Histogram Equalization

Is a popular technique 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 a cross a wide rang 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 can not 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: Create t a running sum of histogram values. $S_k = \sum_{j=0}^{k} P_j$ where p_j is number of image pixel at gray level j.

$$S_0 = \sum_{j=0}^{0} P_j$$

$$S_1 = \sum_{j=0}^{1} P_j = 10 + 8 = 18$$

$$S_2 = 10 + 8 + 9 = 27$$

$$S_3 = 10 + 8 + 9 + 2 = 29$$

$$S_4 = 10 + 8 + 9 + 2 + 14 = 43$$

$$S_5 = 10 + 8 + 9 + 2 + 14 + 1 = 44$$

$$S_6 = 10 + 8 + 9 + 2 + 14 + 1 + 5 = 49$$

$$S_7 = 10 + 8 + 9 + 2 + 14 + 1 + 5 + 2 = 51$$

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.

$$\frac{S_i}{51}$$

$$\frac{10}{51}, \frac{18}{51}, \dots\dots\dots\dots, \frac{51}{51}$$

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.

Original Gray-levels	Histogram Equalization value
0	1
1	2
2	4
3	4
4	6
5	6
6	7
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.
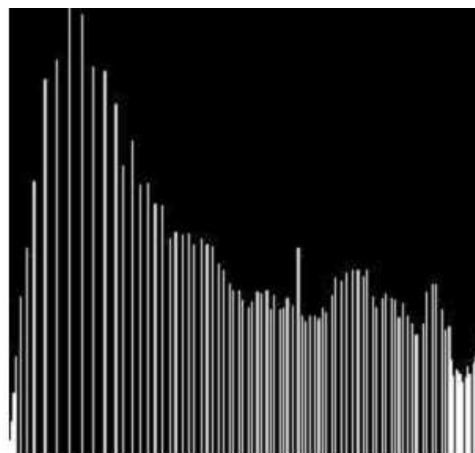

Original image

Histogram of original image

Image after histogram equalization

Histogram after equalization

original image

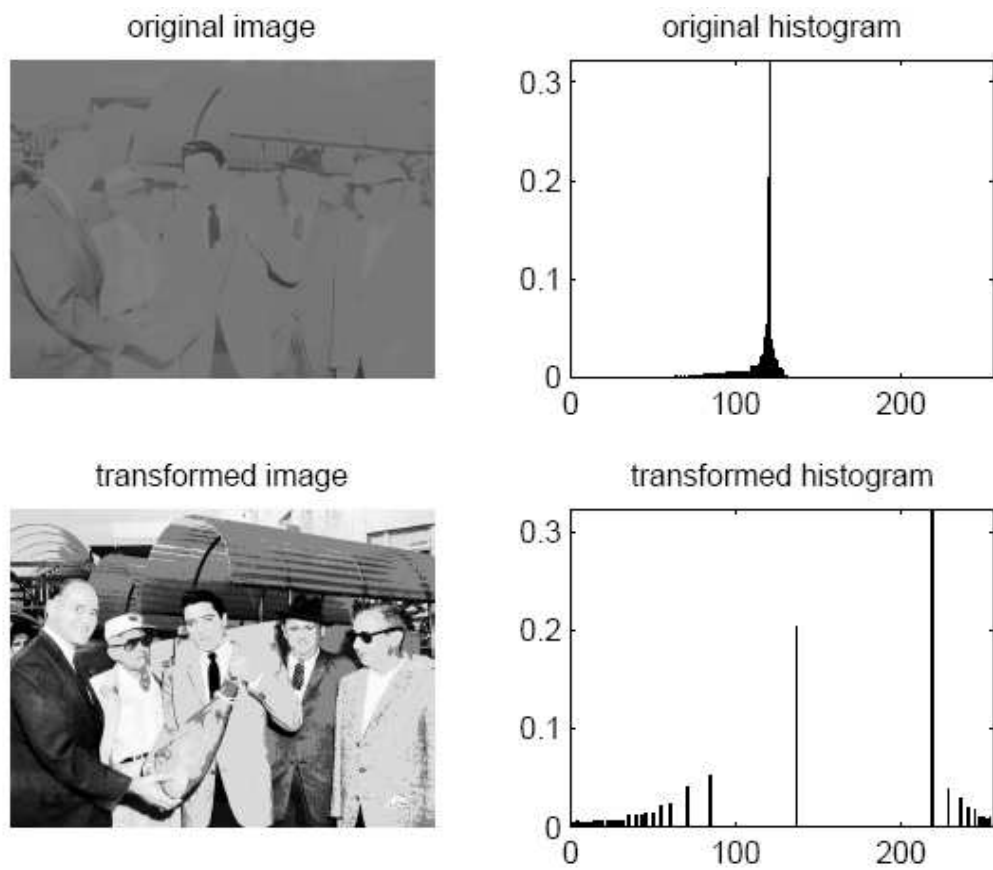original histogram

transformed image

transformed histogram

Figure 1: Histogram equalization applied to low contrast image