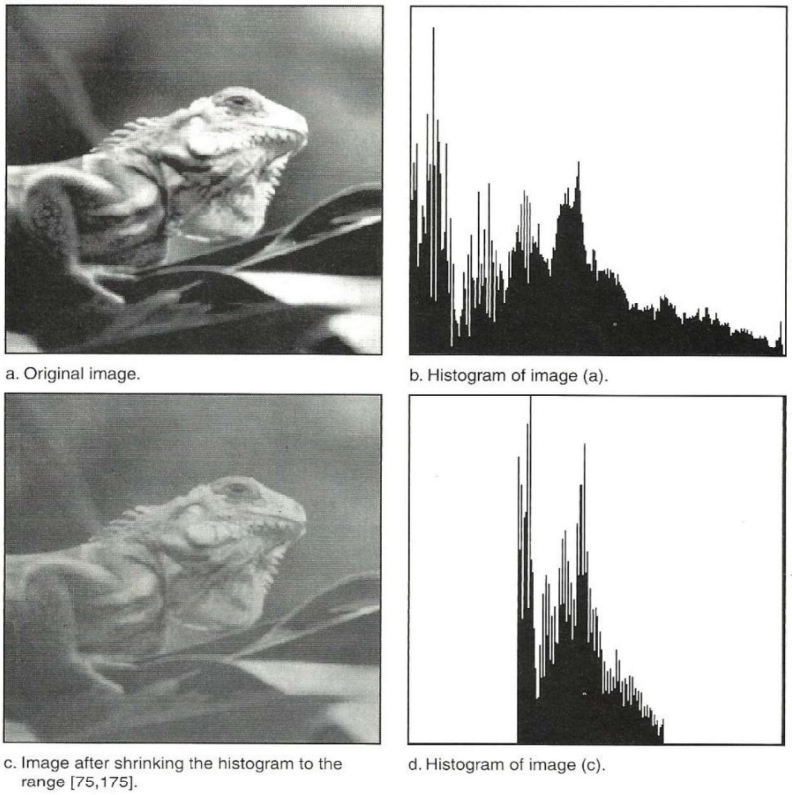


Figure 14: histogram shrink

c. Histogram slide

The histogram slide technique can be used to make an image either ***darker***or***lighter***but retain the relationship between gray-levels values. Thiscan be accomplished by simply **adding** or **subtracting** a fixed number from all the gray level values as follow:

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

Where OFFSET value is the amount to slide the histogram**.**

In this equation, we assume that any values slide past the minimum and maximum value will be clipped to the respective minimum or maximum. Aposative OFFSET value will increase the overall brightness, whereas a negative OFFSET will create a darker image. Figure 15 shows a dark image that has been brightened by

a histogram slide with a positive OFFSET value.

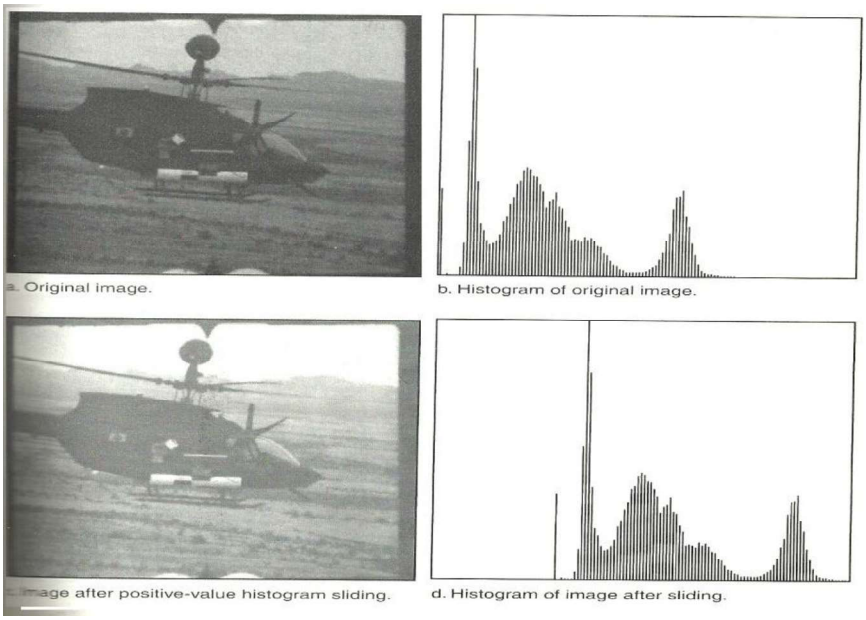


Figure 15: histogram slide

Example: Apply histogram stretching for the following sub image :

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

Where: ***Max*** **=255 ;** ***Min*** **=0**

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

$$\begin{bmatrix} 80 & 147 & 93 \\ 255 & 107 & 67 \\ 120 & 187 & 0 \end{bmatrix}$$

Example: Apply histogram shrink for the following sub image :

$$\begin{bmatrix} 70 & 120 & 80 \\ 200 & 90 & 60 \\ 100 & 150 & 10 \end{bmatrix}$$

Where: **Shrink max =100 ;** **shrink min =20**

Solution:

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

I(r,c)$_{min}$ **= 10 ;** ***I(r,c)$_{max}$*** **= 200 ;** **Shrink max =100 ;** **shrink min =20**

$I_{(0,0)}$ = [100-20 / 200-10] * [**70** – 10] + 20= 45.2
$I_{(0,1)}$ = [100-20 / 200-10] * [**120** – 10] + 20= 66.3
$I_{(0,2)}$ = [100-20 / 200-10] * [**80** – 10] + 20= 49.4
$I_{(1,0)}$ = [100-20 / 200-10] * [**200**– 10] + 20= 100
$I_{(1,1)}$ = [100-20 / 200-10] * [**90** – 10] + 20=53.68
$I_{(1,2)}$ = [100-20 / 200-10] * [**60** – 10] + 20= 41.05
$I_{(2,0)}$ = [100-20 / 200-10] * [**100** – 10] + 20= 57.89
$I_{(2,1)}$ = [100-20 / 200-10] * [**150** – 10] + 20= 78.94
$I_{(2,2)}$ = [100-20 / 200-10] * [**10** – 10] + 20= 20

$$\begin{bmatrix} 45 & 66 & 49 \\ 100 & 53 & 41 \\ 57 & 78 & 20 \end{bmatrix}$$

Example: Apply histogram slide for the following sub image, where OFFSET= 10 :

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

Solution:

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

$$\begin{bmatrix} 17 & 22 & 18 \\ 30 & 19 & 16 \\ 20 & 25 & 11 \end{bmatrix}$$

Histogram equalization

Histogram equalization: is a technique for adjusting image intensities to enhance **contrast**.

Histogram equalization often produces unrealistic effects in photographs; however, it is very useful for scientific images like thermal, satellite or x-ray images. To find the histogram equalization must follow:

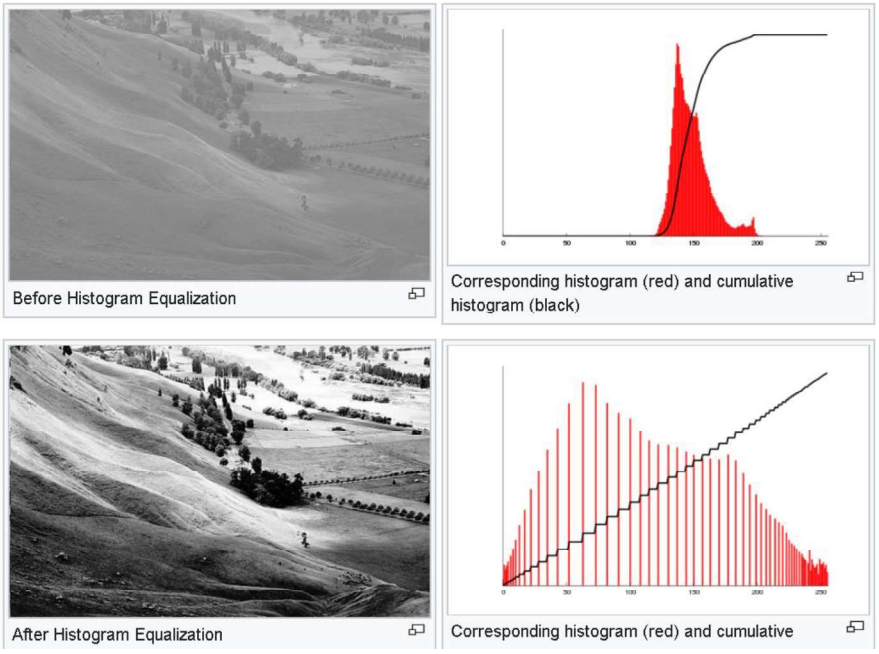
1- Count the total number of pixels associated with each pixel intensity.

2- Cumulative distribution function (CDF)

3- Calculate as transformation function

$$h(v) = \text{round}\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - 1} \times (L - 1)\right)$$

- cdf_{min} is the minimum non-zero value of the cumulative distribution function.
- $M*N$ gives the image's number of pixels.
- L is the number of grey levels used (in most cases 256)



Example:

Apply histogram equalization for the following sub image, where image is gray scale :

$$\begin{bmatrix} 50 & 55 & 150 & 150 \\ 51 & 50 & 55 & 55 \\ 70 & 80 & 90 & 100 \\ 50 & 55 & 70 & 80 \end{bmatrix}$$

Solution:

$$h(v) = \text{round}\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - 1} \times (L - 1)\right)$$

M*N = 4 * 4 = 16***L*** = 256 (because its gray scale)

cdf_{min} = **3**

$$h(50) = round\left(\frac{3-3}{16-1}\right) * (255-1) = 0$$

$$h(51) = round\left(\frac{4-3}{16-1}\right) * (255-1) = 17$$

$$h(55) = round\left(\frac{8-3}{16-1}\right) * (255-1) = 85$$

$$h(70) = round\left(\frac{10-3}{16-1}\right) * (255-1) = 119$$

$$h(80) = round\left(\frac{12-3}{16-1}\right) * (255-1) = 153$$

$$h(90) = round\left(\frac{13-3}{16-1}\right) * (255-1) = 170$$

$$h(100) = round\left(\frac{14-3}{16-1}\right) * (255-1) = 187$$

$$h(150) = round\left(\frac{16-3}{16-1}\right) * (255-1) = 221$$

Pixel Intensity	Count	Cdf_r	$H(r)$
50	3	3	**0**
51	1	4	**17**
55	4	8	**85**
70	2	10	**119**
80	2	12	**153**
90	1	13	**170**
100	1	14	**187**
150	2	16	**221**

$$\begin{bmatrix} 0 & 85 & 221 & 221 \\ 17 & 0 & 85 & 85 \\ 119 & 153 & 170 & 187 \\ 0 & 85 & 119 & 153 \end{bmatrix}$$