Histogram Equalization

Histogram equalization is a technique which consists of adjusting the gray scale of the image so that the graylevel histogram of the input image is mapped on to a uniform histogram. The histogram equalization technique is based on a transformation using the histogram of a complete image in histogram equalization the goal is to obtain a uniform histogram for the output image. Let the variable *r* represents a random variable which indicates the gray level of an image. Initially we can assume that *r* is continuous and lies with in the closed interval [0:1] with *r=0* representing black and *r=1* representing white. For any *r* in the specified interval let us consider a transformation of the form: $s = T(r)$

The transformation produces a level *s* for every pixel value *r* in the original image.

To find the uniform histogram apply the following steps:

1. normalized the graylevels of the image by:

   $r_k = \frac{g_k}{L}$ *where: g_k: represent graylevel , L : maximum of graylevel*

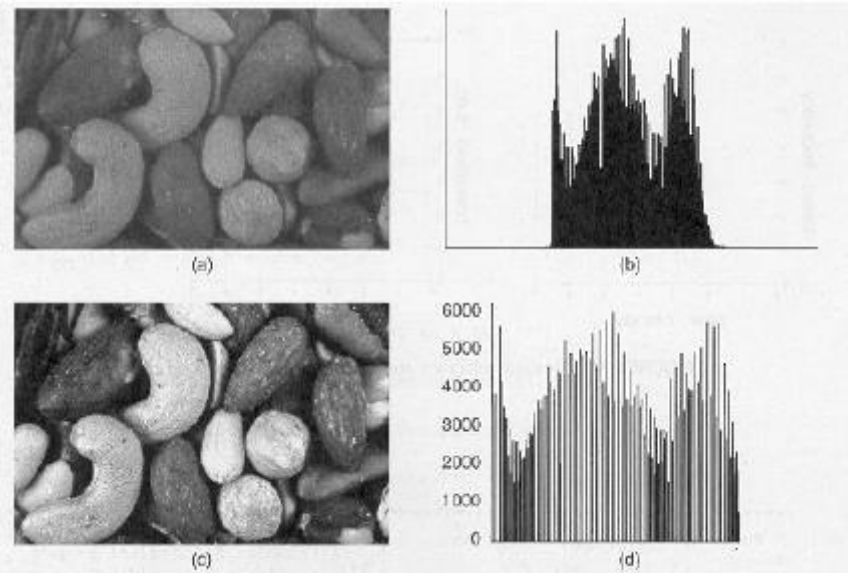
2. find the probability of each gray level of the image by calculate the occurrence of each one using the following equation

   $P_r(r_k) = n_k / n \qquad 0 \le r_k \le 1 \qquad k=0,1,\ldots\ldots,L$

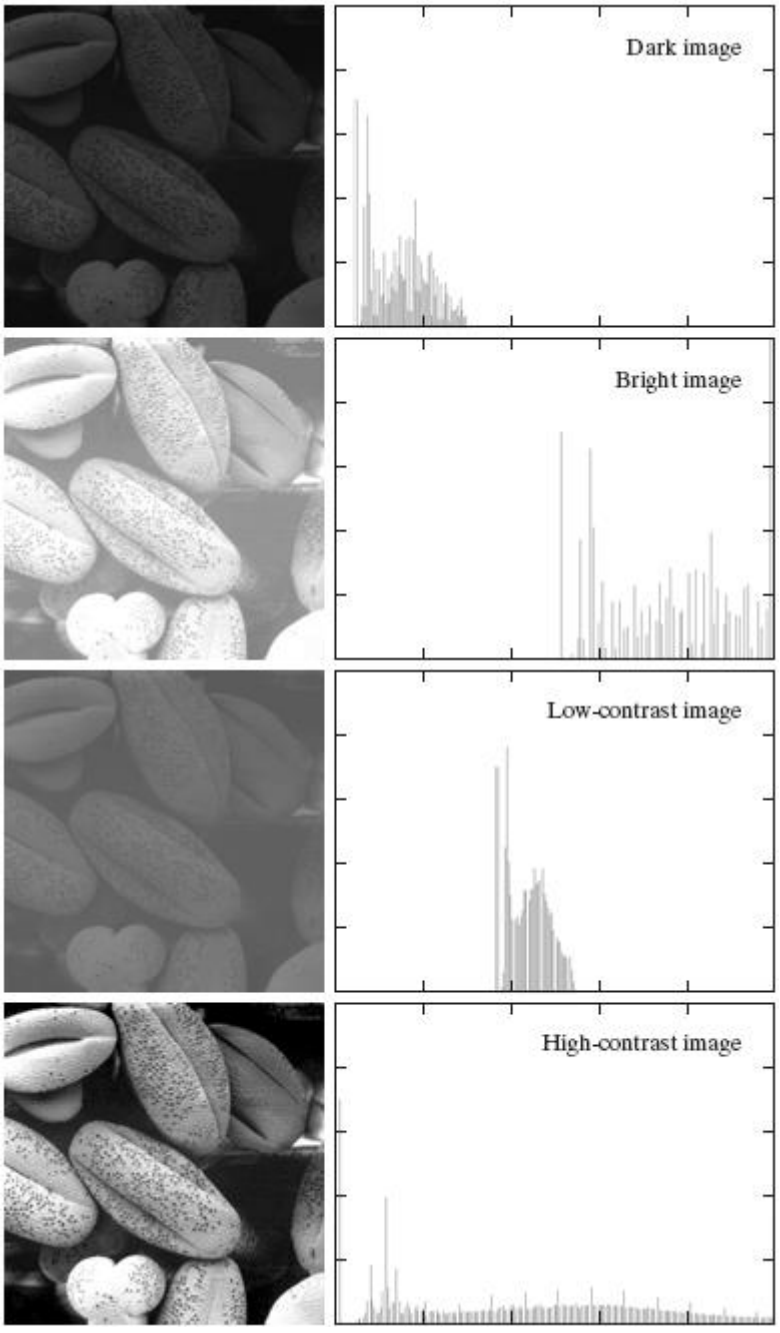
   n_k: represent occurrence of each r_k.
   n: number of total pixel in the image.

3. to find the new graylevel using the following equation:

   $$S_k = T(r_k) = \sum_{j=0}^{k} n_j / n = \sum_{j=0}^{k} P_r(r_j)$$



(a) Original image; (b) Histogram of original image; (c) Equalized image; (d) Histogram of equalized image.



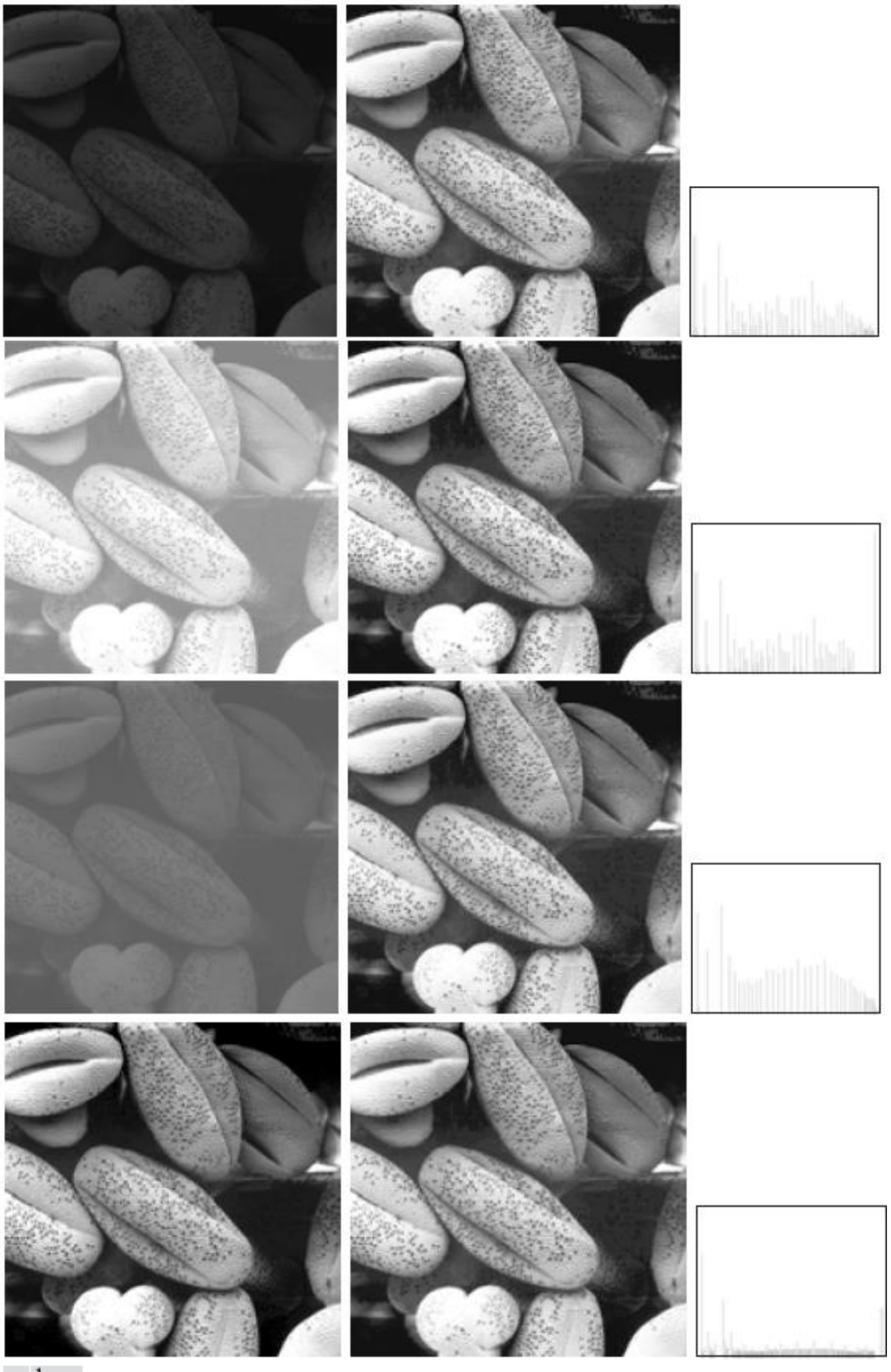


Figure: (a) Original Images (b) Results of histogram equalization (c) Corresponding histograms

Example: Suppose that a 64*64 , 8-level image has the gray-level distribution:

r_k	n_k	$P_r(r_k)=n_k/n$	$S_k=\sum_{j=0}^{k}P_r(r_j)$	S on 8level: closest valid level(s_k*L)
r_0=0	790	0.19	0.19	0.19*7=1.33=1/7
r_1=1/7	1023	0.25	0.44	0.44*7=3.08=3/7
r_2=2/7	850	0.21	0.65	0.65*7=4.55=5/7
r_3=3/7	656	0.16	0.81	0.81*7=5.67=6/7
r_4=4/7	329	0.08	0.89	0.89*7=6.23=6/7
r_5=5/7	245	0.06	0.95	0.95*7=6.65=7/7
r_6=6/7	122	0.03	0.98	0.98*7=6.86=7/7
r_7=1	81	0.02	1.00	1*7=7=7/7
	n=4096	1.00		

$$S_0=T(r_0)=\sum_{j=0}^{0}P_r(r_j)=p_r(r_0)=0.19$$

$$S_1=T(r_1)=\sum_{j=0}^{1}P_r(r_j)=p_r(r_0)+p_r(r_1)=0.19+0.25=0.44$$

s_k*L	n_k	$p_s(s_k)$
1/7	790	0.19
3/7	1023	0.25
5/7	850	0.21
6/7	656+329=985	0.24
7/7	245+122+81=448	0.11