Histogram Processing
直方图处理

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Contents

Histogram

1. The definition of histogram:

$$h(r_k) = n_k \quad k = 0, 1, ..., L-1$$

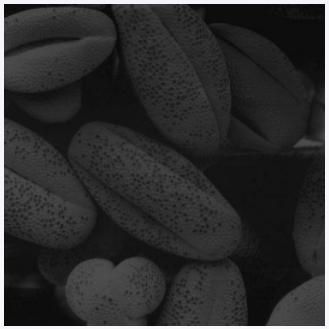
where r_k is the kth intensity value and n_k is the number of pixels in the image with intensity r_k.

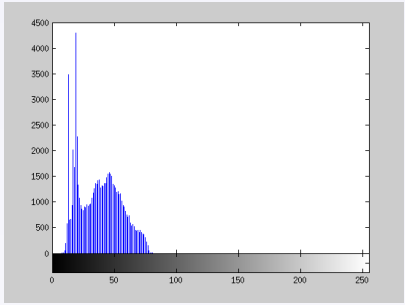
2. Normalize a hitstogram:

$$p(r_k) = \frac{n_k}{MN} \quad k = 0, 1, ..., L-1$$

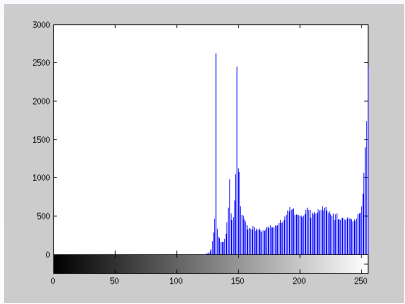
$p(r_k)$ is the probability of occurrrnce of intensity level r_k in an image.The sum of all components of a normalized histogram is equal to 1.

Four basic image types and their correponding histograms



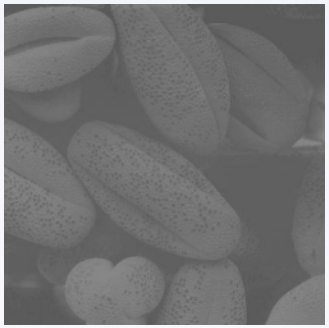


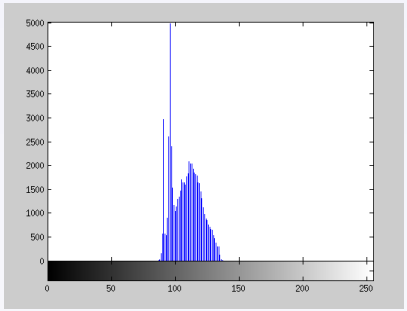
dark image



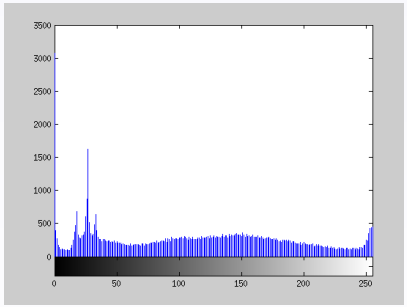
light image

Four basic image types and their correponding histograms





low contrast image



high contrast image

Transformations

Transformations(intensity mappings)of the form:

$$s = T(r) \quad 0 \leq r \leq L-1 \tag{1}$$

(a) $T(r)$is a monotonically increasing function in the interval $0 \leq r \leq L-1$.
(b)$0 \leq T(r) \leq L-1$ for $0 \leq r \leq L-1$.

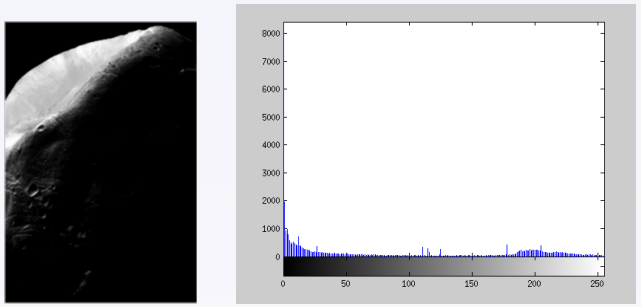
Histogram Equalization

$$s_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j) \tag{2}$$

$$= \frac{(L-1)}{MN}\sum_{j=0}^{k} n_j \quad k = 0, 1, 2..., L-1$$

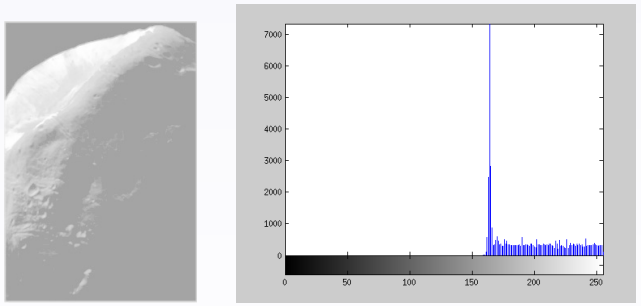
a processed image is obtained by mapping rach pixel in the input image with intensity r_k into a corresponding pixel with level s_k in the output image,using(2).The transformation $T(r_k)$ in this equation is called a *histogram equalization*.

Result



(a) (b)

(a)Origin image.(b)Histogram of (a).



(a) (b)

(c)Histogram-equalized image.(d)Histogram of (c).

Histogram Matching

(a)Obtain the values of s by using the histogram equalization transformation:

$$s_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j) \tag{3}$$

$$= \frac{(L-1)}{MN}\sum_{j=0}^{k} n_j \quad k = 0, 1, 2..., L-1$$

(b)Compute all values of the transformation function G using the specified PDF:

$$G(z_q) = (L-1)\sum_{i=0}^{q} p_z(z_i) \tag{4}$$

Histogram Matching

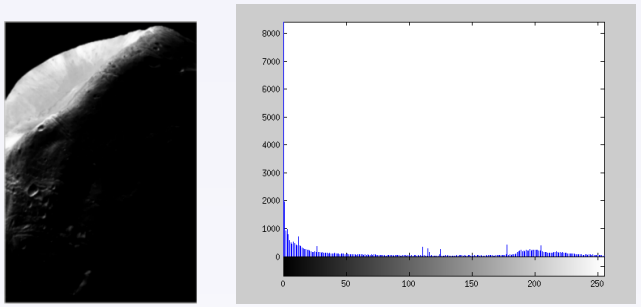
(c)Find the corresponding value ofz_q so that $G(z_q)$ is closest to s_k :

$$G(z_q) = s_k \tag{5}$$

(d)Get the desired value z_q by obtaining the inverse transformation:

$$z_q = G^{-1}(s_k) \tag{6}$$

Result



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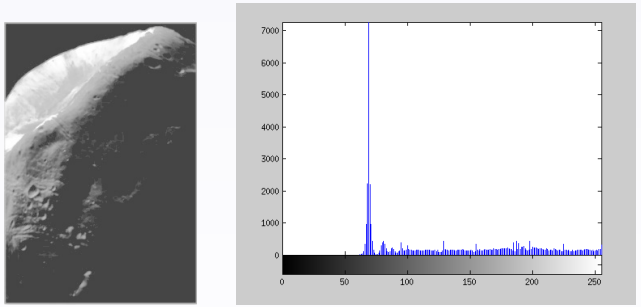
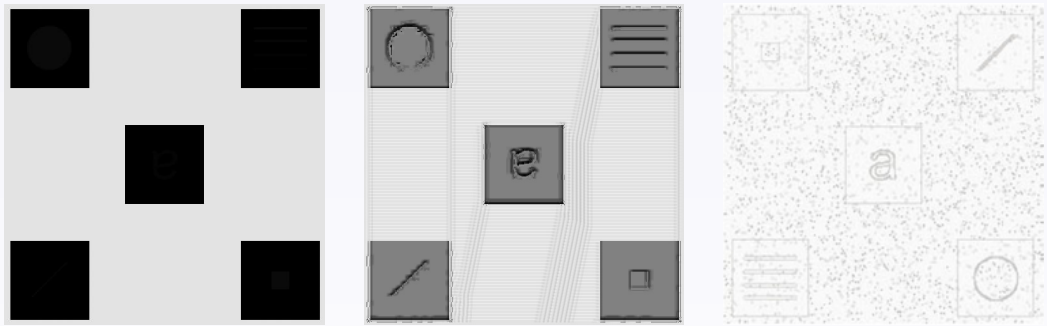


(a) (b)

(c)Histogram-specified image.(d)Histogram of (c).

Local Histogram Equalization

Use local histogram equalization with a neighborhood of size 3×3:



(a) (b) (c)

(a)Origin image.(b)Result of local histogram equalization applied to (a).

Using Histogram Statistics for Image Enhancement

Use local histogram statistics with a neighborhood of size 3×3:

(a) (b) (c)

(a)Origin image.(b)Image enhanced using local histogram statistics.