Image Processing in Python

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Image Enhancement

› No Explicit definition
› Methods
–Spatial Domain:
–Linear
› Nonlinear
› Frequency Domain:
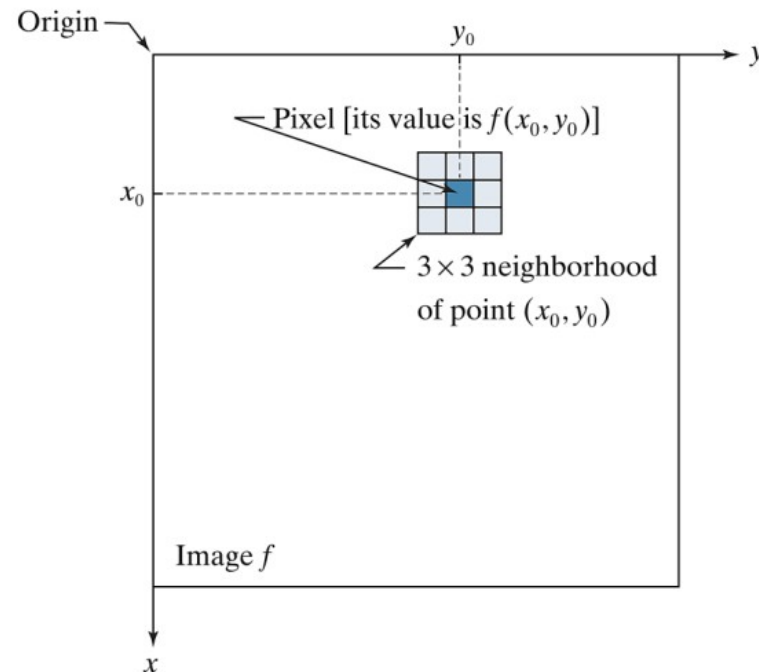–Linear
–Nonlinear

Image Enhancement

Image Enhancement

Spatial Domain Process

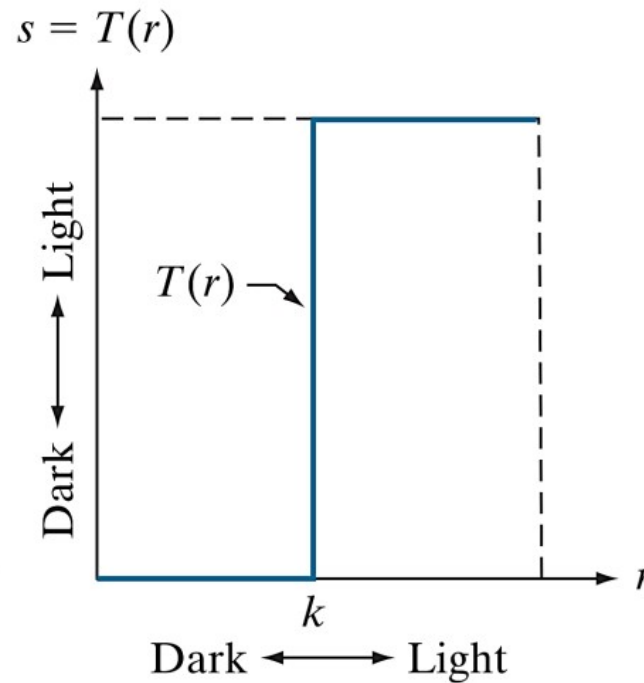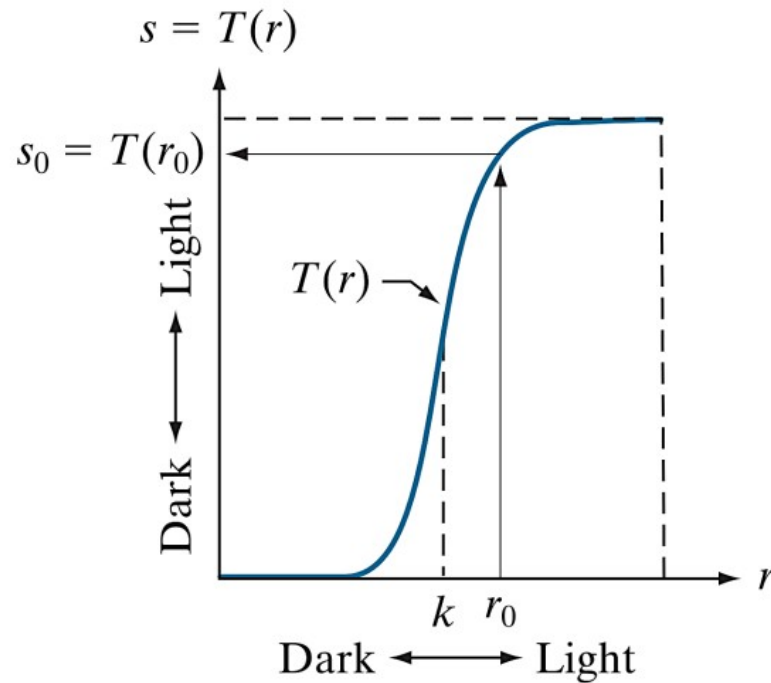› Formulation and Illustration:

$$g(x, y) = T\{f(x, y)\}$$

Image Enhancement

Spatial Domain Process

› For 1×1 window, $s = T(r)$
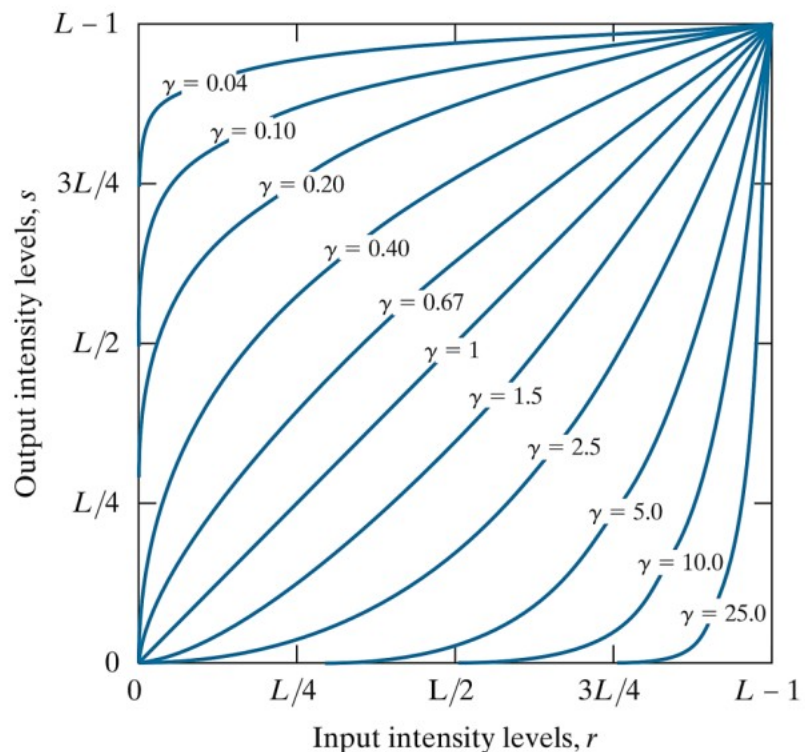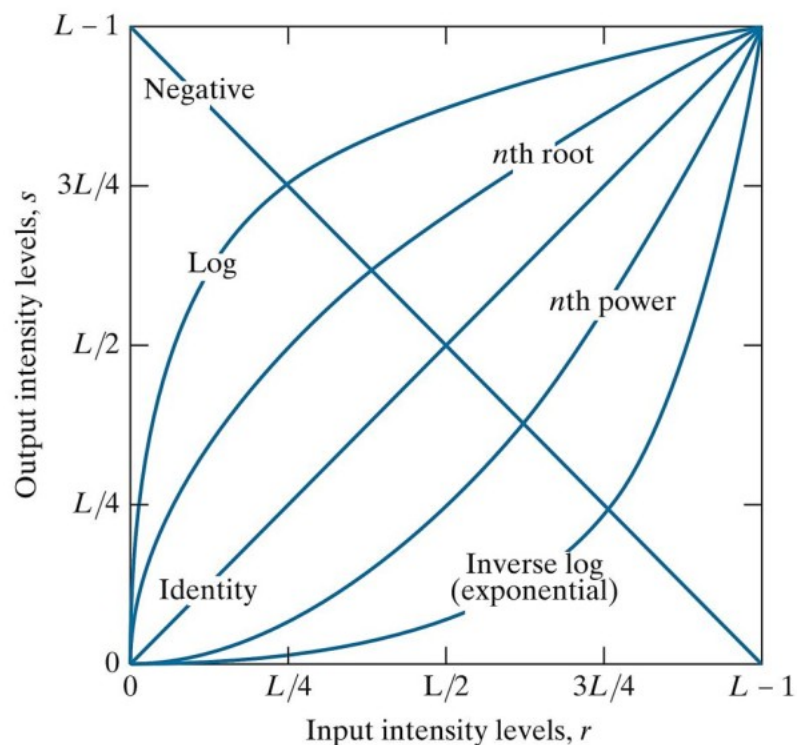 – Contrast Enhancement/Stretching/Point process

Image Enhancement

Spatial Domain Process

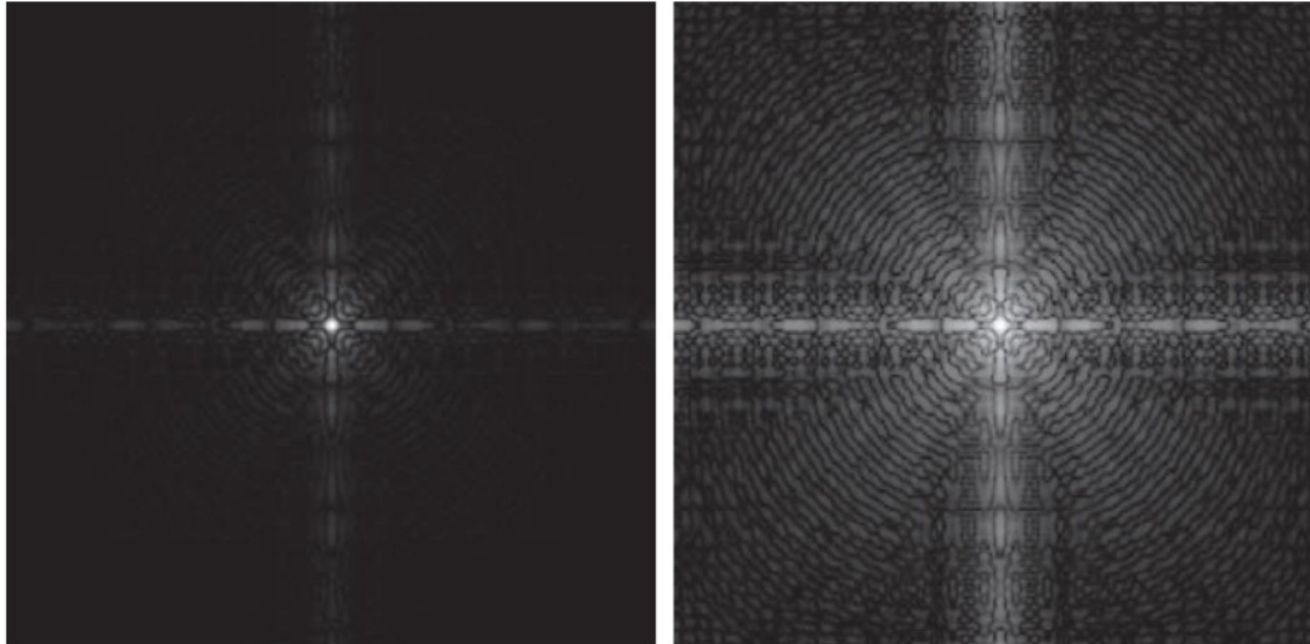› Gray Level Transformation, $s = T(r)$

Image Enhancement

Spatial Domain Process

› Logarithmic Transformation:

$$s = (L - 1)\frac{log(r + 1)}{log(L)}$$

Image Enhancement

Spatial Domain Process

› Power-Law Transformation:

$$s = (L - 1)\left(\frac{r}{L - 1}\right)^{\gamma}$$

| $\gamma = 1.0$ | $\gamma = 0.6$ | $\gamma = 0.4$ | $\gamma = 0.3$ |

Image Enhancement

> Power-Law Transformation:

$$s = (L - 1)\left(\frac{r}{L - 1}\right)^{\gamma}$$

$\gamma = 1.0$ $\gamma = 3.0$ $\gamma = 4.0$ $\gamma = 5.0$
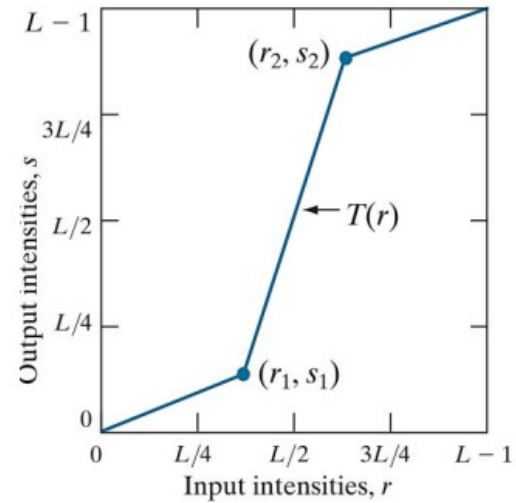
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› Power-Law Transformation:

$$s = (L - 1) \left(\frac{r}{L - 1} \right)^{\gamma}$$
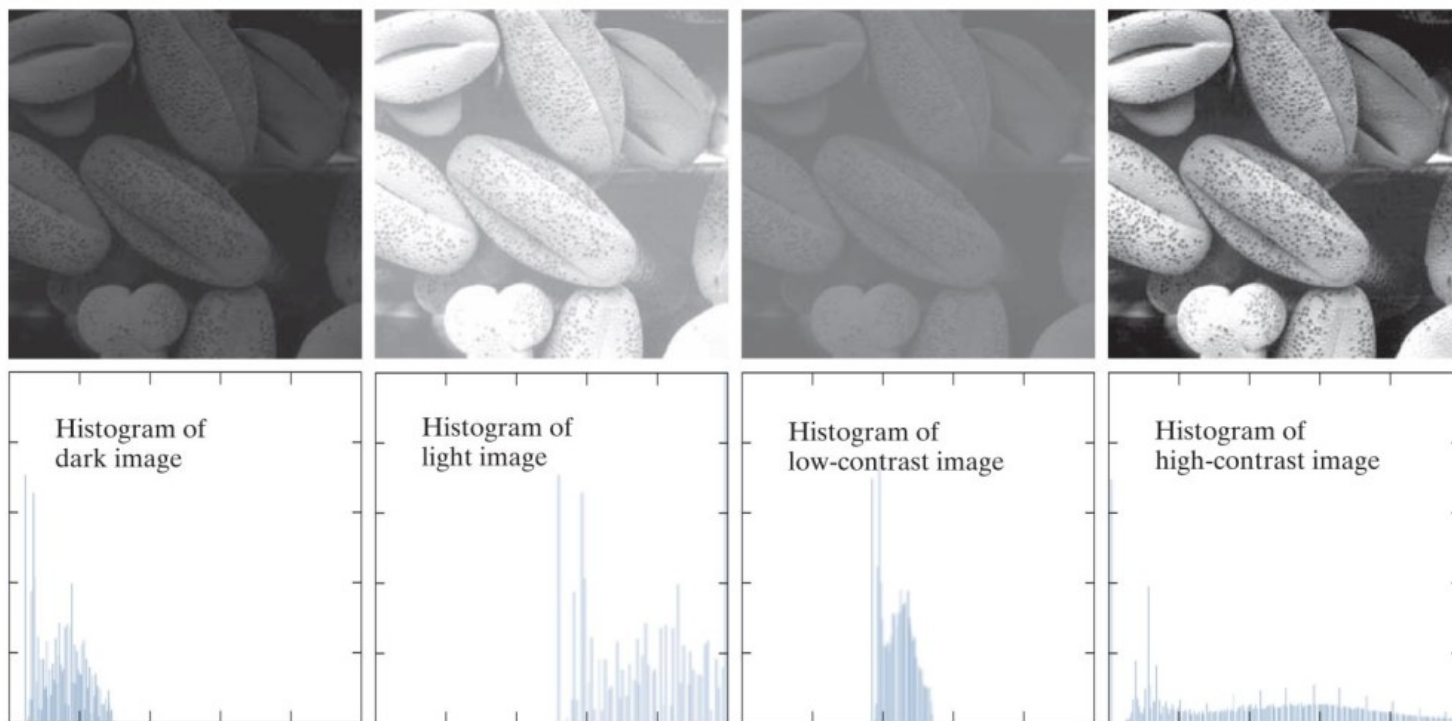
Image Enhancement

> Hand Design Transform

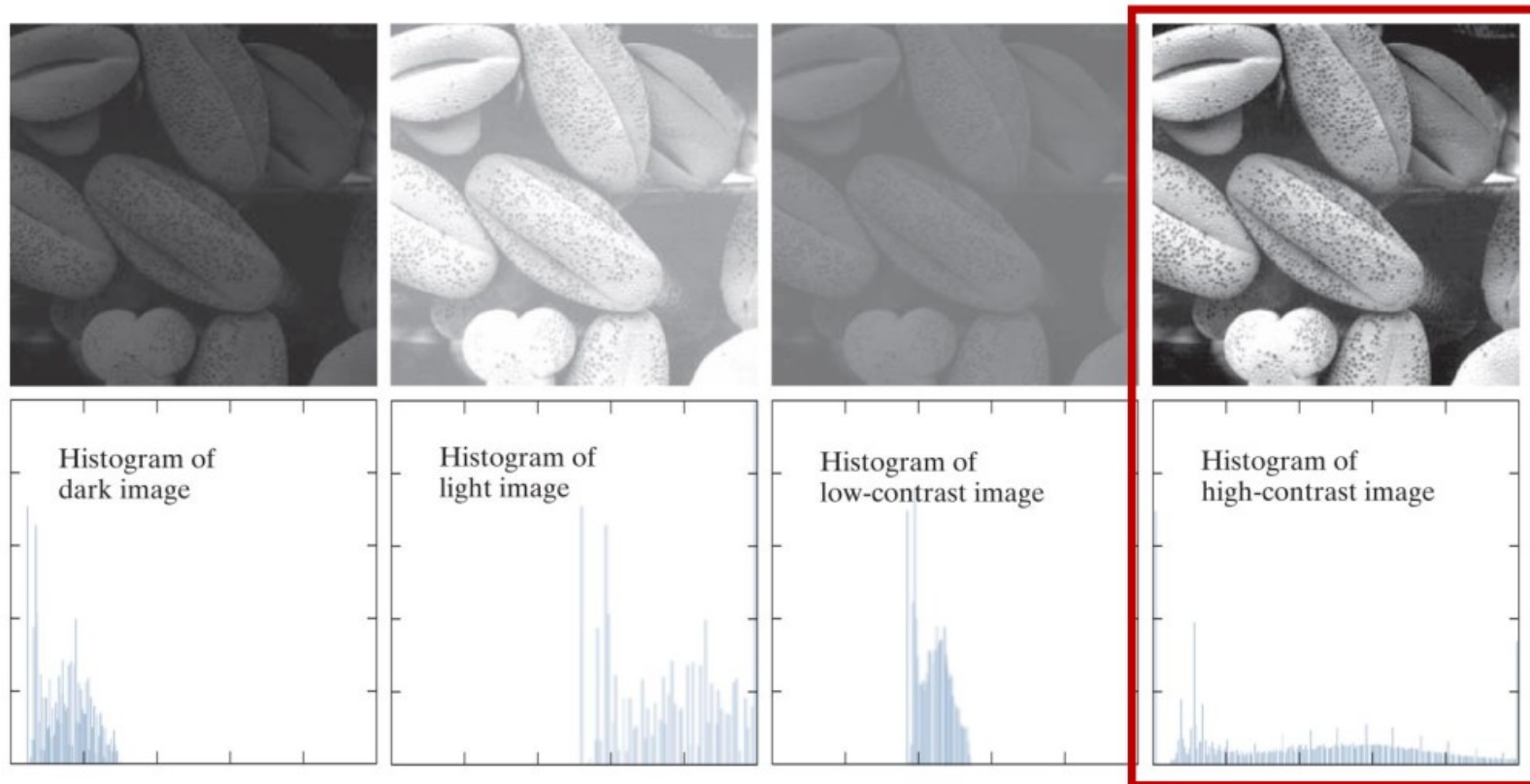# Histogram Processing

› Image Histogram and Normalized Histogram:

› $h(r_k) = n_k, \quad k = 0,1,2, \cdots, L-1 \Rightarrow p(r_k) = \frac{n_k}{MN}$

Histogram of dark image

Histogram of light image

Histogram of low-contrast image

Histogram of high-contrast image

Image Enhancement

> Effect of histogram on Image quality:

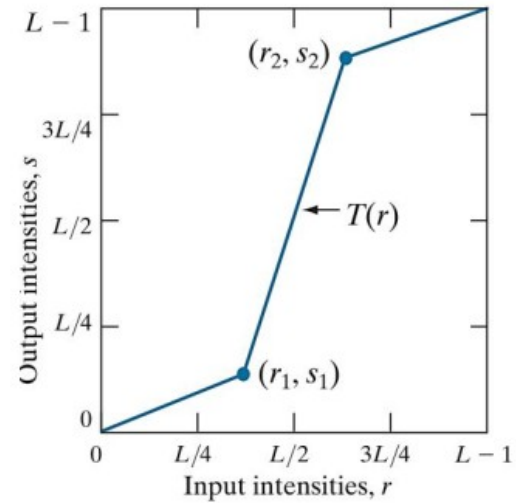| Histogram of dark image | Histogram of light image | Histogram of low-contrast image | Histogram of high-contrast image |

Image Enhancement

› Hand Design Transform

Image Enhancement
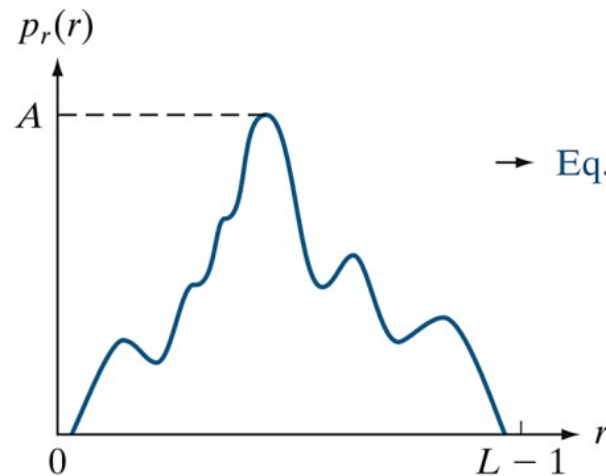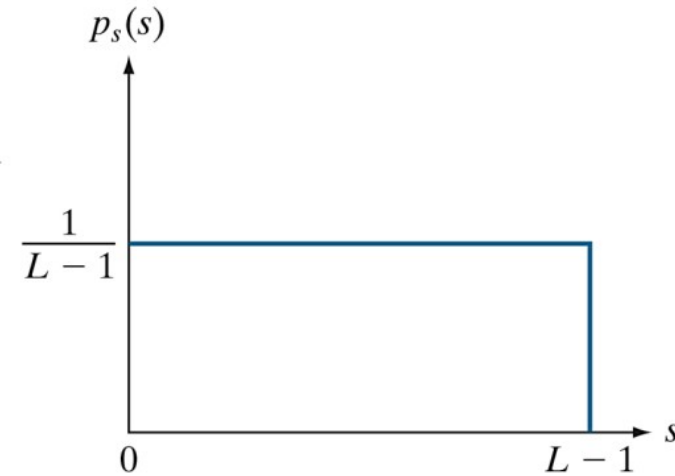
Histogram Equalization

› Continuous case:

$$p_r(r) \sim Input\ Image\ pdf$$

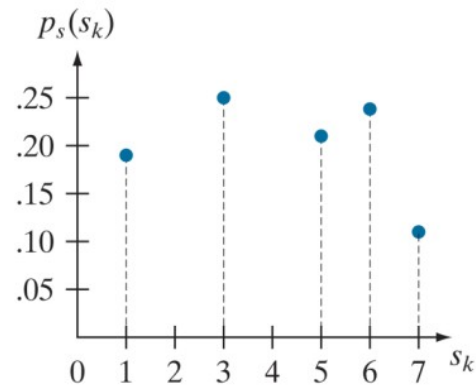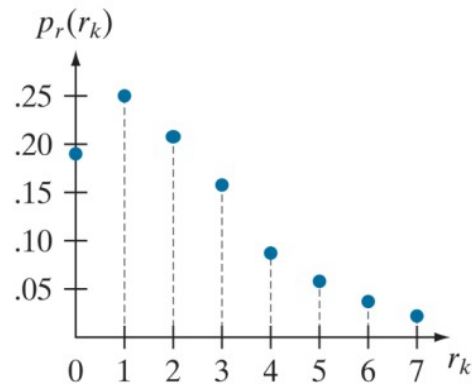$$s = T(r) = (L-1) \int_0^r p_r(w)dw \propto Uni[0, L-1]$$

Image Enhancement

Histogram Equalization

› Discrete case:

$$p_r(r_k) = \frac{n_k}{MN}$$

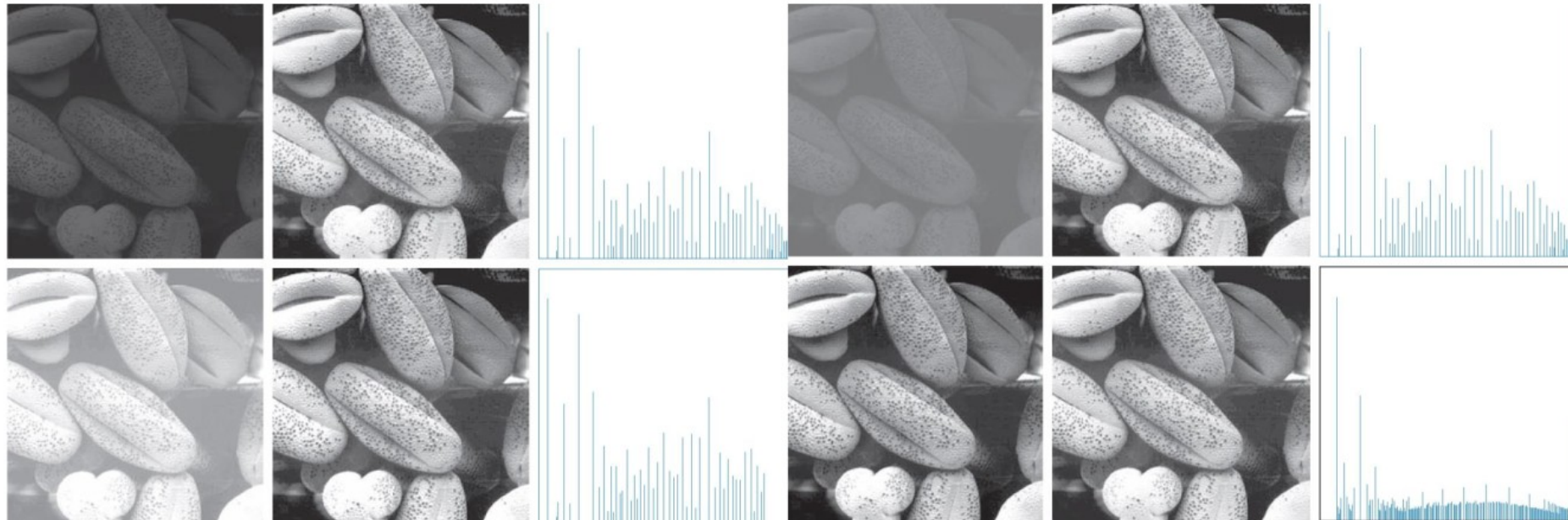$$s = T(r) = (L - 1) \sum_{j=0}^{k} p_r(r_j) \propto \;???$$

Histogram Equalization

› Example:
  – Exact equalization in NOT achieved!

Thank you!