Intensity-based operations

Histogram processing

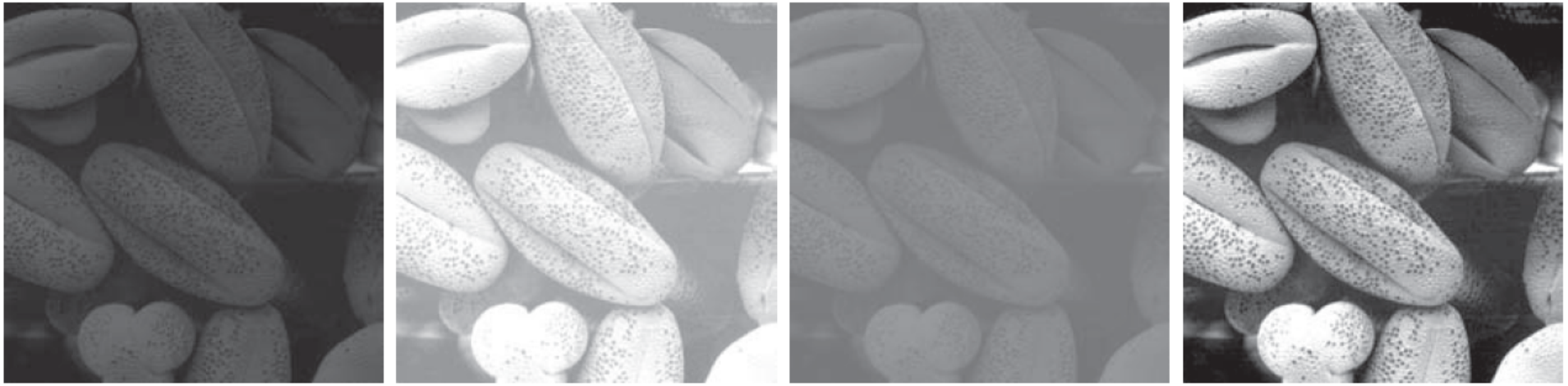
Histogram: $h(r_k) = n_k$

Gray levels: r_k

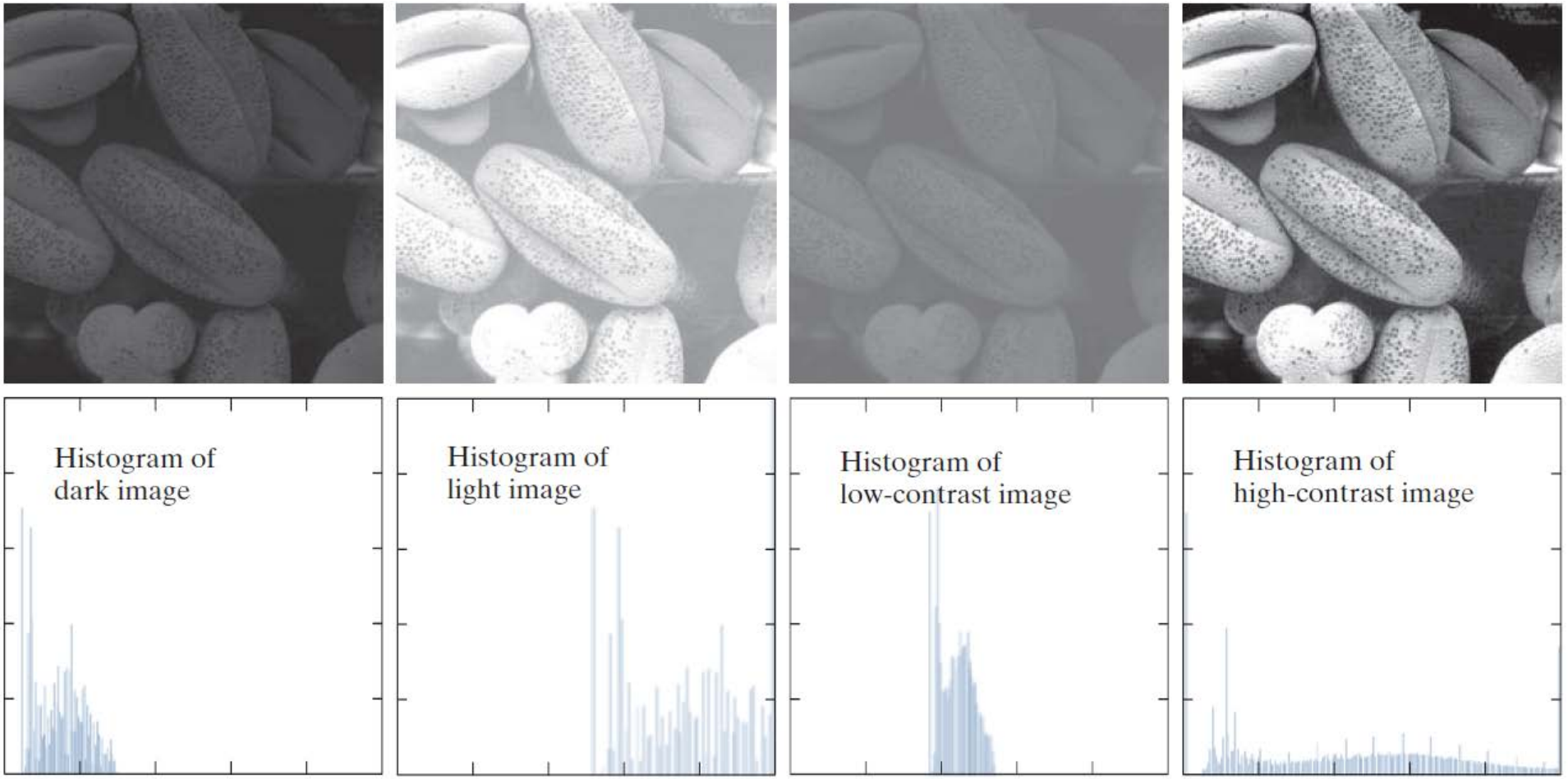
Repetition of each gray level: n_k

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.

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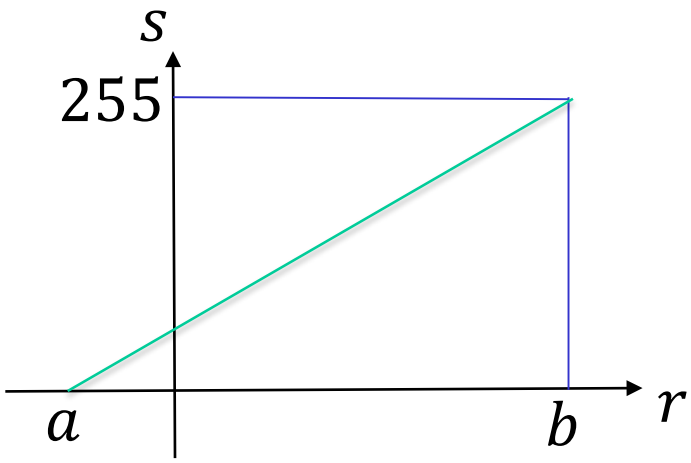
We could use linear scaling:



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

Intensity transformation

Image negative:

$$s = L - 1 - r$$

Log:

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

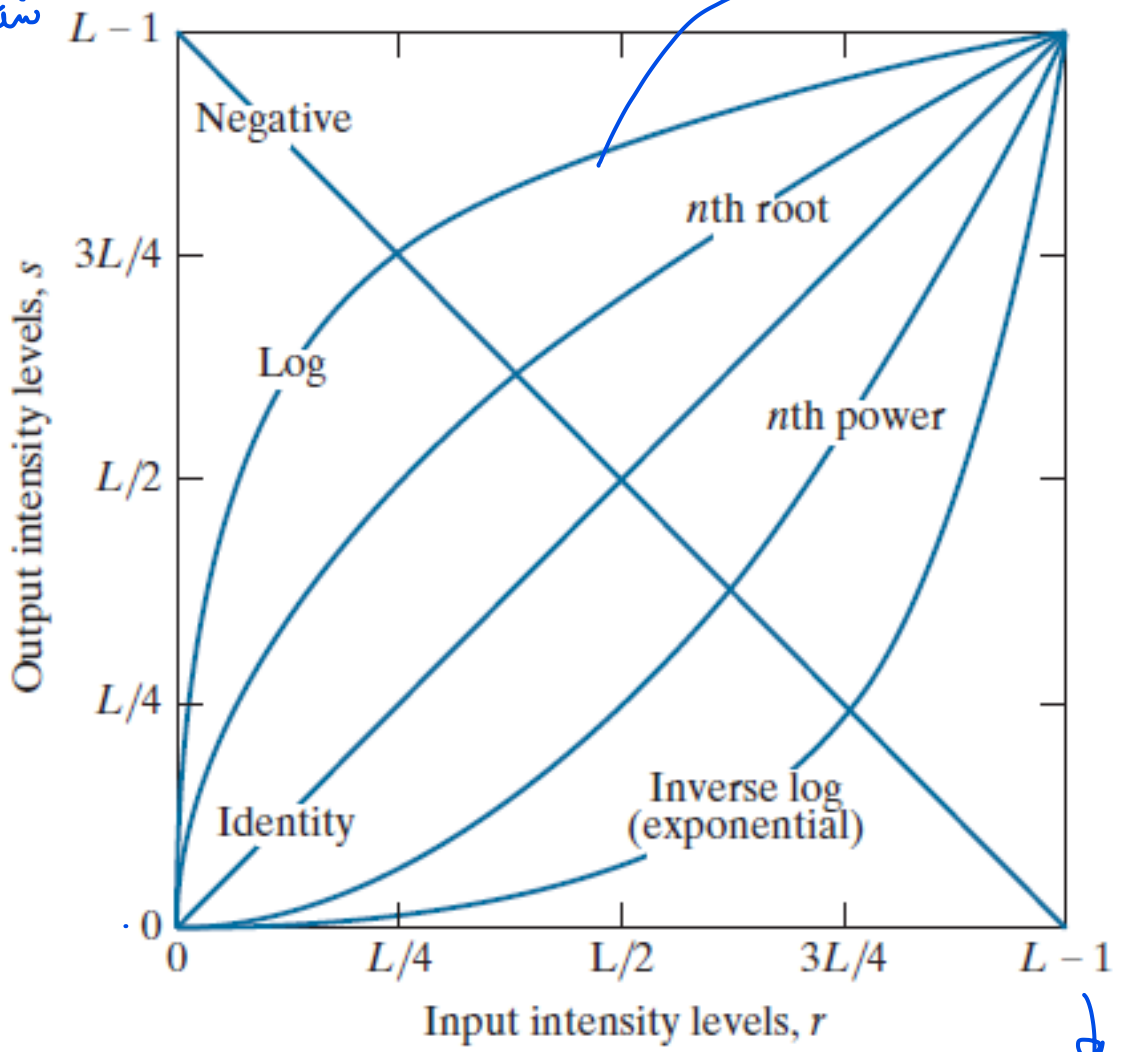
$$s = L - 1$$

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

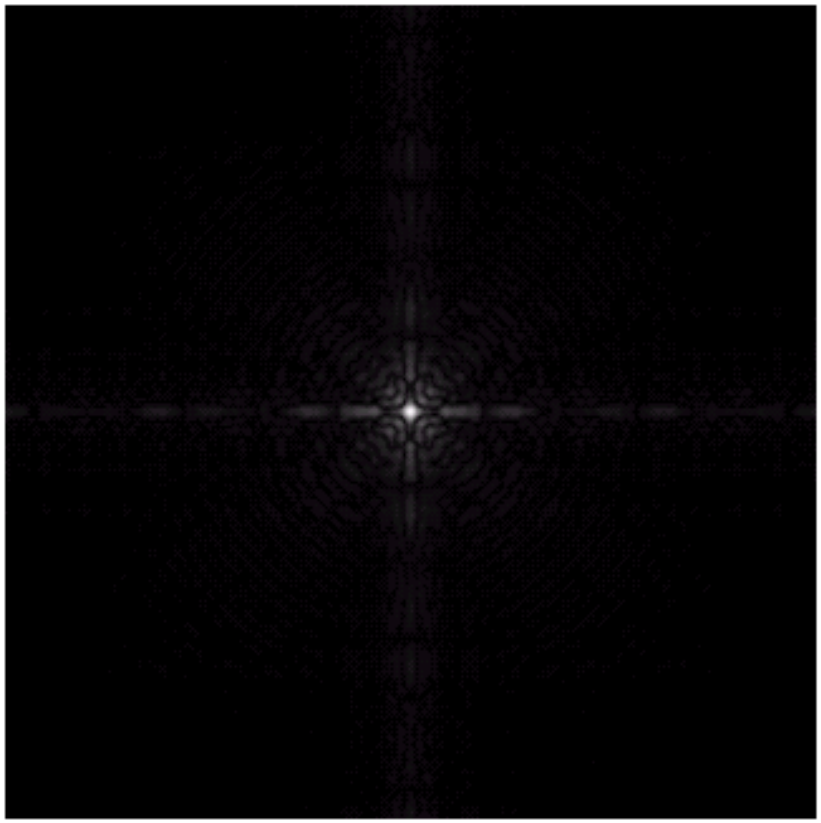
Power-law:

$$s = cr^{\gamma}$$

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

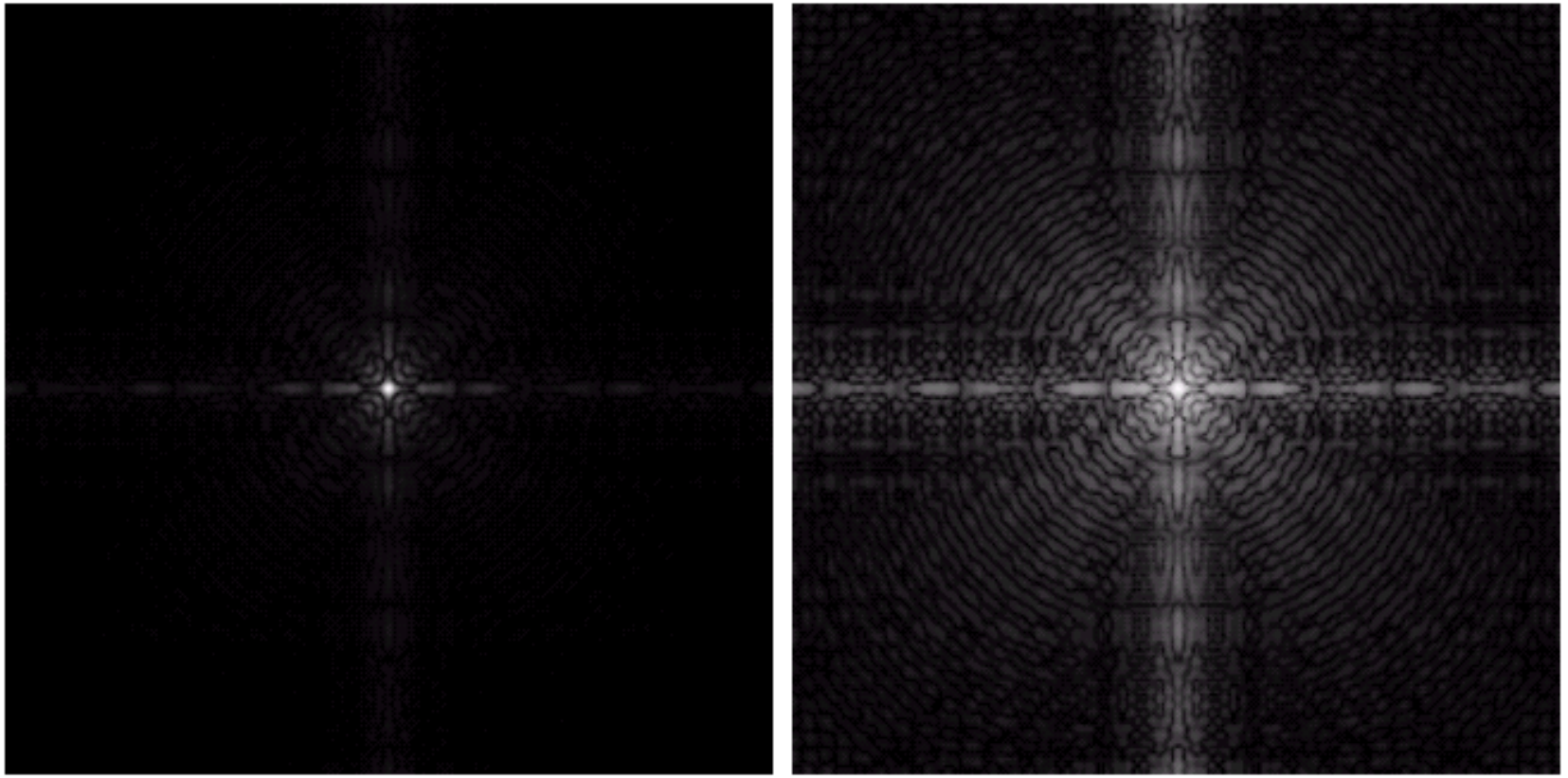


Log transformation



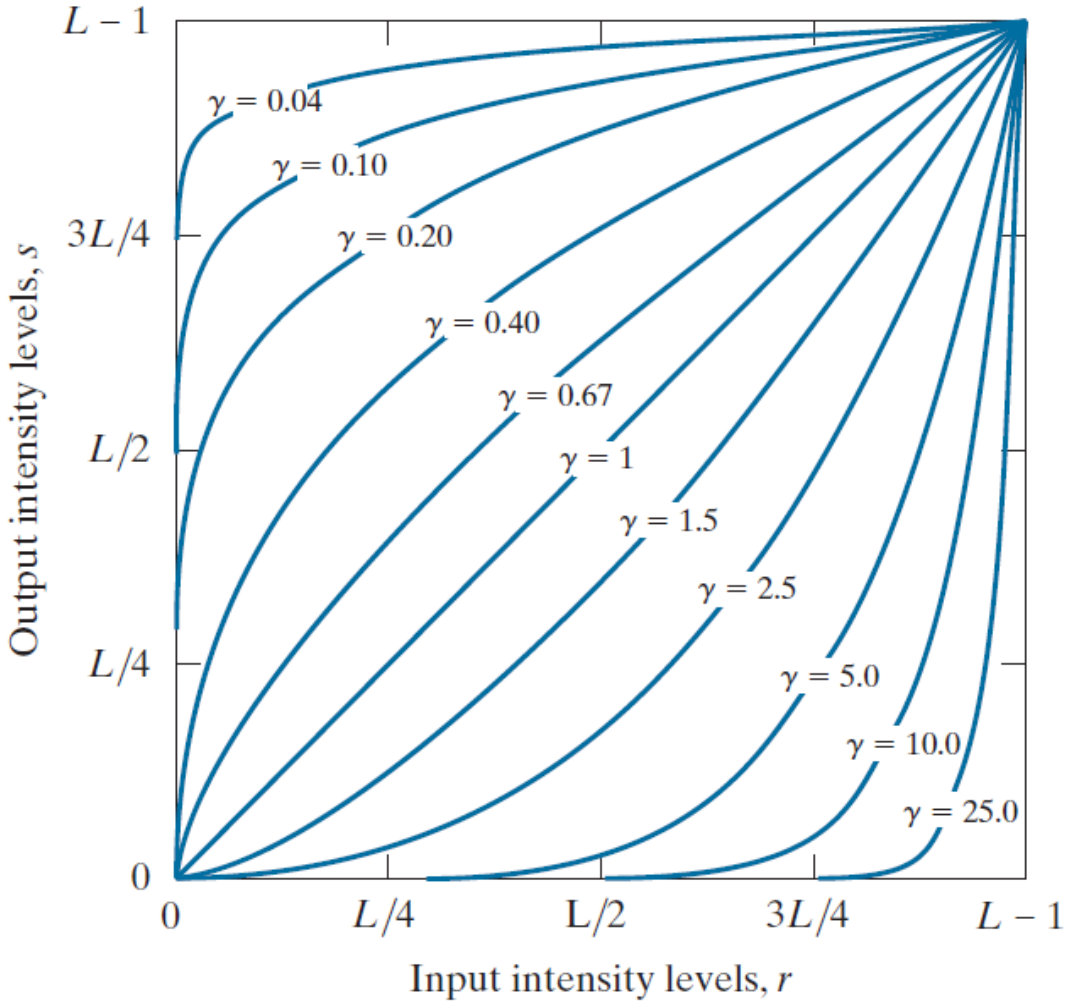
Fourier spectrum display enhancement using log

Log transformation



Fourier spectrum display enhancement using log

Power law transformation



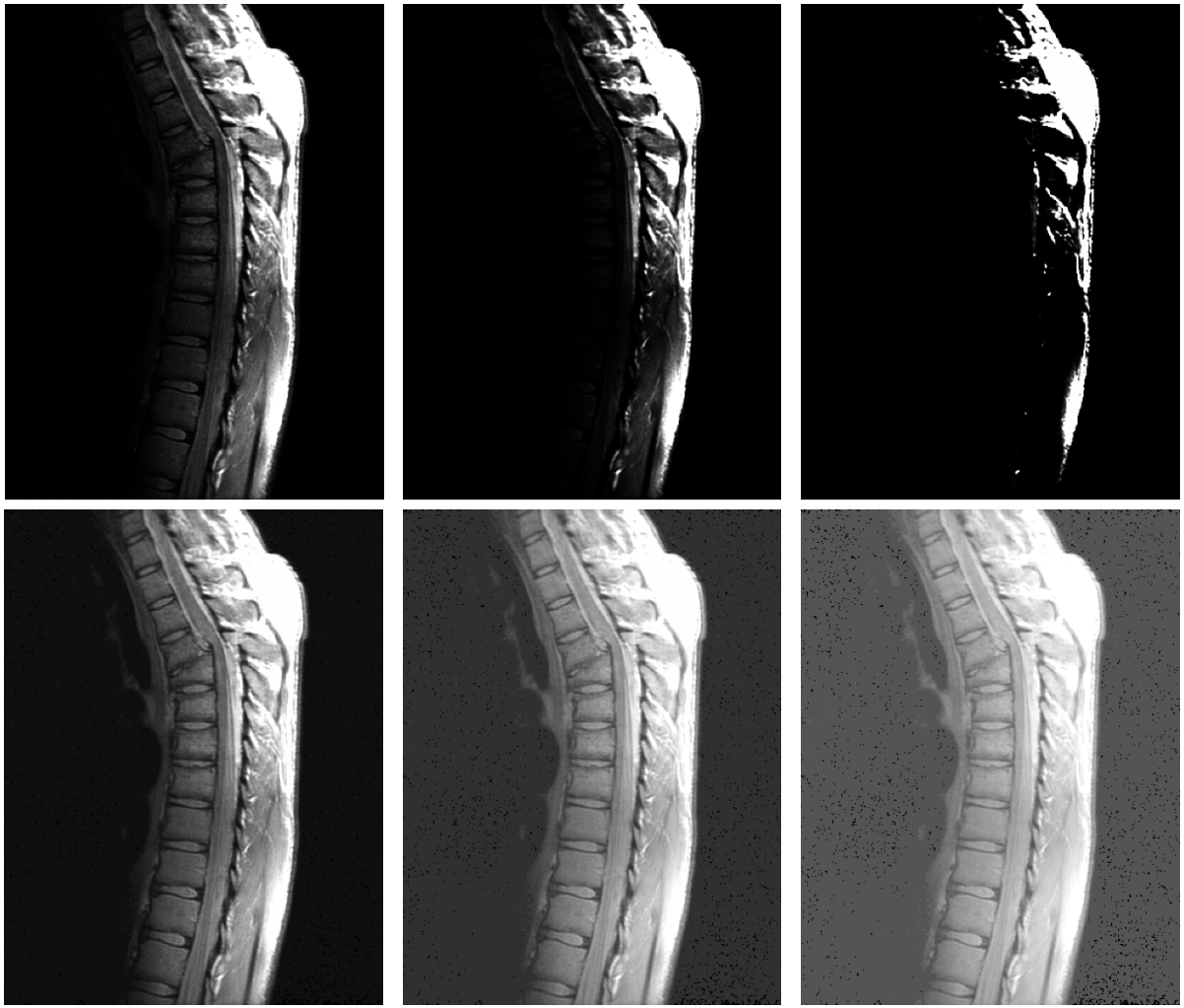
$s = cr^{\gamma}, c = (L-1)^{1-\gamma}$

Power law transformation

Power law transformation

$\gamma = 2$
$c = 2.36\text{E}{-10}$

$\gamma = 10$
$c = 2.19\text{E}{-22}$

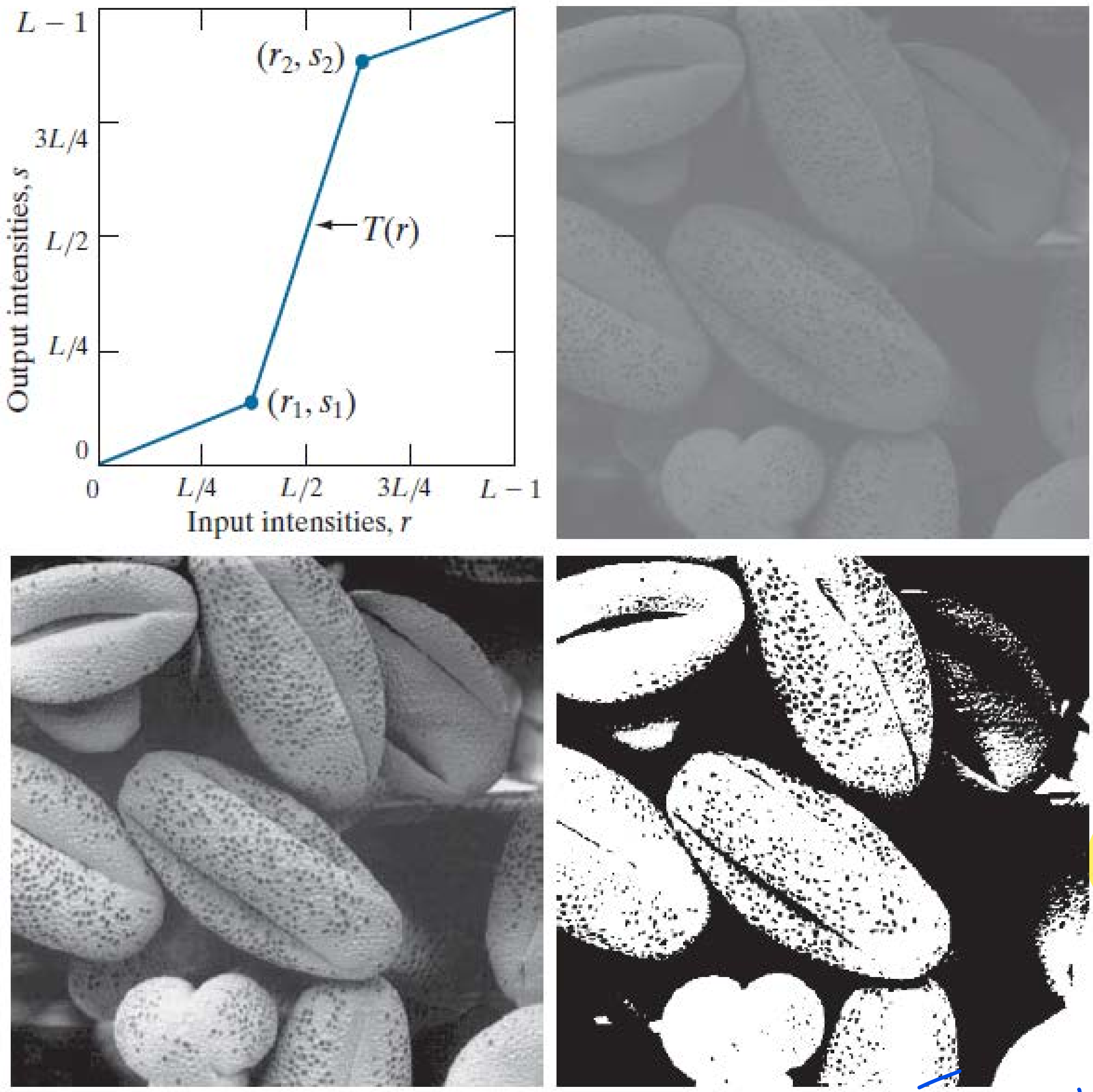


$\gamma = 0.5$
$c = 15.97$

$\gamma = 0.3$
$c = 48.37$

$\gamma = 0.2$
$c = 84.18$

Contrast stretching



Contrast stretching

تصویر باینری

$r_1 = r_2$

$s_1 = 0$

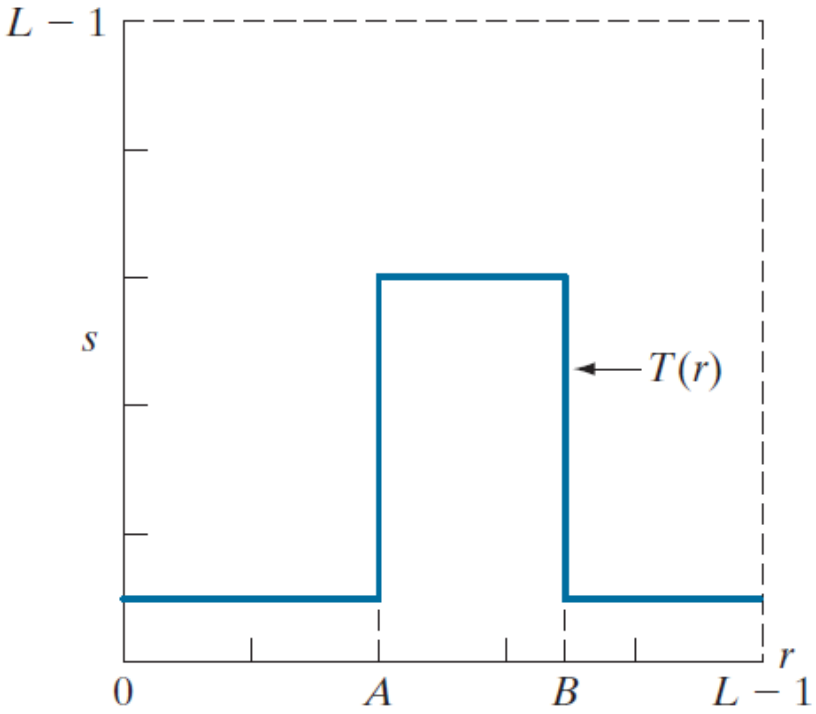
$s_2 = L - 1$

Thresholding

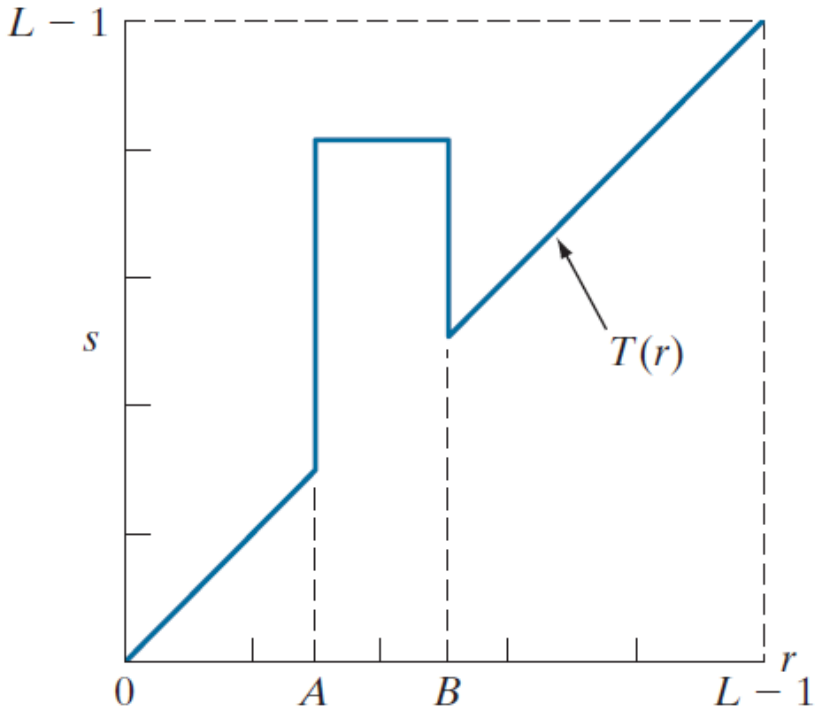
پایین‌تری از مقداری رو حذف کنیم و بقیه رو نگه می‌داریم.

Intensity level slicing

Highlight gray level range [*A*,*B*]

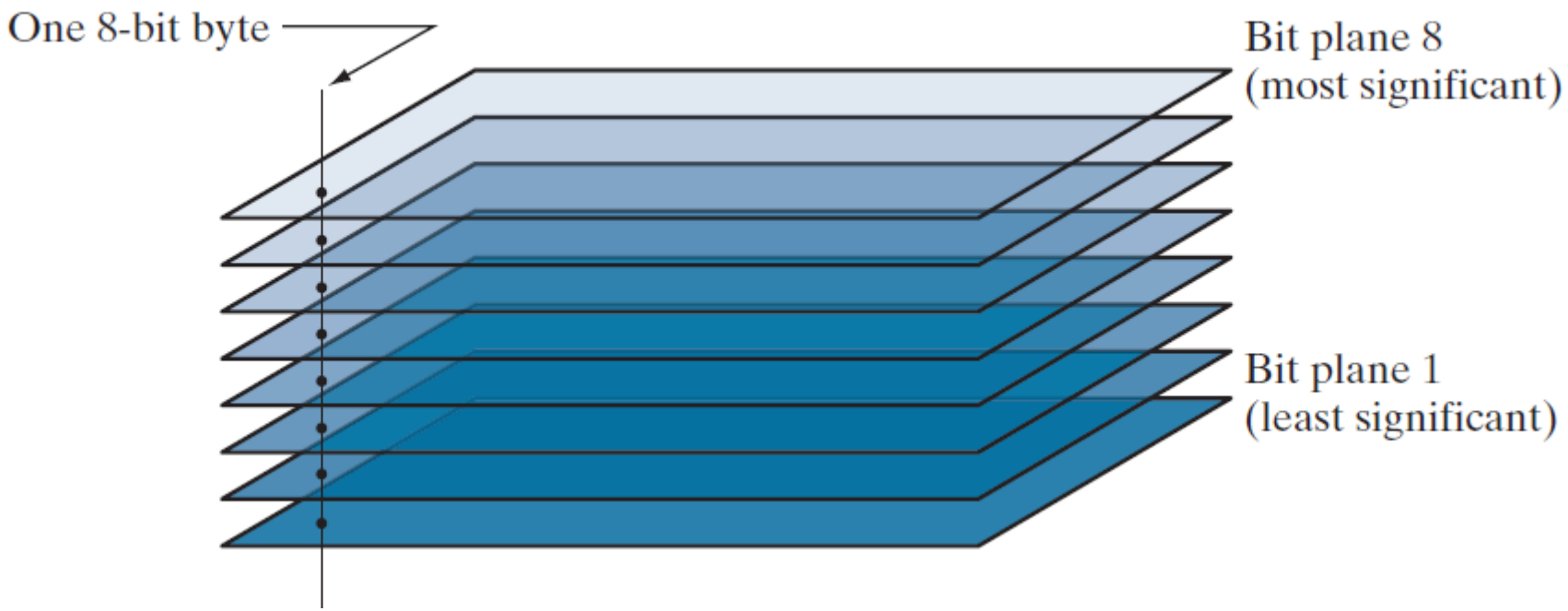


Reduces other gray level

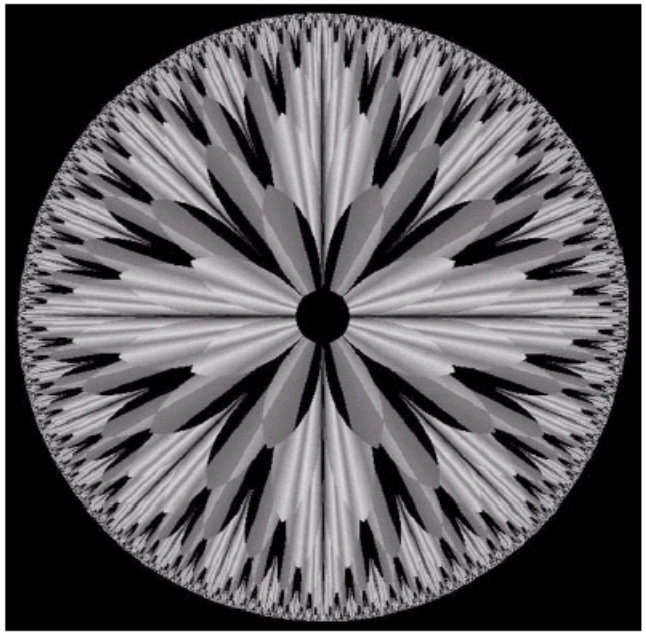


Preserves other gray level

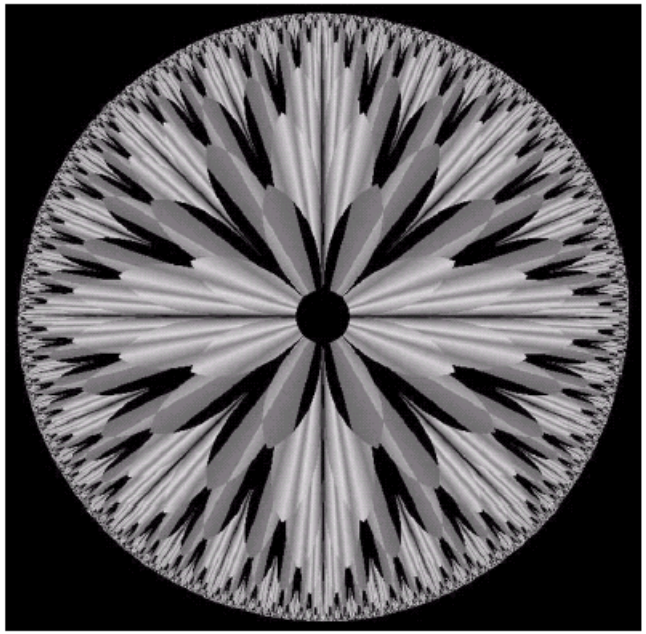
Bit plane slicing



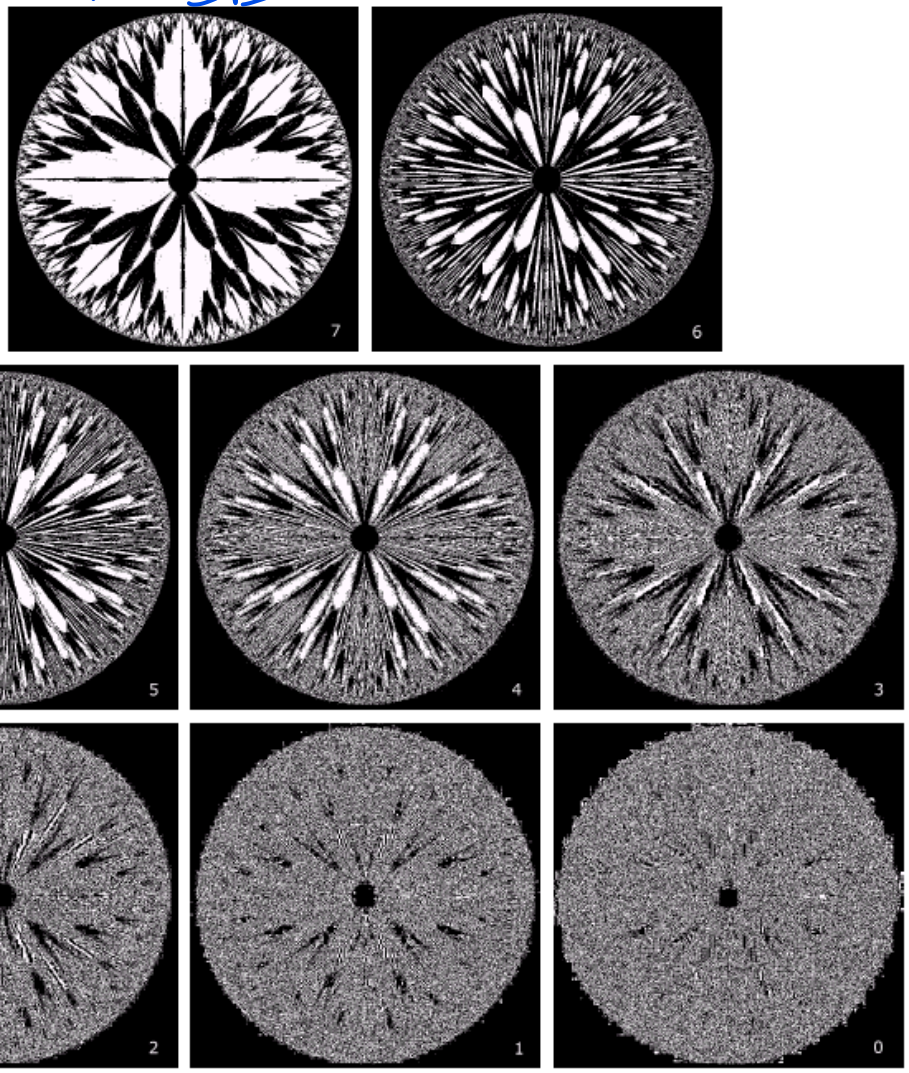
Bit plane slicing



Bit plane slicing



MSB



8 bit planes

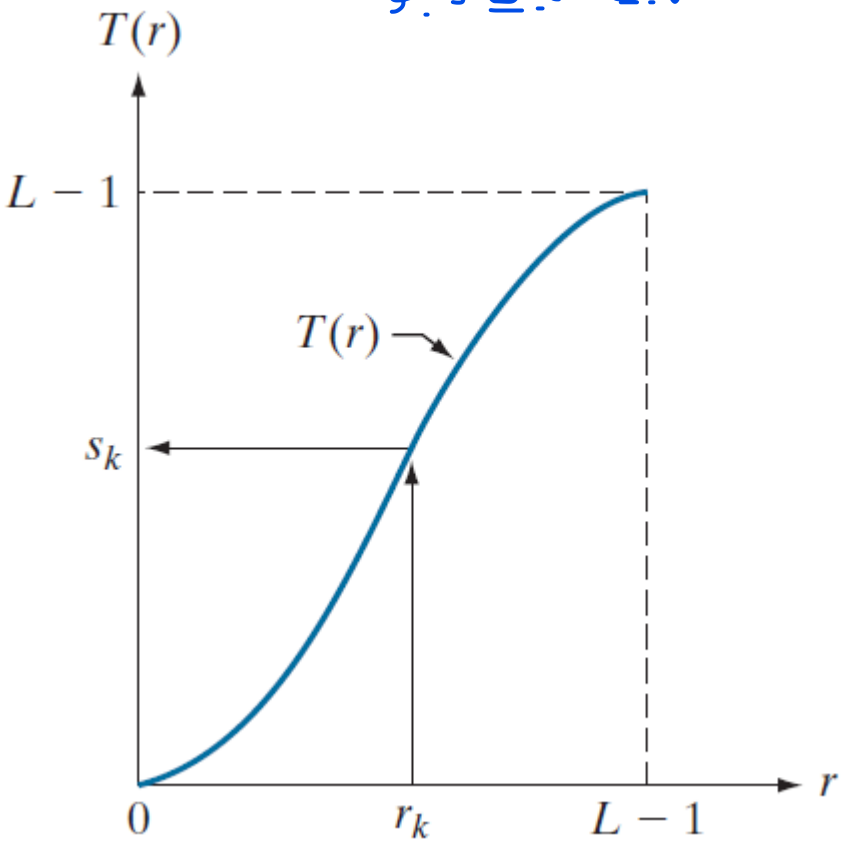
LSB

Histogram equalization

$$s = T(r) \qquad 0 \le r \le L-1$$

$T(r)$:Monotonously increasing

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



Histogram equalization

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

شدت جدید شدت قدیم

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

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

$$p_s(s) = p_r(r)\left|\frac{dr}{ds}\right| = p_r(r)\left|\frac{1}{(L-1)p_r(r)}\right|$$

$$= \frac{1}{L-1} \qquad 0 \le s \le L-1$$

Histogram equalization

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

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

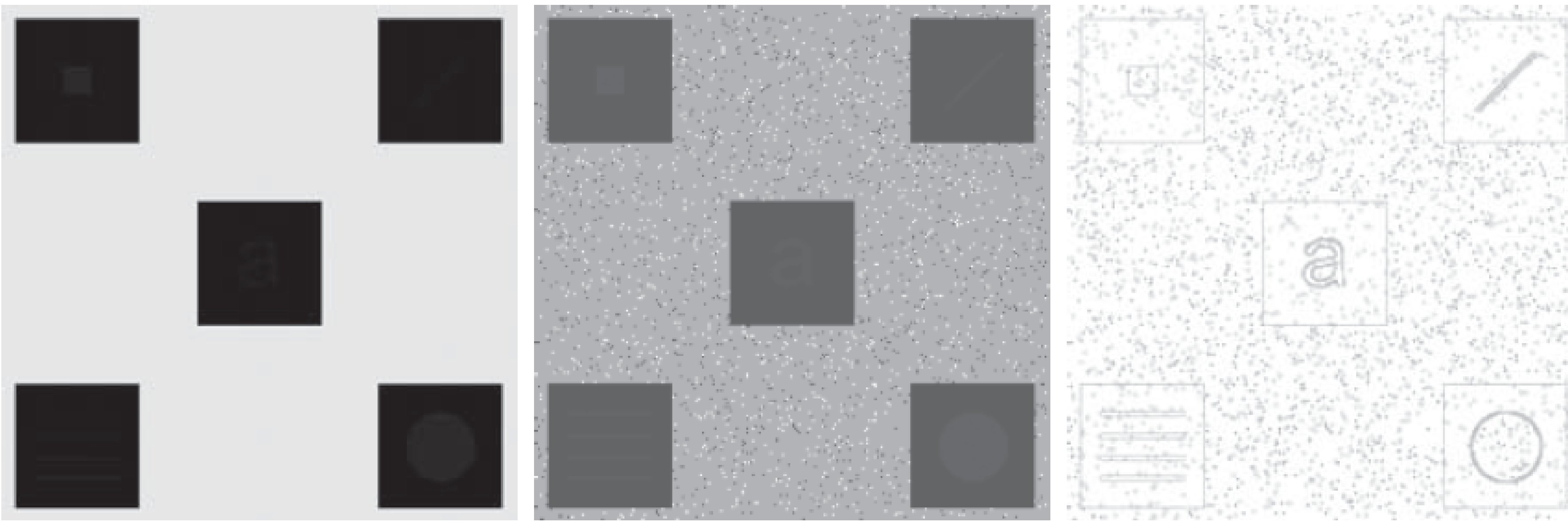
$$= \frac{r^2}{L-1}$$

Histogram equalization

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

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

Local histogram processing



Original | Global | Local

برای همه سطح ها یک تبدیل انجام می دیم

ها

توجه location که قواعد داریم

Histogram statistics

Normalized histogram: $p(r_i)$

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

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