University of Al-Hamdaniya
Computer Science Department
Digital image processing

Histogram Equalization

Lec-10

By

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Histogram Equalization

- It 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 .
- It is a technique where the histogram of the resultant image is as **flat** as possible.
- The **results 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.**

Histogram Equalization

For continuous function , the intensity (Gray level) in an image may be viewed as a random variable with its probability density function (PDF). the PDF at a Gray level (r) represents the expected proportion (likelihood) of occurrence of Gray level (r) in the image. a transformation function has the form:

$$s = T(r) = (L-1)\int_0^r p_r(w)\,dw$$

Where (w) is a variable of integration. the right side of this equation is called the cumulative distribution function (CDF) of random variable (r). for discrete Gray level values, we deal with **probabilities** (histogram values) and **summations** instead of **probity density function** and **integrals**.

Histogram Equalization

The transform will be :

$$s_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j) = (L-1)\sum_{j=0}^{k} \frac{n_j}{M \times N}$$

$$= \frac{(L-1)}{M \times N}\sum_{j=0}^{k} n_j \qquad k = 0,1,2,\dots,L-1$$

- This transformation is called histogram equalization or histogram linearization

Histogram Equalization

Example

suppose that a **3-bit image (L=8)** of **size 64 x 64 pixels** has the Gray level (intensity) distribution shown in the table below

r_k	n_k
$r_0 = 0$	790
$r_1 = 1$	1023
$r_2 = 2$	850
$r_3 = 3$	656
$r_4 = 4$	329
$r_5 = 5$	245
$r_6 = 6$	122
$r_7 = 7$	81

Perform histogram equalization on this image , and draw its normalized histogram, transformation function , and the histogram of the equalized image

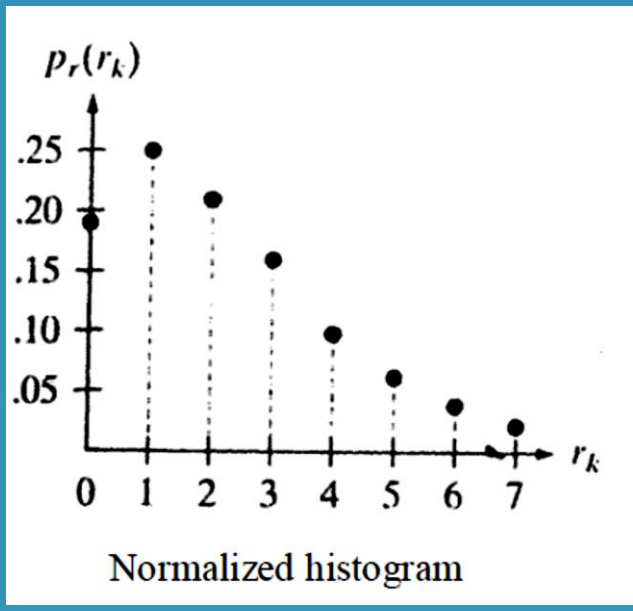
Histogram Equalization

Solution :

M x N = 4096

We compute the normalized histogram

r_k	n_k	$p_r(r_k) = n_k/MN$
$r_0 = 0$	790	0.19
$r_1 = 1$	1023	0.25
$r_2 = 2$	850	0.21
$r_3 = 3$	656	0.16
$r_4 = 4$	329	0.08
$r_5 = 5$	245	0.06
$r_6 = 6$	122	0.03
$r_7 = 7$	81	0.02

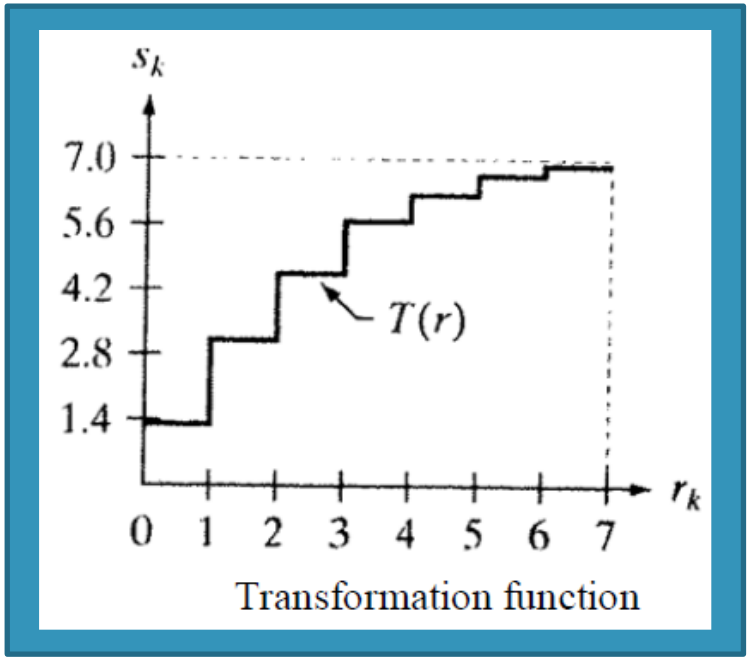


Normalized histogram

Histogram Equalization

Then we find the transformation function

$$s_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j)$$



$$s_0 = T(r_0) = 7\sum_{j=0}^{0} p_r(r_j) = 7p_r(r_0) = 1.33$$

$$s_1 = T(r_1) = 7\sum_{j=0}^{1} p_r(r_j) = 7p_r(r_0) + 7p_r(r_1) = 3.08$$

and $s_2 = 4.55, s_3 = 5.67, s_4 = 6.23, s_5 = 6.65, s_6 = 6.86, s_7 = 7.00$

Histogram Equalization

We round the values of s to the nearest integer

$$s_0 = 1.33 \rightarrow 1 \qquad s_1 = 3.08 \rightarrow 3 \qquad s_2 = 4.55 \rightarrow 5$$

$$s_3 = 5.67 \rightarrow 6 \qquad s_4 = 6.23 \rightarrow 6 \qquad s_5 = 6.65 \rightarrow 7$$

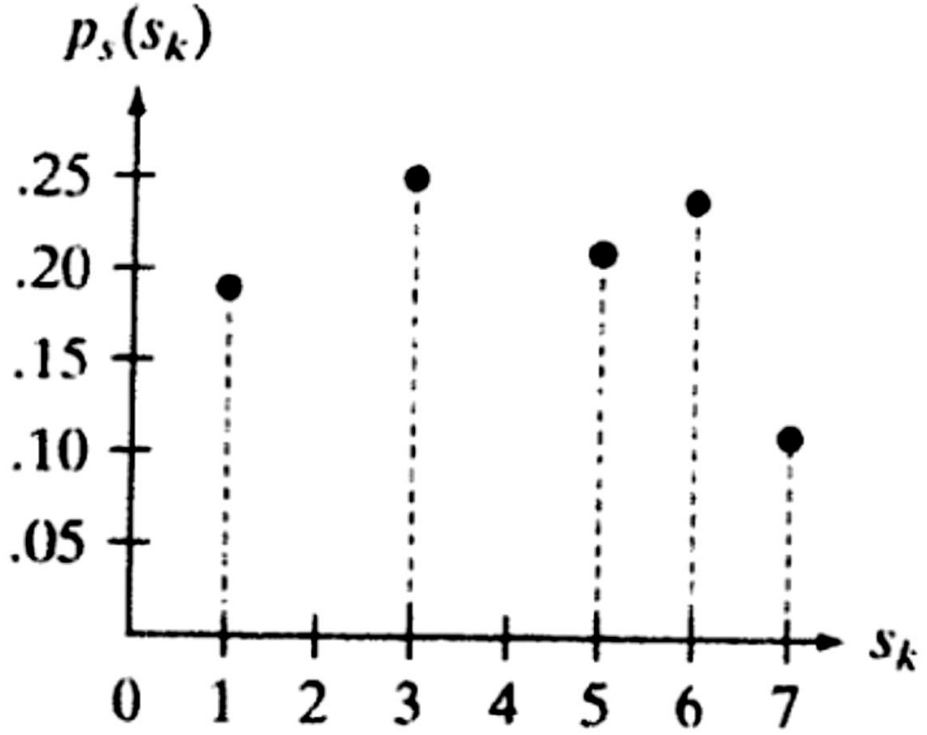
$$s_6 = 6.86 \rightarrow 7 \qquad s_7 = 7.00 \rightarrow 7$$

These are the values of the equalized histogram. Note that there are only five Gray levels.

r_k	n_k	s_k	$New\ n_k$	$p_s(s_k) = New\ n_k/MN$
$r_0 = 0$	790	$s_0 = 1$	790	0.19
$r_1 = 1$	1023	$s_1 = 3$	1023	0.25
$r_2 = 2$	850	$s_2 = 5$	850	0.21
$r_3 = 3$	656	$s_3 = 6$	985	0.24
$r_4 = 4$	329	$s_4 = 6$		
$r_5 = 5$	245	$s_5 = 7$	448	0.11
$r_6 = 6$	122	$s_6 = 7$		
$r_7 = 7$	81	$s_7 = 7$		

Histogram Equalization

Thus, **the histogram of the equalized** image can be drawn as follows:



Histogram of equalized image

Histogram Equalization

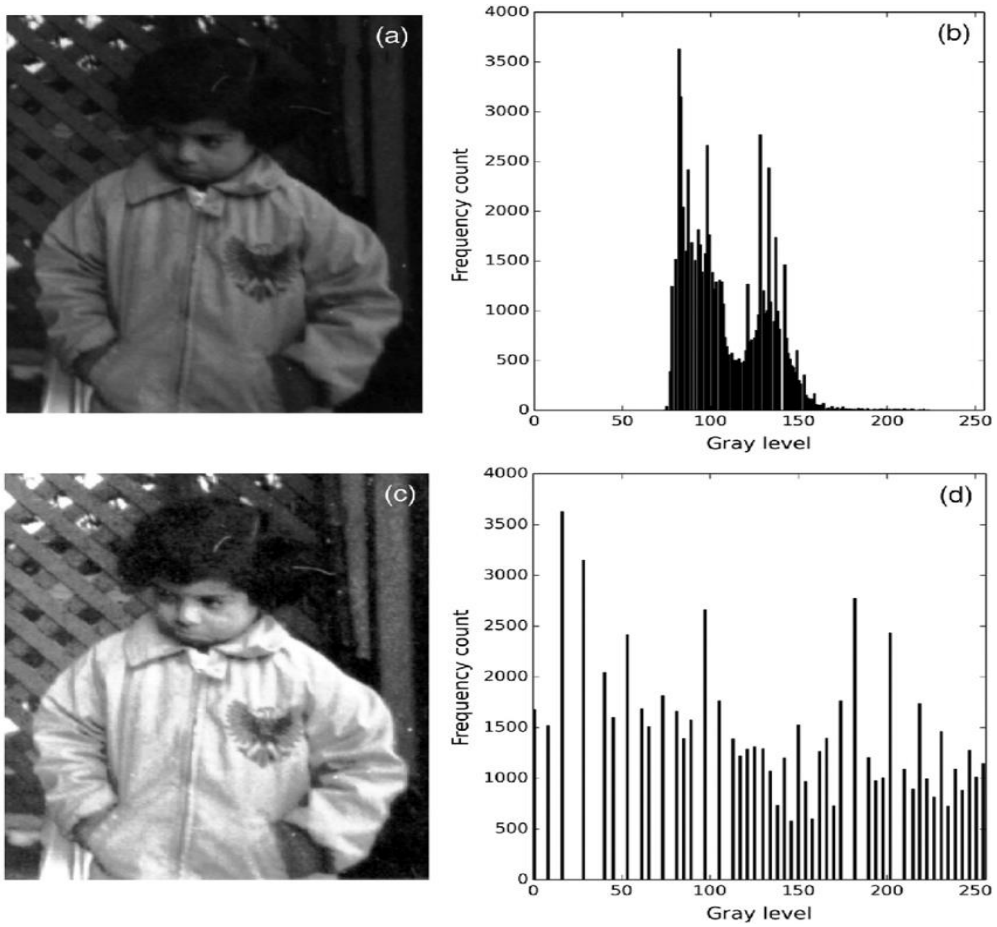


Figure of histogram equalization : (a) The input image and (b) its graylevel histogram, which shows that the graylevel distribution is concentrated in a small range. Although histogram equalization (HE) improves the overall contrast of the image, (c) by distributing the pixel values more uniformly over the available graylevel range, (d) some image regions are clearly overenhanced.

End of Lecture