

# **Intensity-based operations**

# Histogram processing

فرکانس و تکرار  
gray level در تصویر

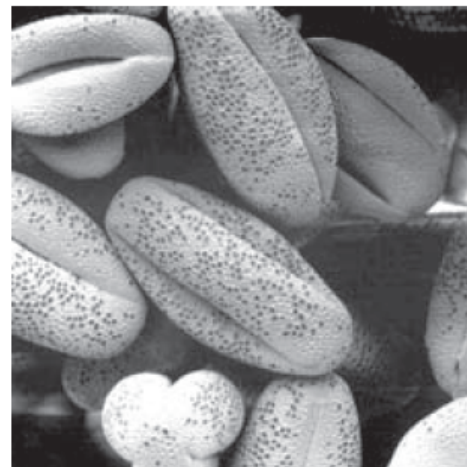
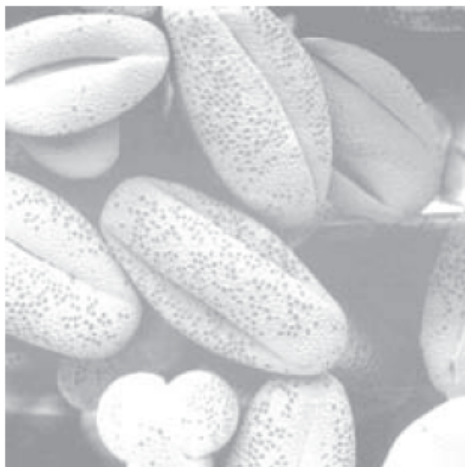
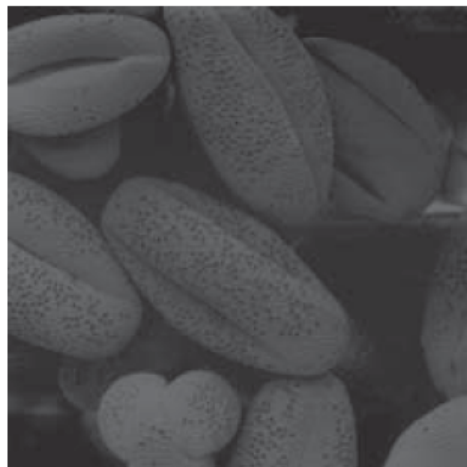
Histogram:  $h(r_k) = n_k$

Gray levels:  $r_k$

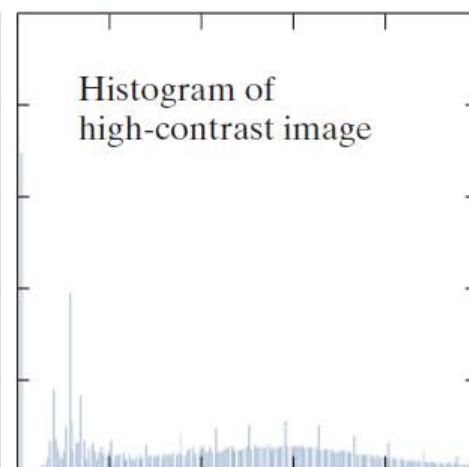
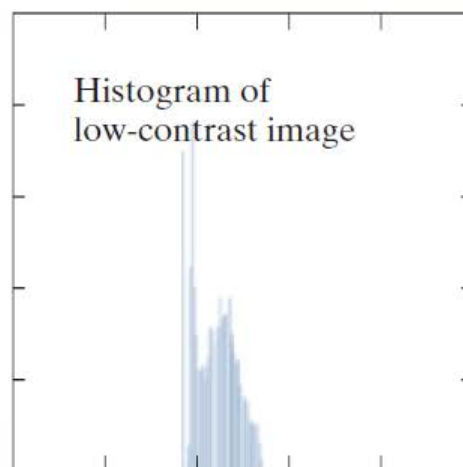
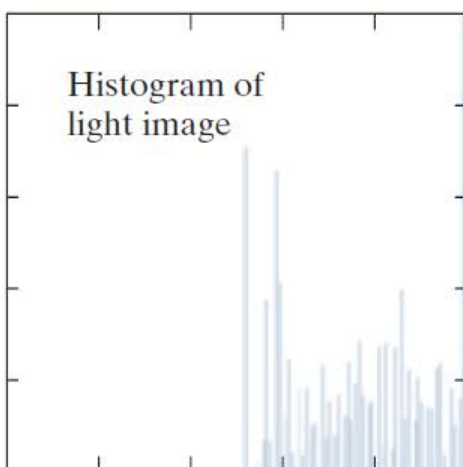
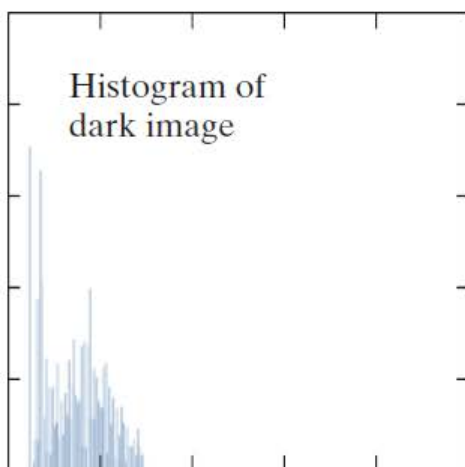
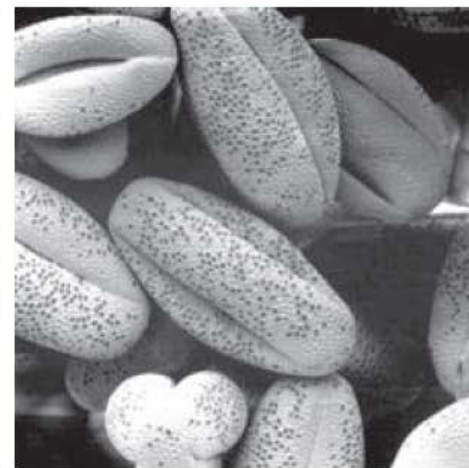
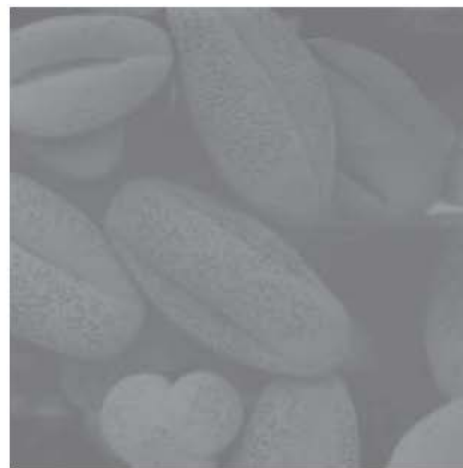
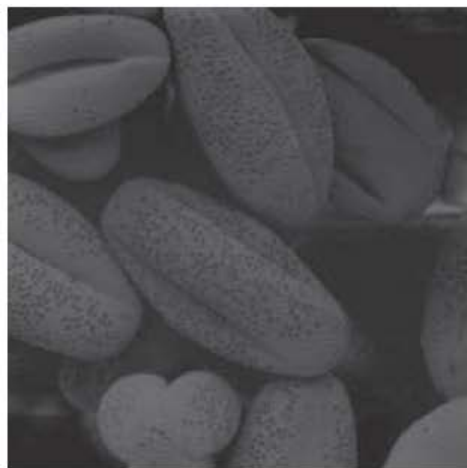
Repetition of each gray level:  $n_k$

Normalized histogram:  $p(r_k) = \frac{n_k}{MN}$

# Histogram processing



# Histogram processing



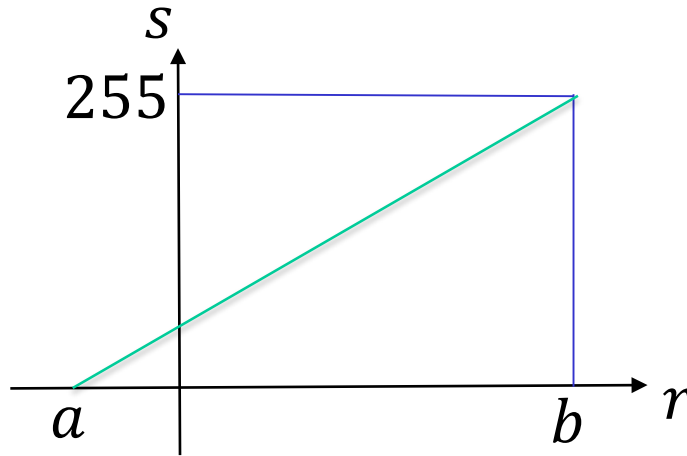
# Contrast stretching

After arithmetic operation pixel intensities could become negative and the range may be different from  $[0, 255]$  for 8-bit representation.

# Contrast stretching

After arithmetic operation pixel intensities could become negative and the range may be different from  $[0, 255]$  for 8-bit representation.

We could use linear scaling:



$$s - 0 = \frac{255 - 0}{b - a} (r - a)$$

روشن‌ها رو تاریک کنه  
تاریک‌ها رو روشن

# Intensity transformation

contrast ↑  
تاریک‌تر  
روشن‌تر

## Image negative:

شدت جدید

$$s = L - 1 - r$$

شدت جدید

## Log:

$$s = c \log_k(1 + r)$$

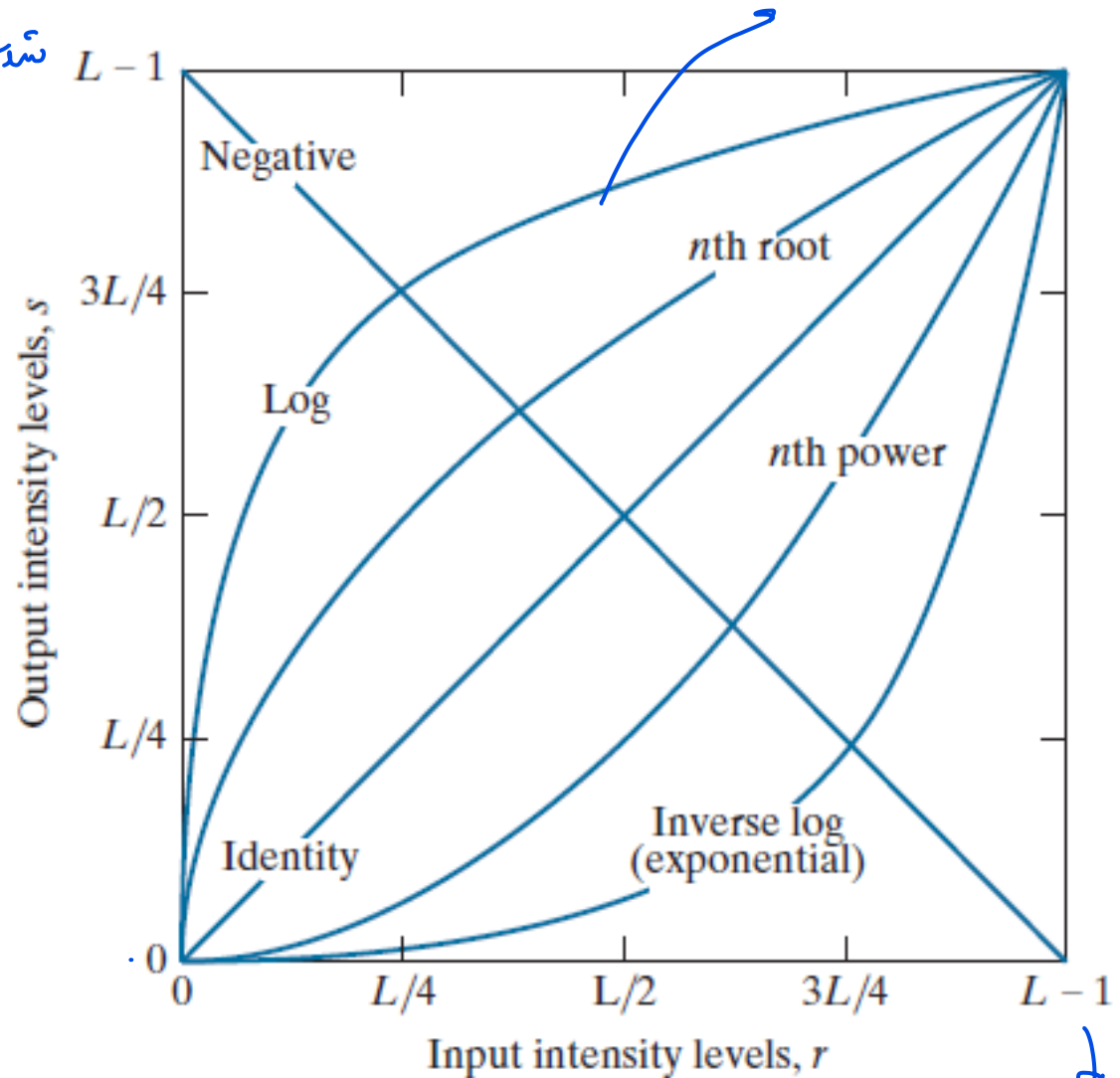
$$s = L - 1$$

$$\Rightarrow c = \frac{L - 1}{\log_k(L)}$$

## Power-law:

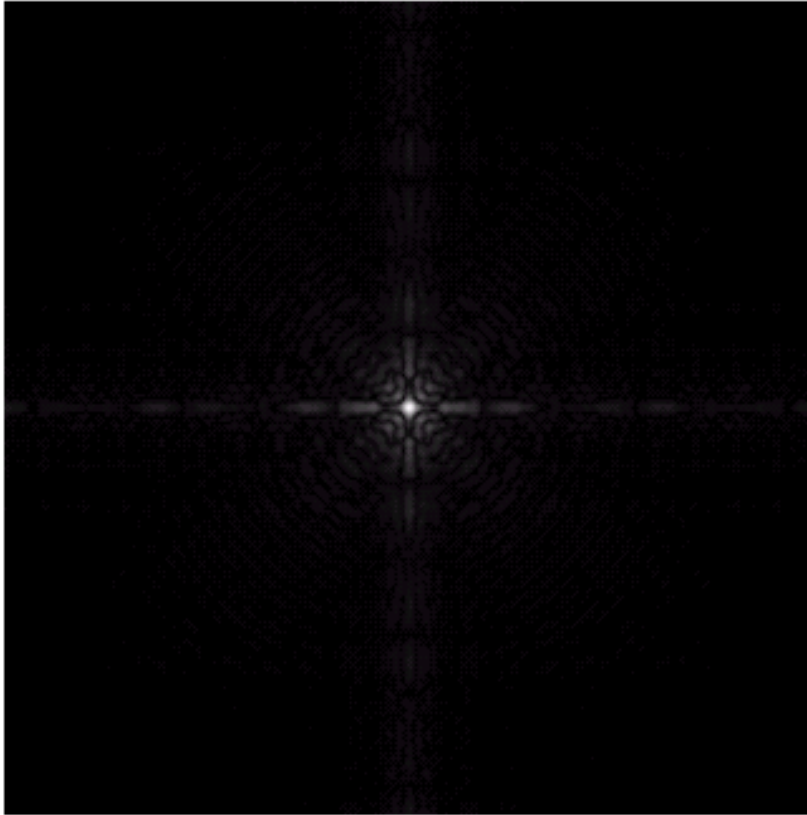
$$s = cr^\gamma$$

$$\Rightarrow c = (L - 1)^{1-\gamma}$$



شدت‌های قبلی

# Log transformation

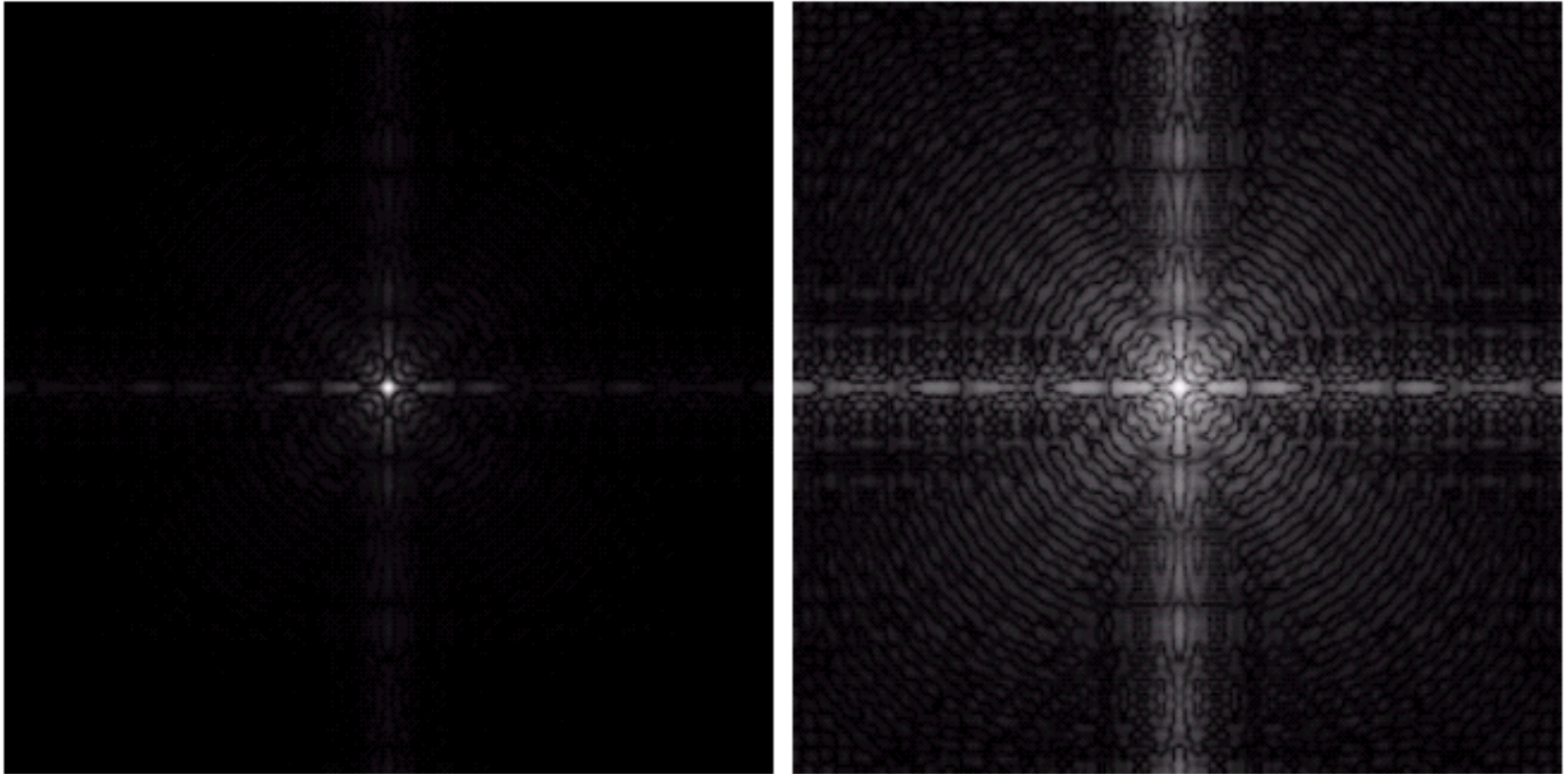


از روش استفاده کنیم  
contrast درست تار یک بزرگ

Fourier spectrum display enhancement using log

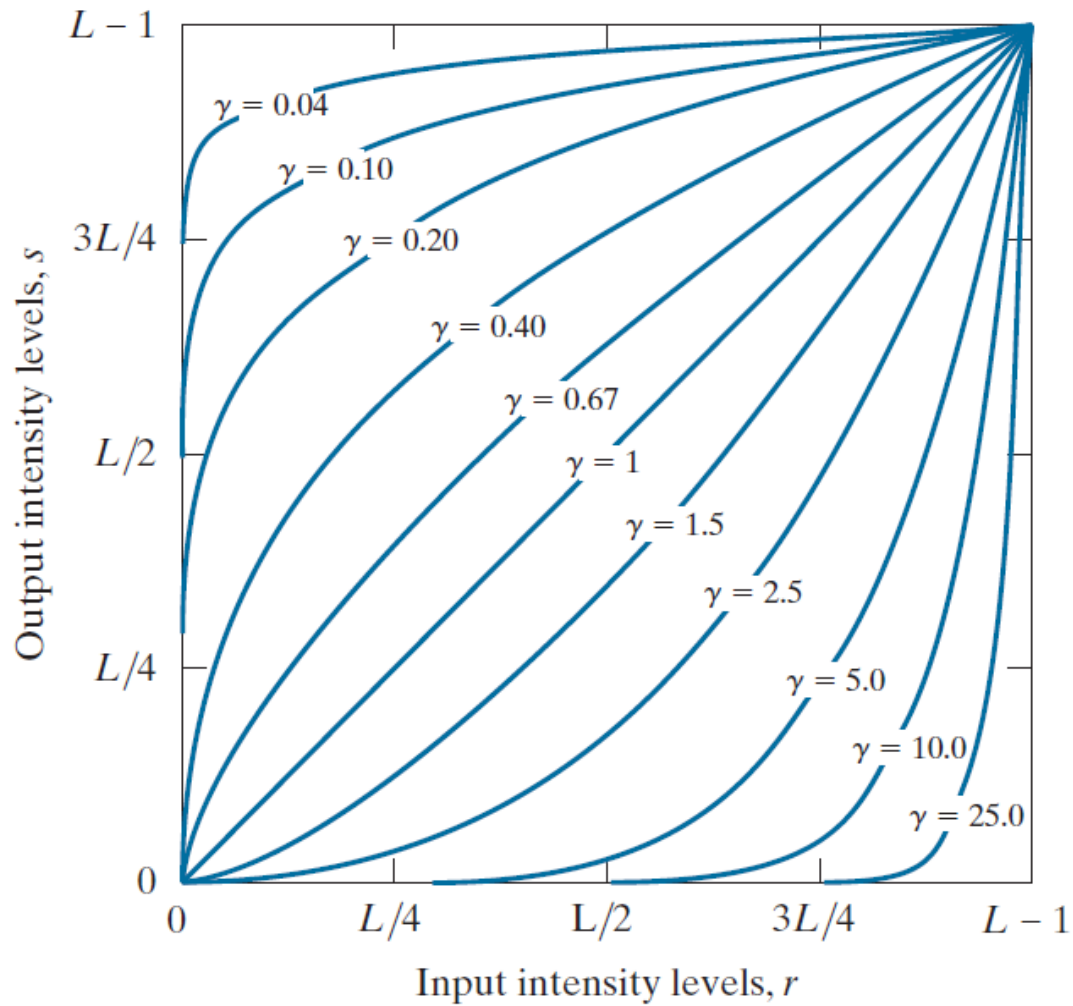


# Log transformation



Fourier spectrum display enhancement using log

# Power law transformation



$$s = cr^\gamma, c = (L-1)^{1-\gamma}$$

# Power law transformation



# Power law transformation

$$\gamma = 2$$

$$c = 2.36\text{E}-10$$

$$\gamma = 10$$

$$c = 2.19\text{E}-22$$



$$\gamma = 0.5$$

$$c = 15.97$$

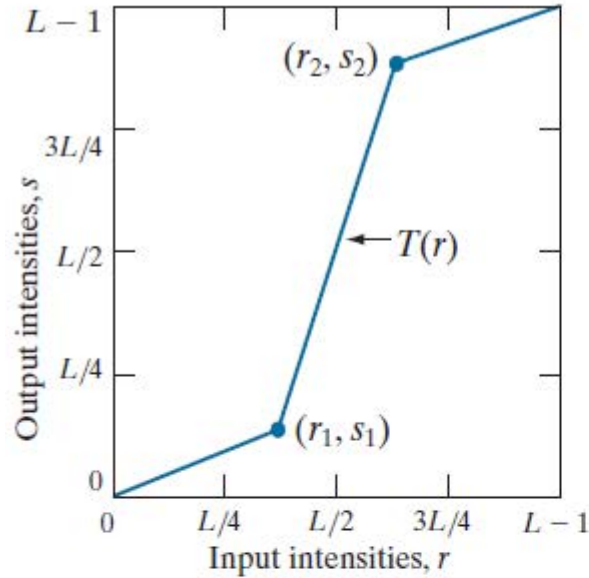
$$\gamma = 0.3$$

$$c = 48.37$$

$$\gamma = 0.2$$

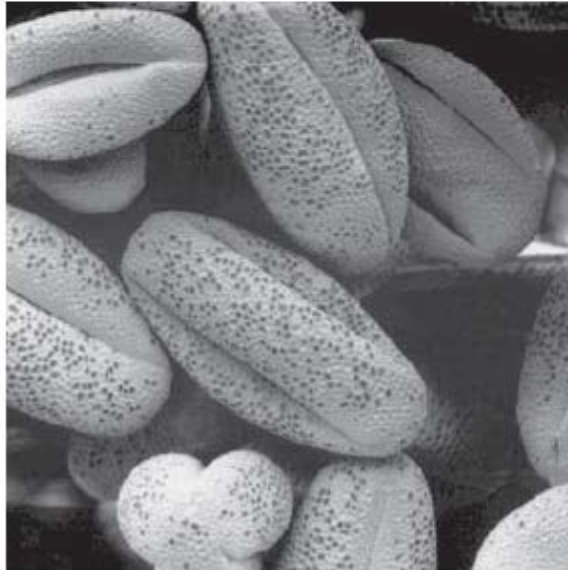
$$c = 84.18$$

# Contrast stretching



تصویر با سبزی

Contrast stretching



$$r_1 = r_2$$

$$s_1 = 0$$

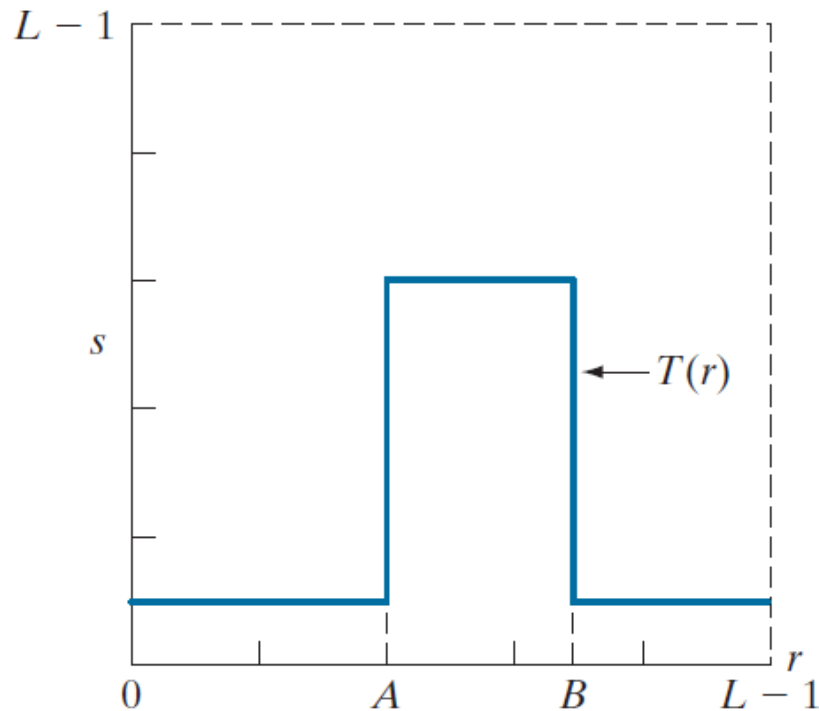
$$s_2 = L - 1$$

Thresholding

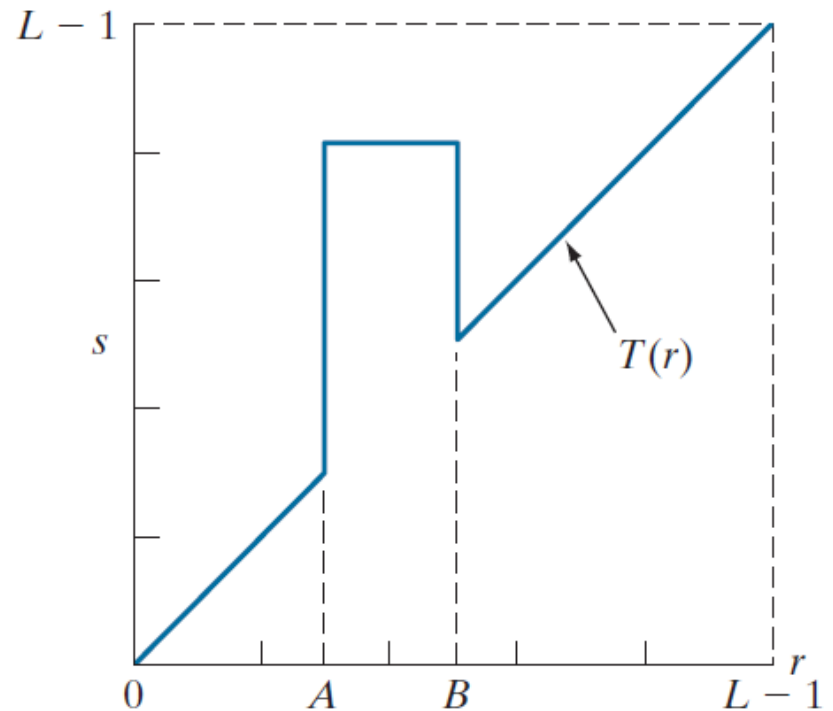
با سبزی از دستکاری و حذف کالیم و بقیه روشهای داریم

# Intensity level slicing

Highlight gray level range  $[A, B]$

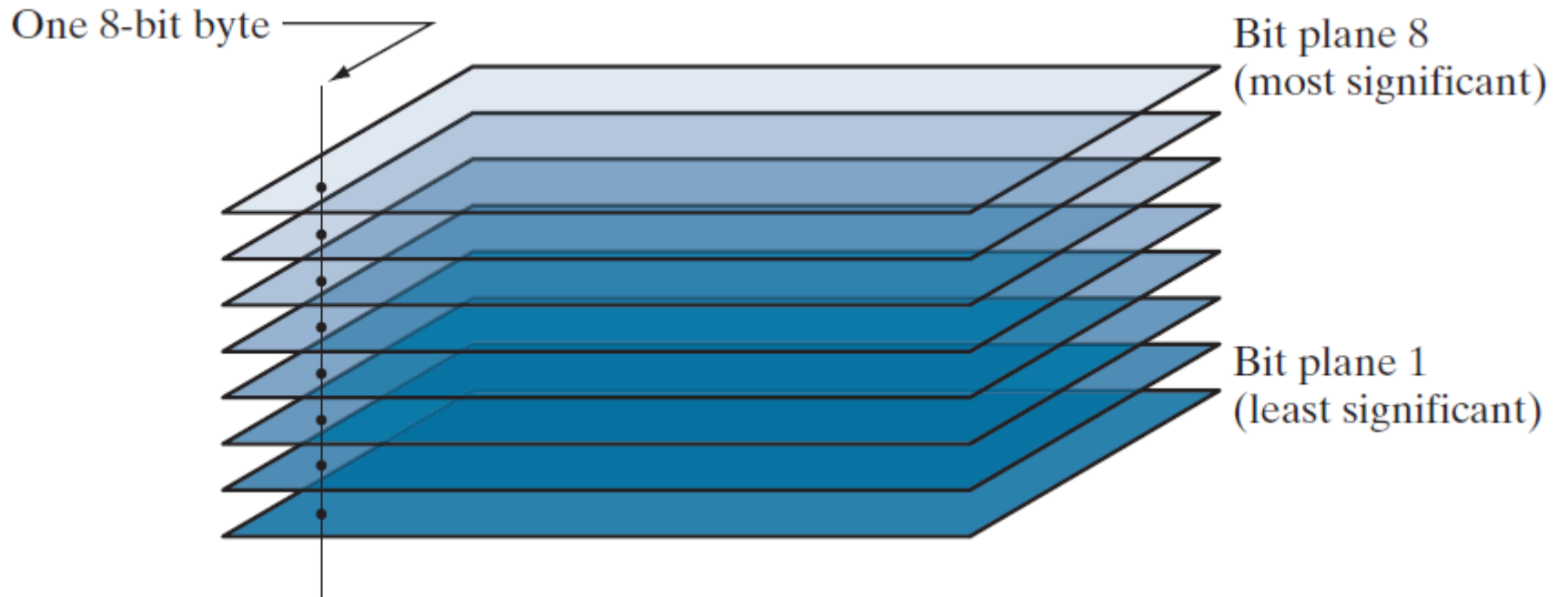


Reduces other gray level



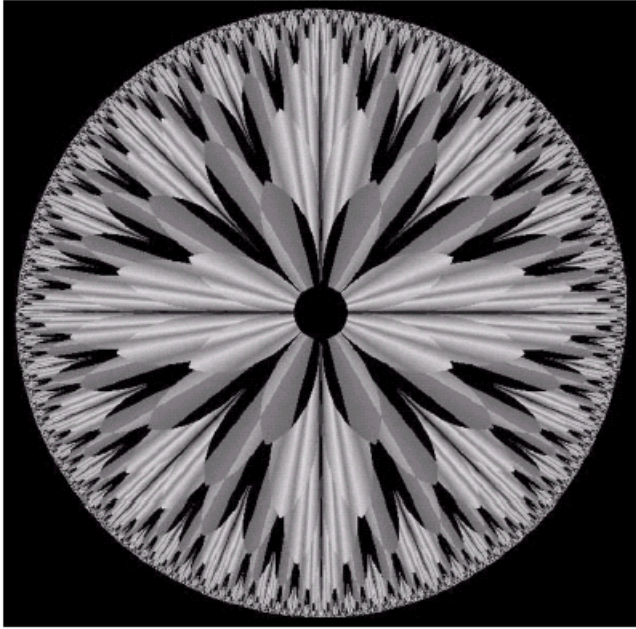
Preserves other gray level

# Bit plane slicing





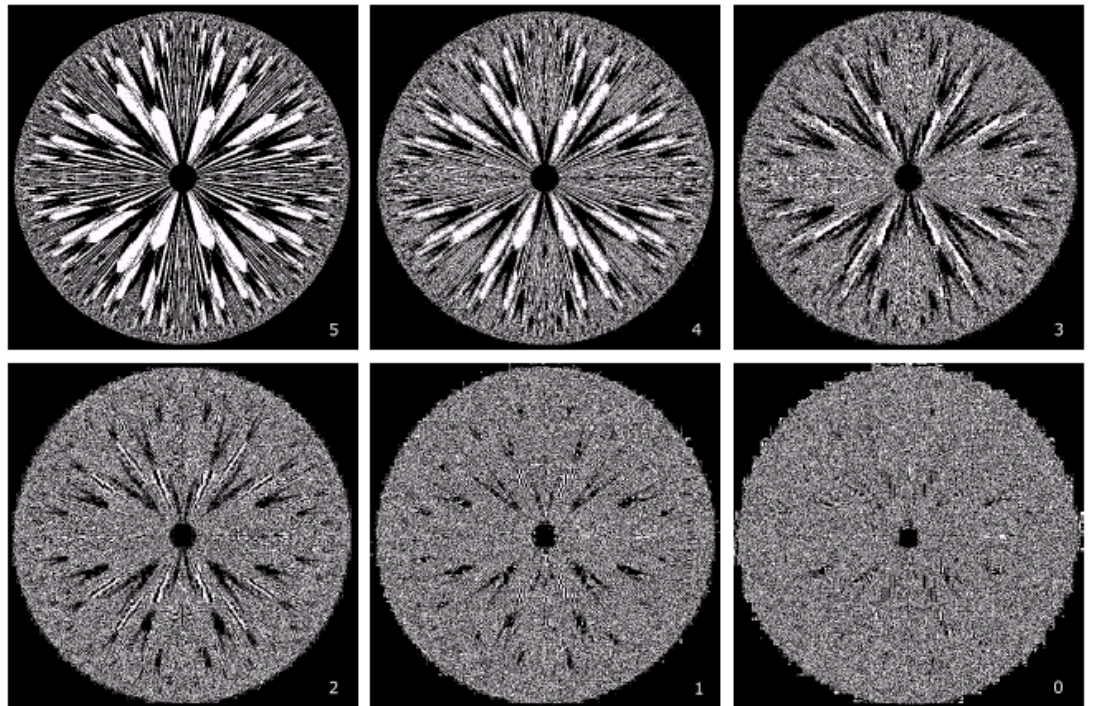
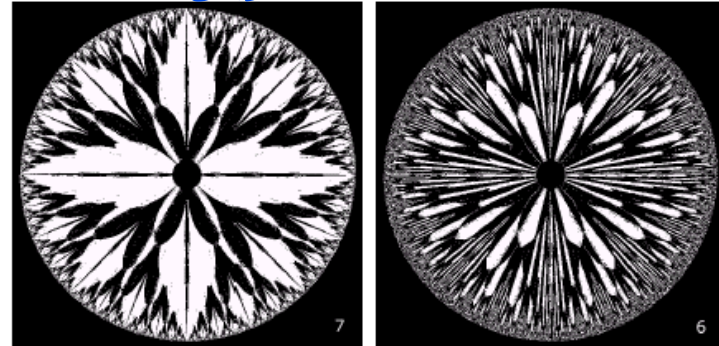
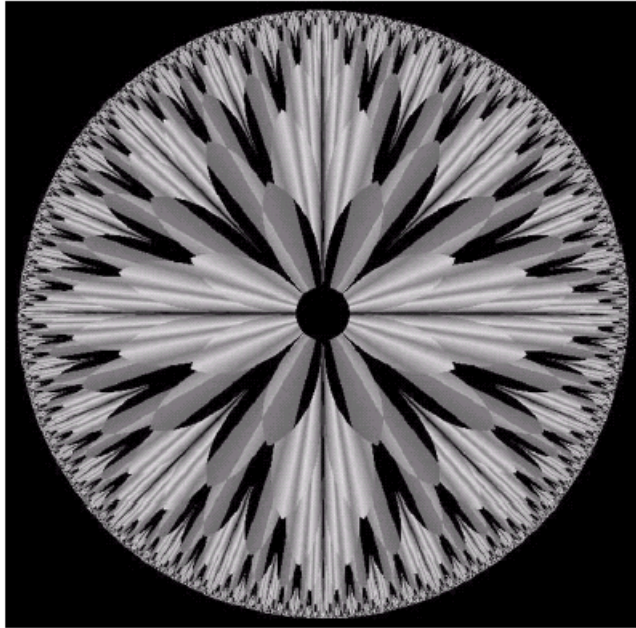
# Bit plane slicing





# Bit plane slicing

MSB



8 bit planes

LSB

# Histogram equalization

نقشه  
یا جدول  
و به این خالی  
بگویند

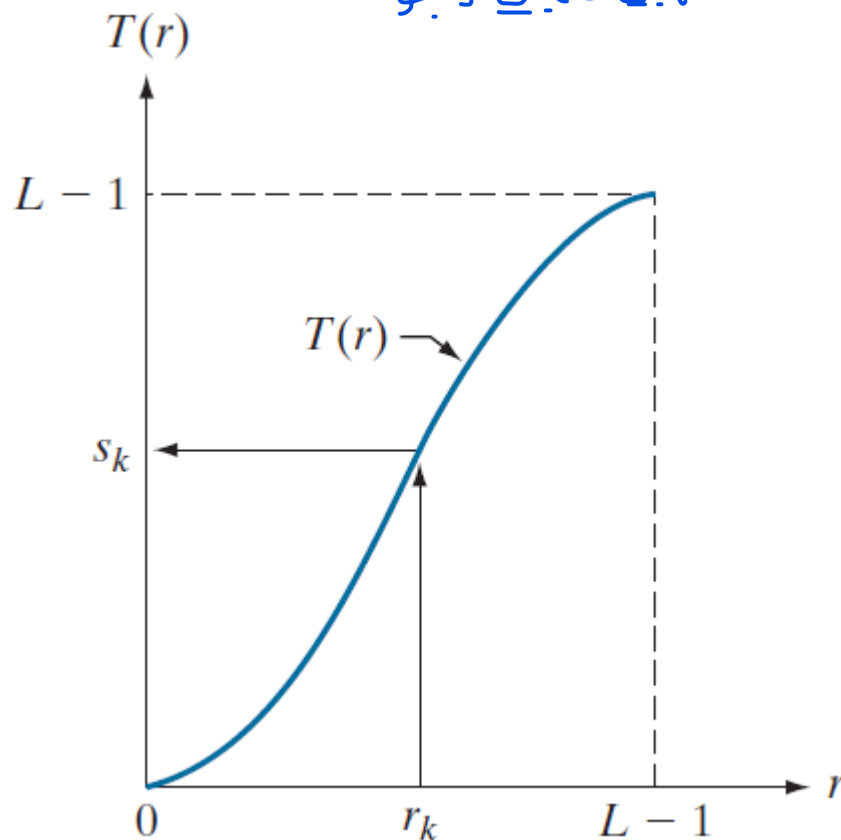
Stretching → map

معمودی ← بالاتر بلاتر بگویند  
پایین تر یا پایین تر بگویند

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

$T(r)$  : Monotonously increasing

$$0 \leq T(r) \leq L - 1$$



صاحبای فضای شدت رو پر کنیم  
(یکنواخت می‌کنیم)  
از تمام سطرها استفاده کنیم

# Histogram equalization

$$p_s(s) = \left| \frac{dr}{ds} \right| p_r(r)$$

نست غلط  
نست جديد

$$s = T(r) = (L - 1) \int_0^r p_r(\omega) d\omega$$

$$\frac{ds}{dr} = \frac{dT(r)}{dr} = (L - 1) \frac{d}{dr} \left[ \int_0^r p_r(\omega) d\omega \right] = (L - 1) p_r(r)$$

$$\begin{aligned} p_s(s) &= p_r(r) \left| \frac{dr}{ds} \right| = p_r(r) \left| \frac{1}{(L - 1) p_r(r)} \right| \\ &= \frac{1}{L - 1} \quad 0 \leq s \leq L - 1 \end{aligned}$$

# Histogram equalization

$$p_r(r) = \begin{cases} \frac{2r}{(L-1)^2} & 0 \leq r \leq L-1 \\ 0 & \text{otherwise} \end{cases}$$

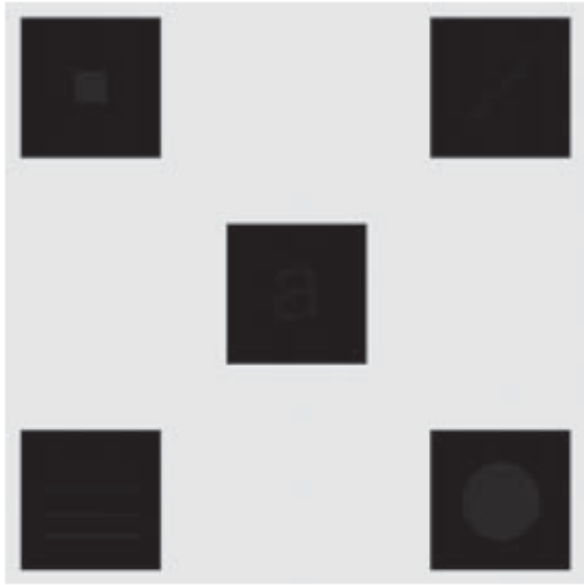
$$\begin{aligned} s = T(r) &= (L-1) \int_0^r p_r(\omega) d\omega = \frac{2}{L-1} \int_0^r \omega d\omega \\ &= \frac{r^2}{L-1} \end{aligned}$$

# Histogram equalization

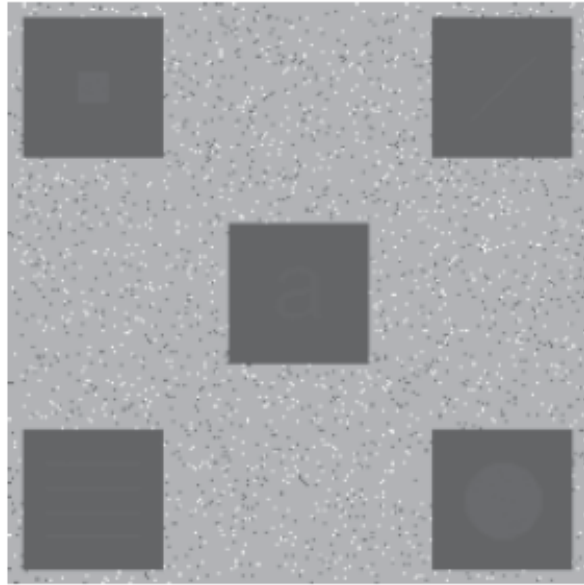
$$p_r(r_k) = \frac{n_k}{MN} \quad k = 0, 1, 2, \dots, L - 1$$

$$s_k = T(r_k) = (L - 1) \sum_{j=0}^k p_r(r_j) = \frac{L - 1}{MN} \sum_{j=0}^k n_j \quad k = 0, 1, 2, \dots, L - 1$$

# Local histogram processing



Original



Global



Local

برای هر سبک، یک تبدیل انجام می‌دهیم.

Local → Location based قواعد دایر

# Histogram statistics

Normalized histogram:  $p(r_i)$

تصویر روشن تر  $\uparrow$  Mean:  $m = \sum_{i=0}^{L-1} r_i p(r_i)$

افزایش شدت  
contrast  $\downarrow$  Variance:  $\sigma^2 = \sum_{i=0}^{L-1} (r_i - m)^2 p(r_i)$