Digital Image Processing

Image Enhancement in the Spatial Domain

Topics

- Definitions and basics
- Some Basic Gray Level Transformations
- Histogram Processing
- Enhancement Using Arithmetic/Logic Operations

Image Enhancement

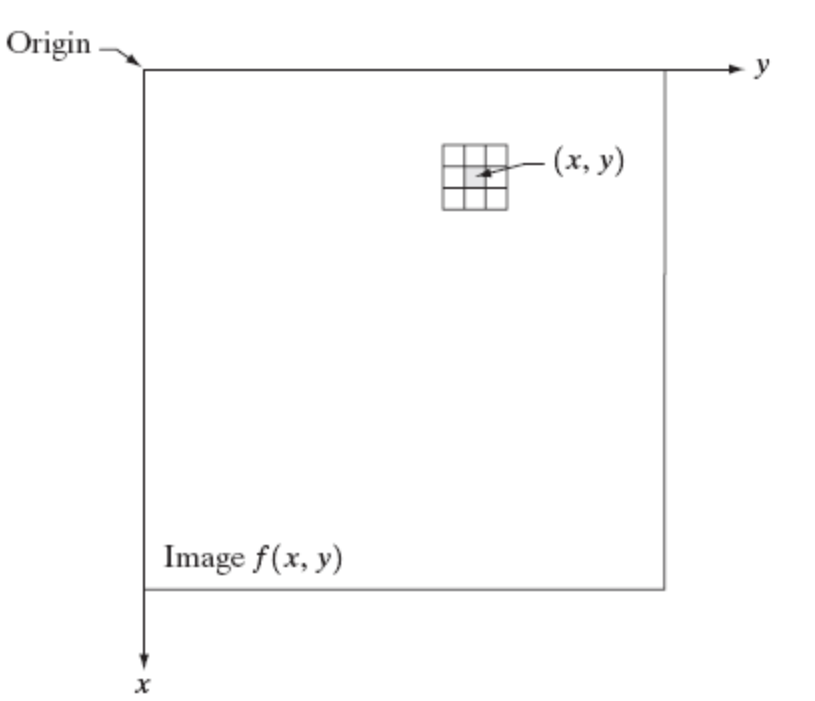
- The principal objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application
- Enhancement Categories:
  - *spatial domain enhancement:* refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image
  - *Frequency domain enhancement:* processing techniques are based on modifying the Fourier transform of an image.

Spatial Domain Processes

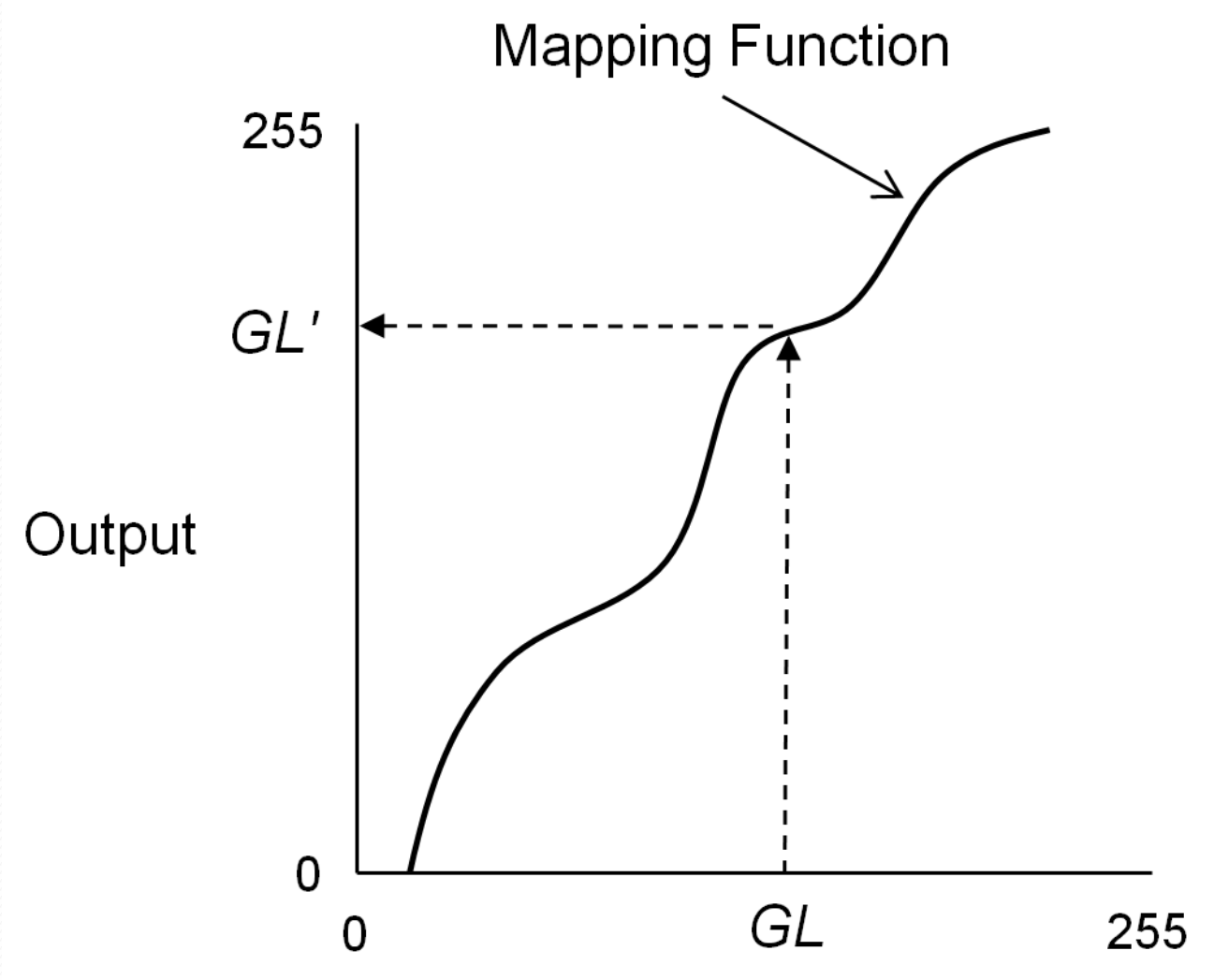
- Spatial domain processes are denoted by

$$g(x,y) = T[\, f(x,y) \,]$$

- A neighborhood about a point (x, y) is a square or rectangular sub-image area centered at (x, y)

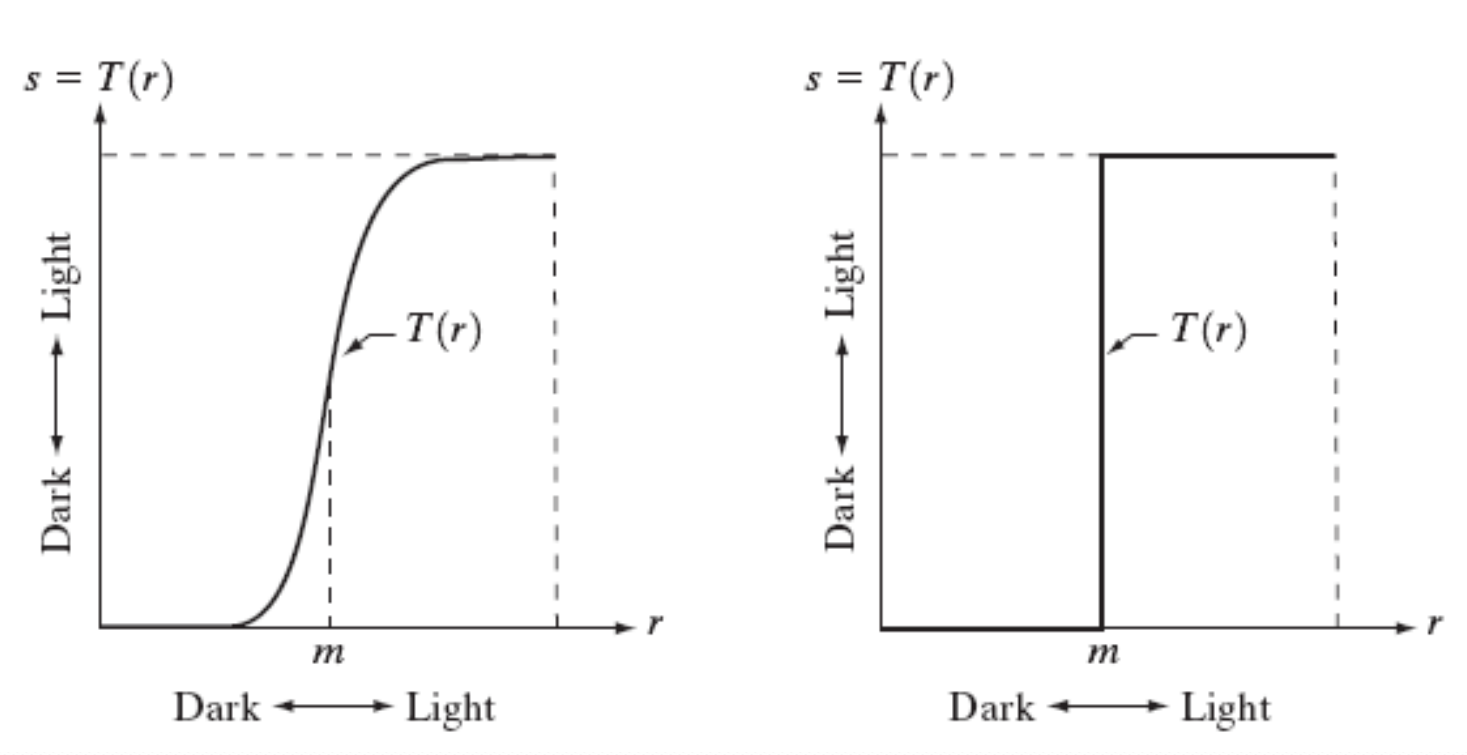


Basic Gray Level Transformations (1)



Basic Gray Level Transformations(2)

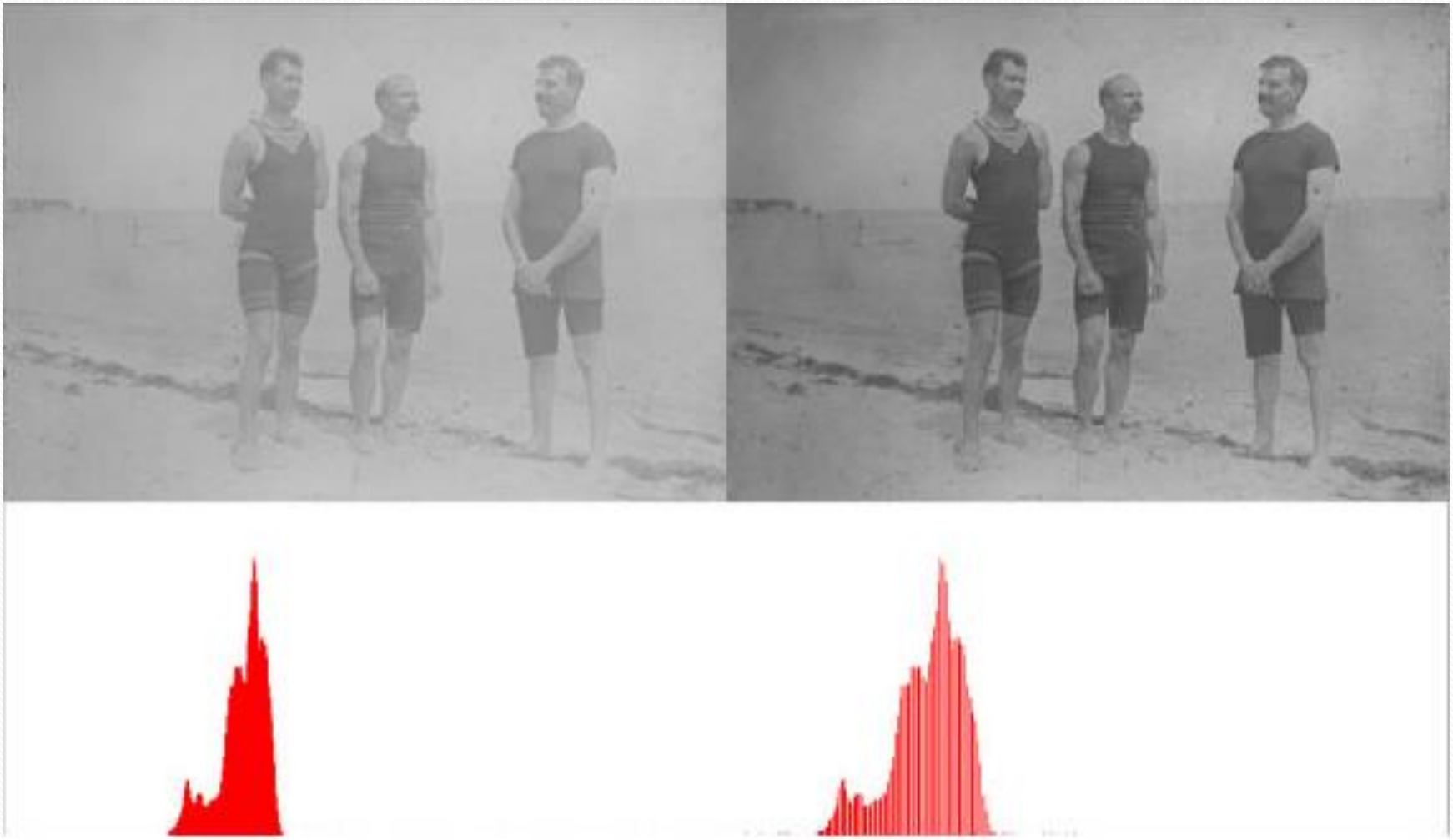
- Contrast enhancement



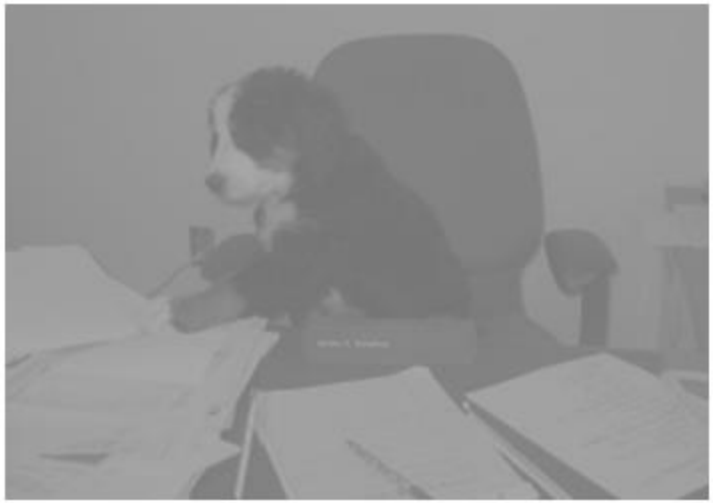
Contrast Stretching

- Contrast is the difference in intensity
- Contrast of an image is largest if the full range of intensity values is used.
- Therefore, contrast stretching is changing the intensity values of all pixels such that they cover a wider range

Contrast Stretching



Contrast Stretching



Low Contrast

High Contrast

Image negation

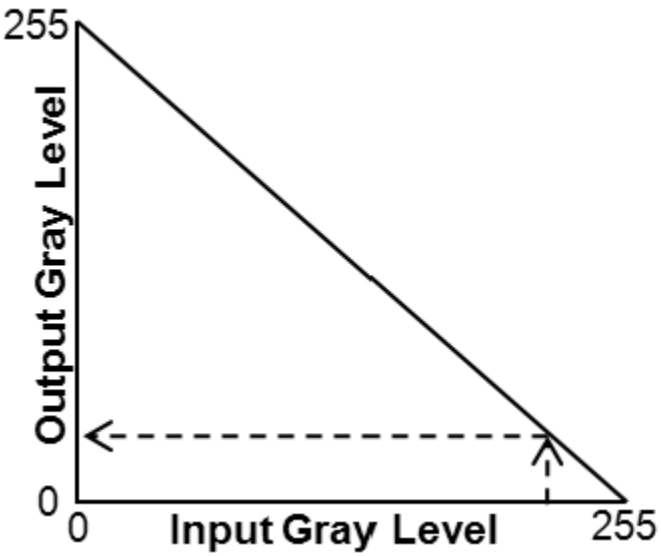
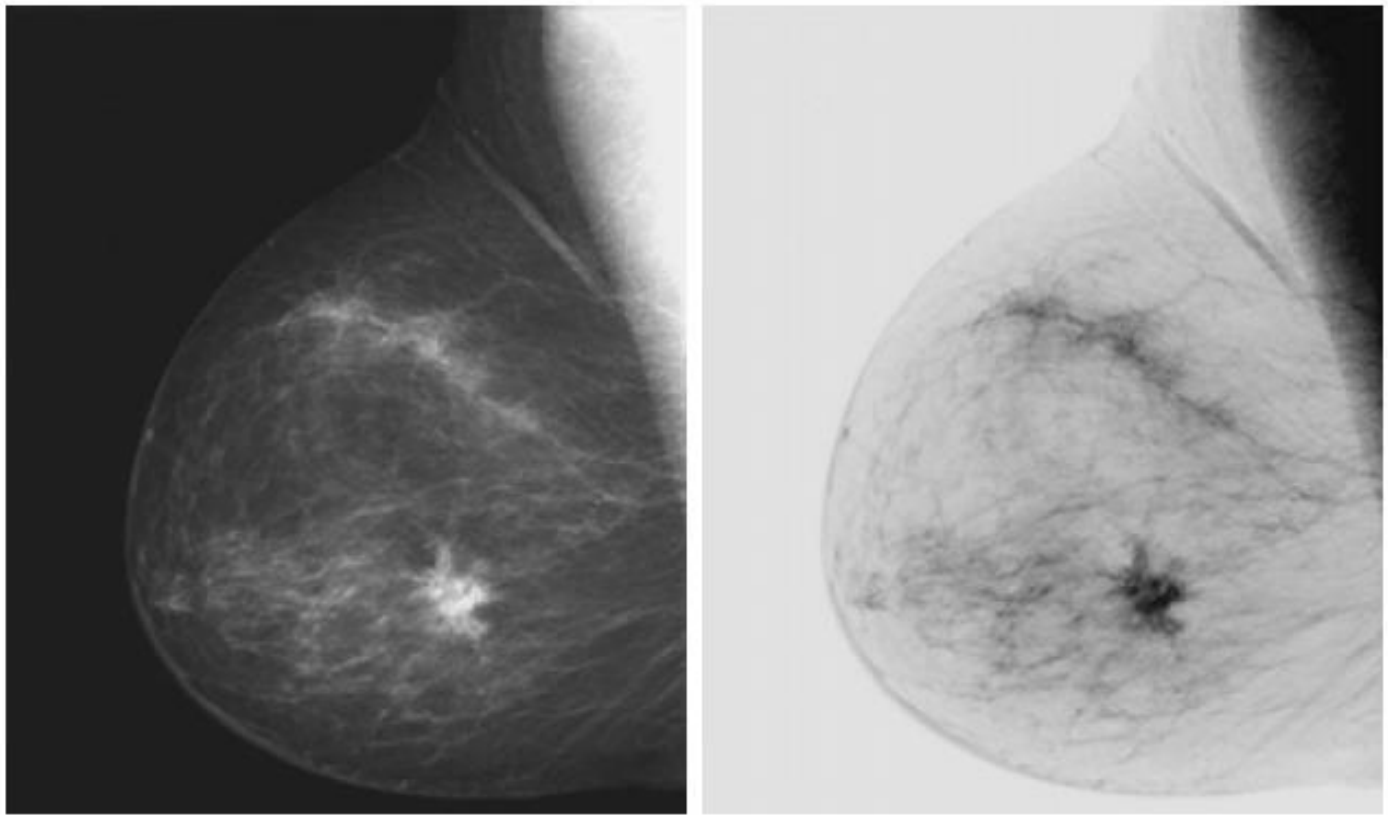


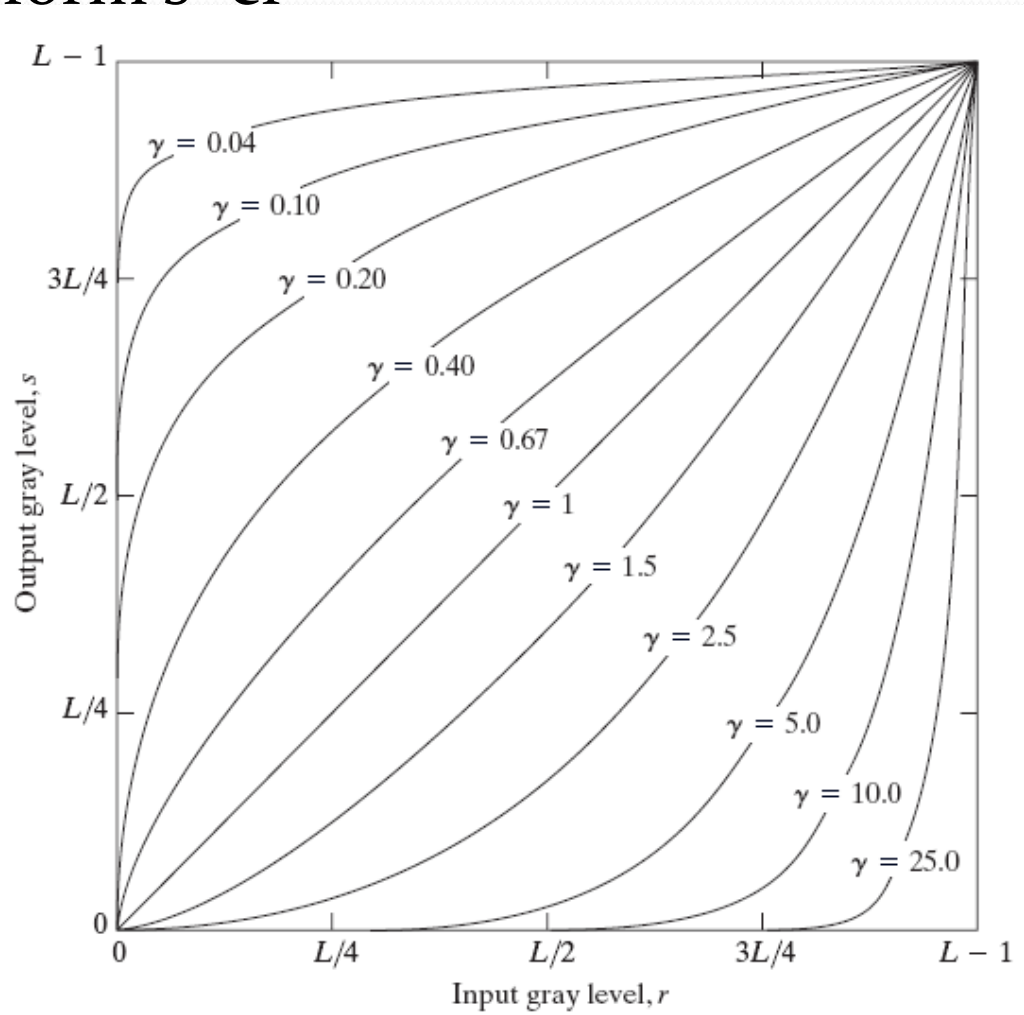
Image negation

- A mammography image

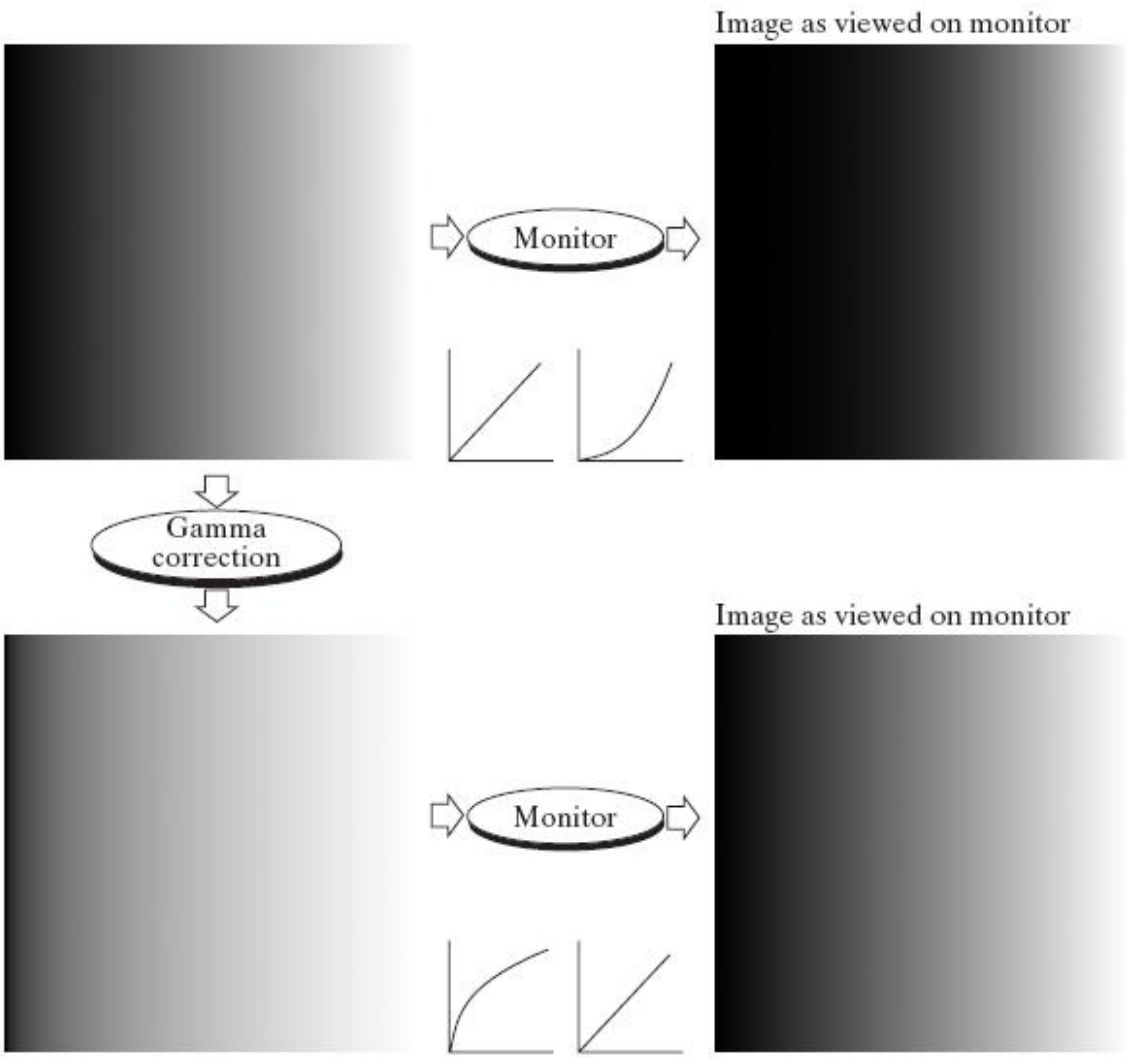


Basic Gray Level Transformations

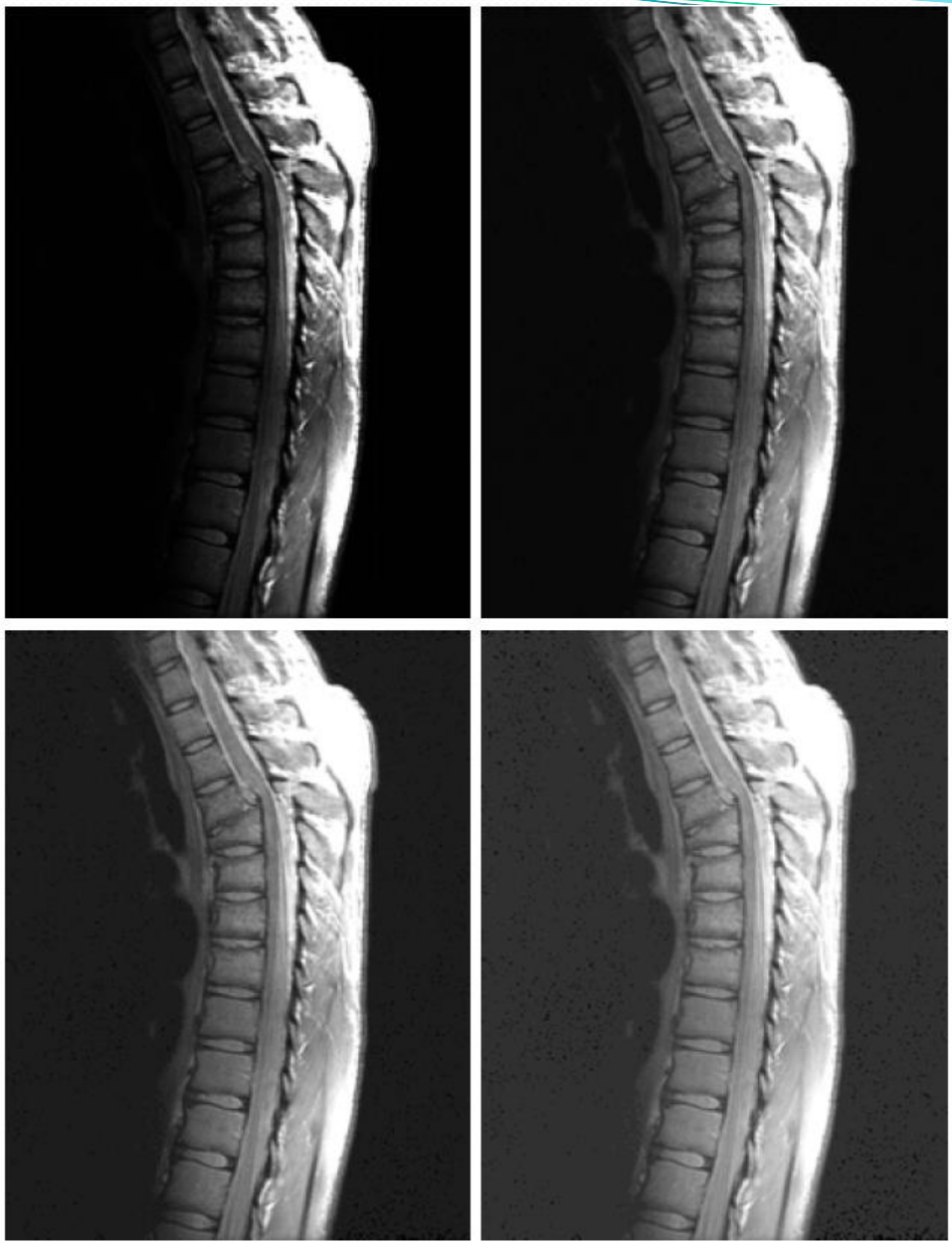
- Gamma correction: Power-law transformations have the basic form $s=cr^{\gamma}$



Gamma Correction



Original Image



Gamma Correction with c=1, γ=0.6

Gamma Correction with c=1, γ=0.4

Gamma Correction with c=1, γ=0.3

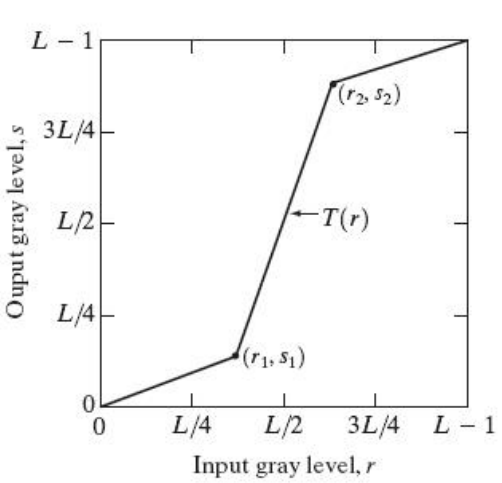
Original Image

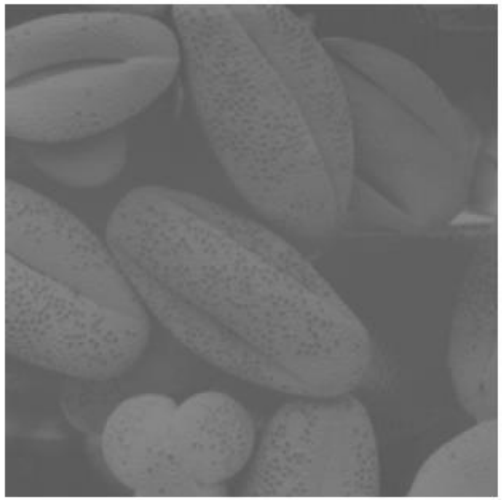
Gamma Correction
c=1, γ=3

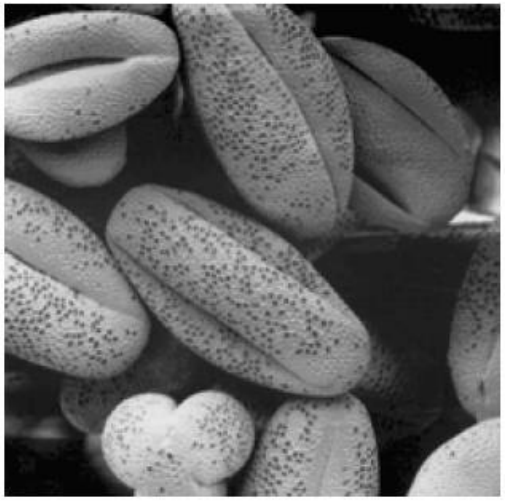
Gamma Correction
c=1, γ=4

Gamma Correction
c=1, γ=5

Piecewise Linear Contrast Stretching

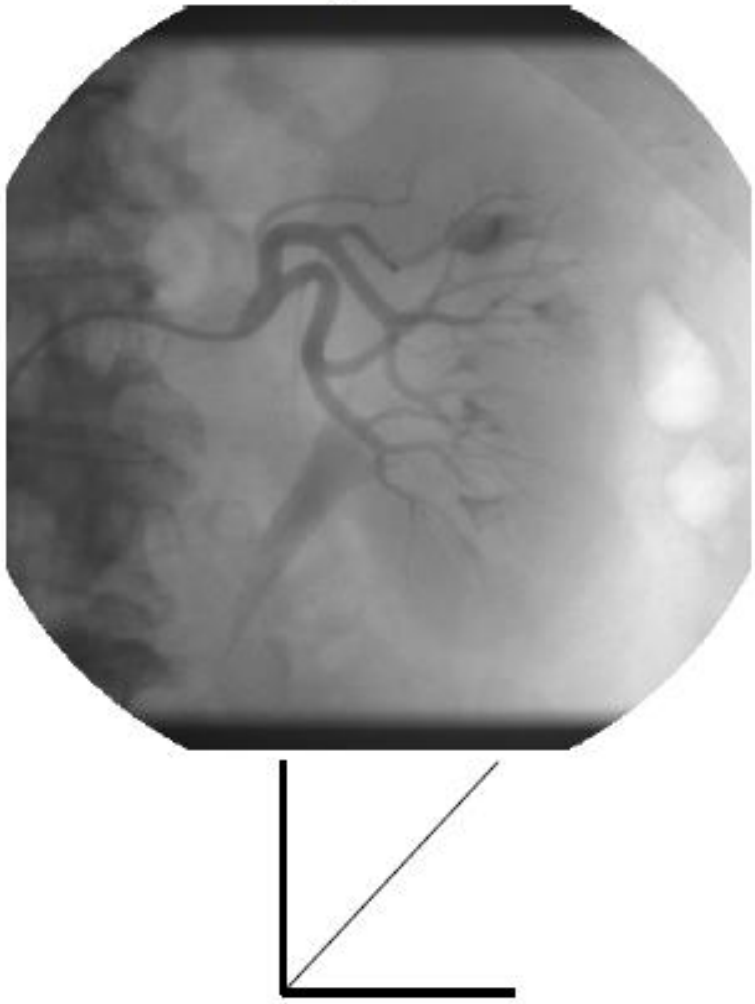




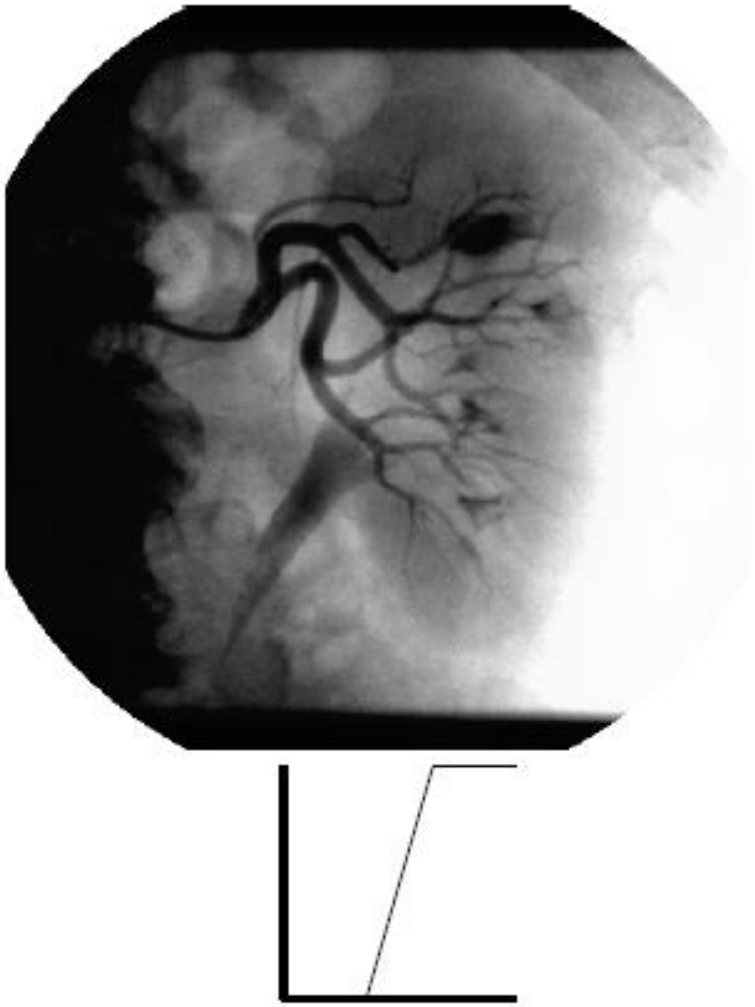


Piecewise Linear Contrast Stretching

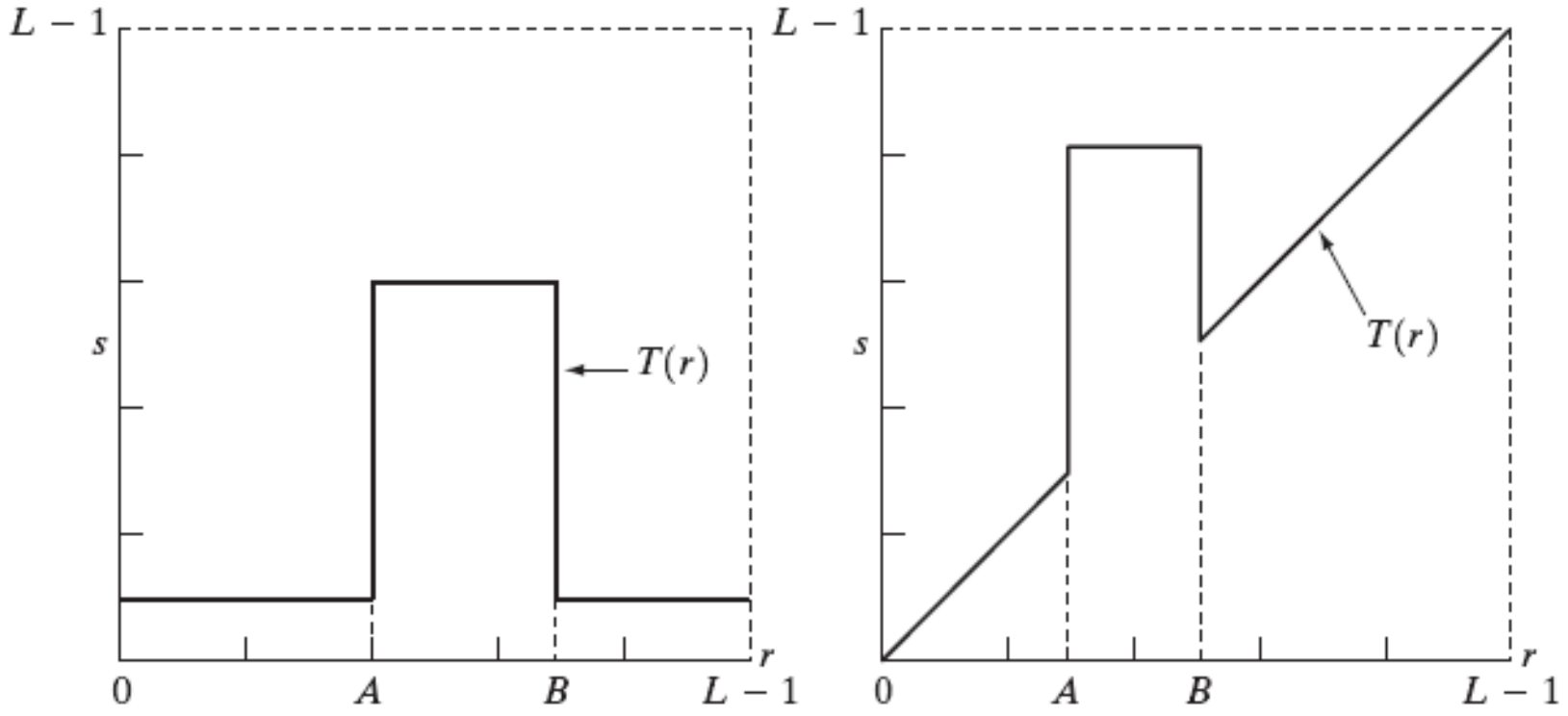
Example: original



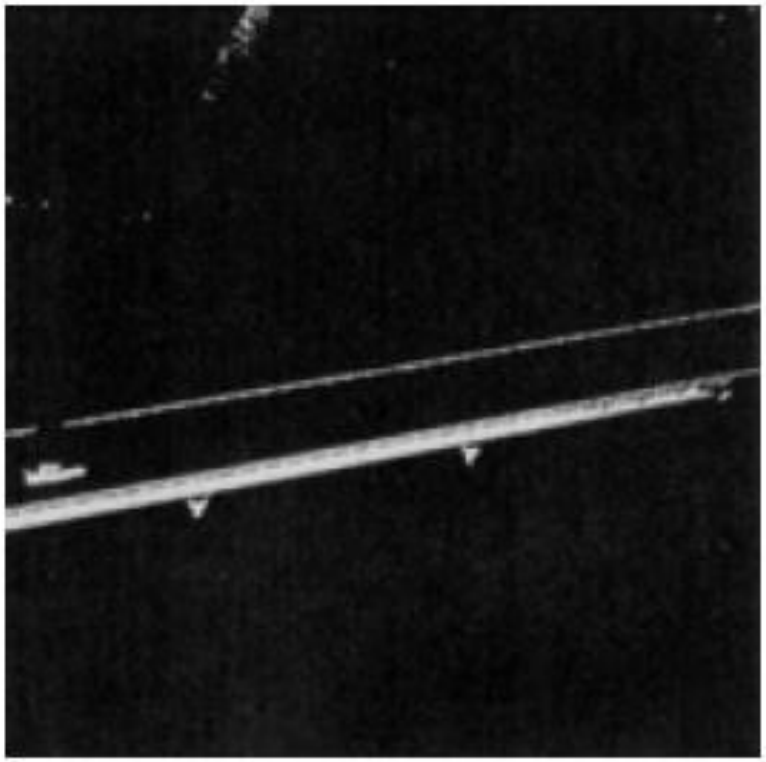
windowed



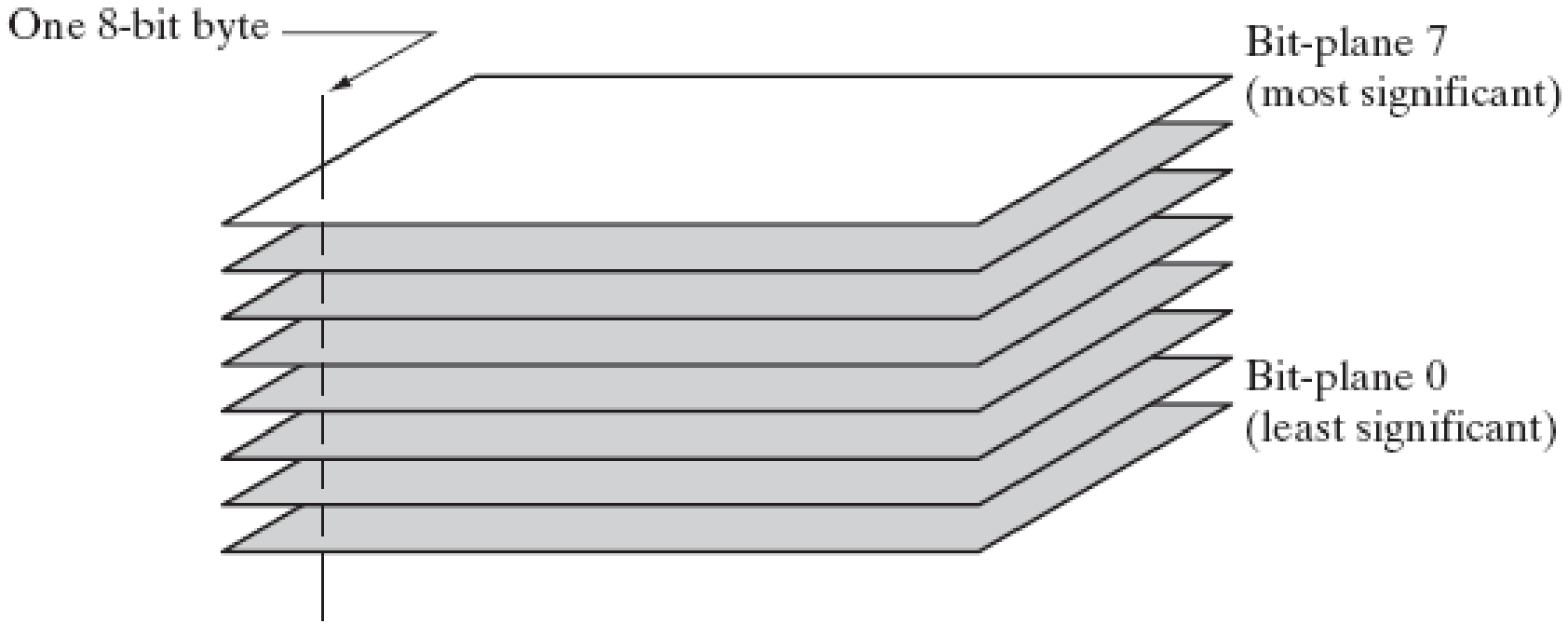
Gray Level Slicing



Gray Level Slicing Example



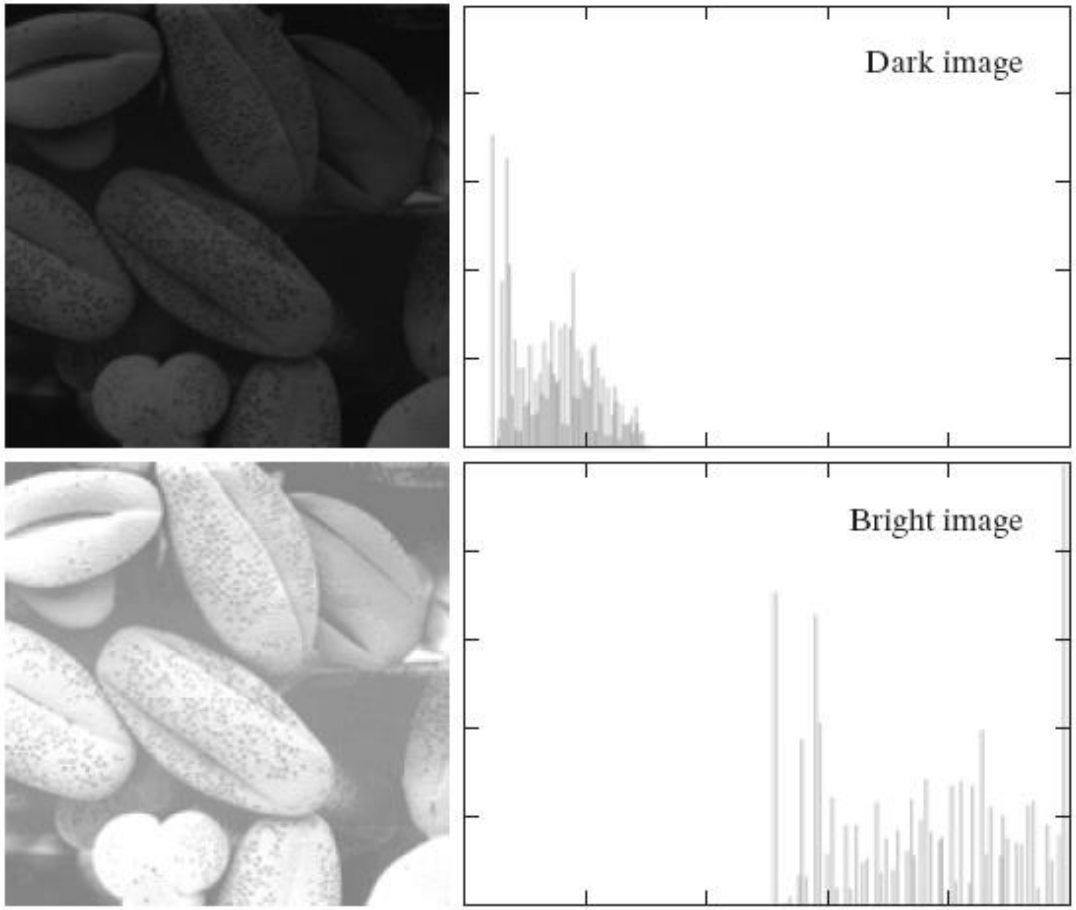
Bit-plane Slicing

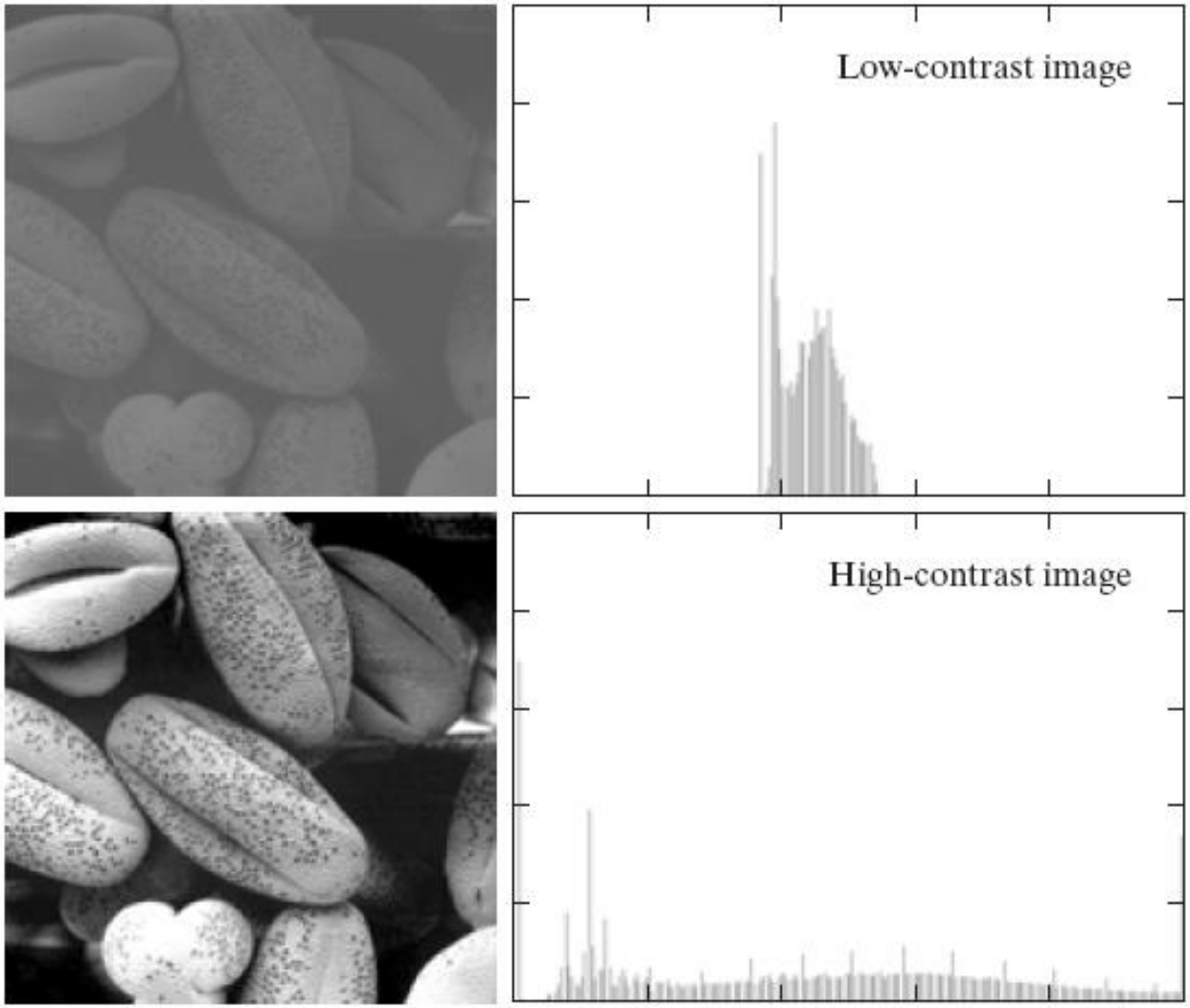


Histogram Analysis

- The histogram of a digital image with gray levels in the range [0, L-1] is a discrete function $h(r_k)=n_k$, where r_k is the *k^{th} gray level and n_k is the number* of pixels in the image having gray level r_k.

Example




Low-contrast image
High-contrast image

Histogram Equalization

- Histogram equalization is mapping each pixel with level r_k in the input image into a corresponding pixel with level s_k in the output image

- After equalization the gray levels in the histogram are more uniformly distributed

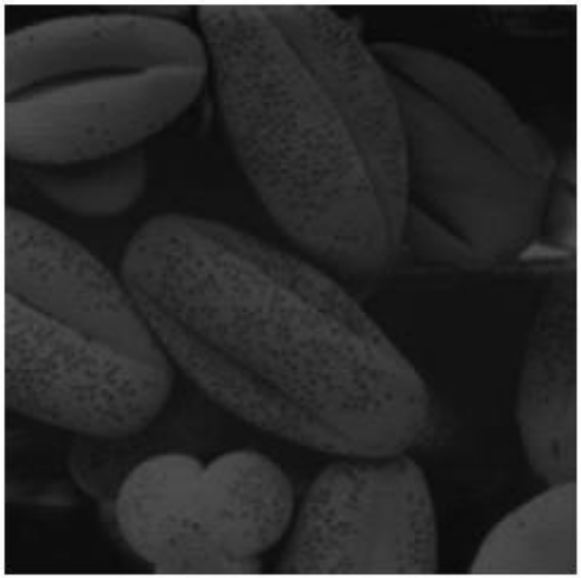
Histogram equalization (cont.)

- The probability of occurrence of gray level r_k in an image is approximated by $p_r(r_K) = n_k/n$ for k=0,..,L-1

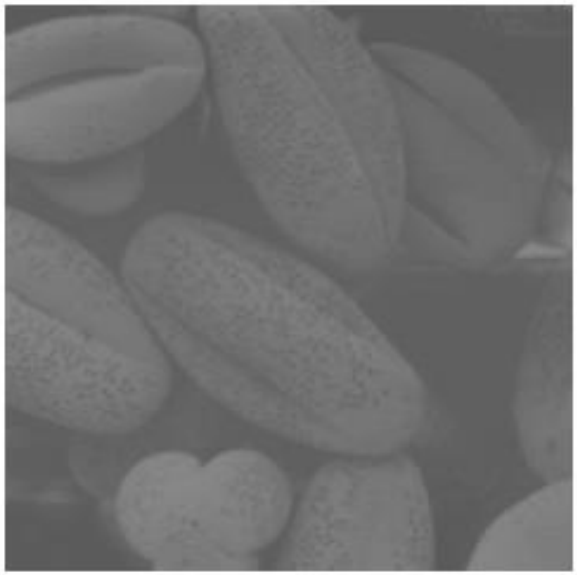
- The converted gray level value is:

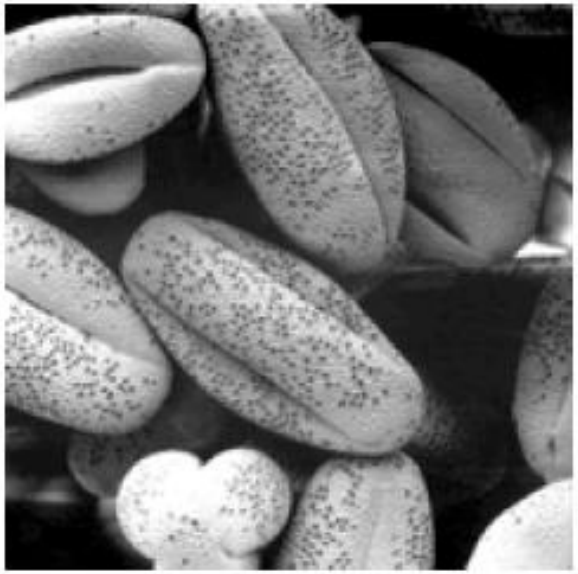
$$S_k = T(r_k) = \sum_{j=0}^{k} P_r(r_j) = \sum_{j=0}^{k} \frac{n_j}{n}$$

for k=0,.., L-1

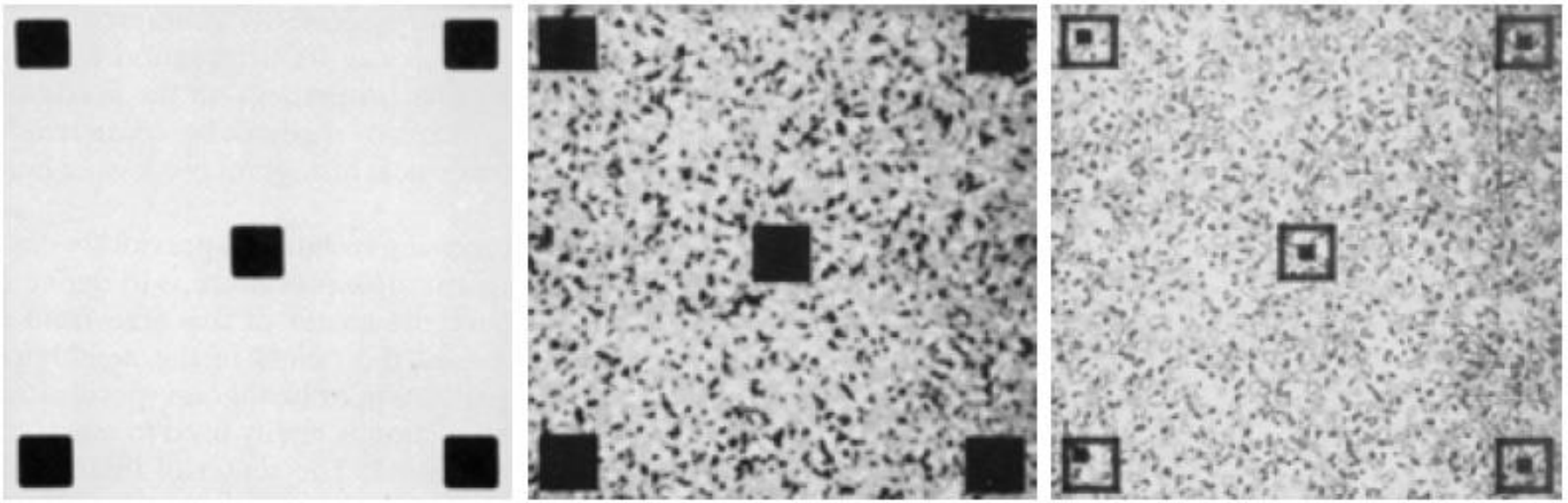




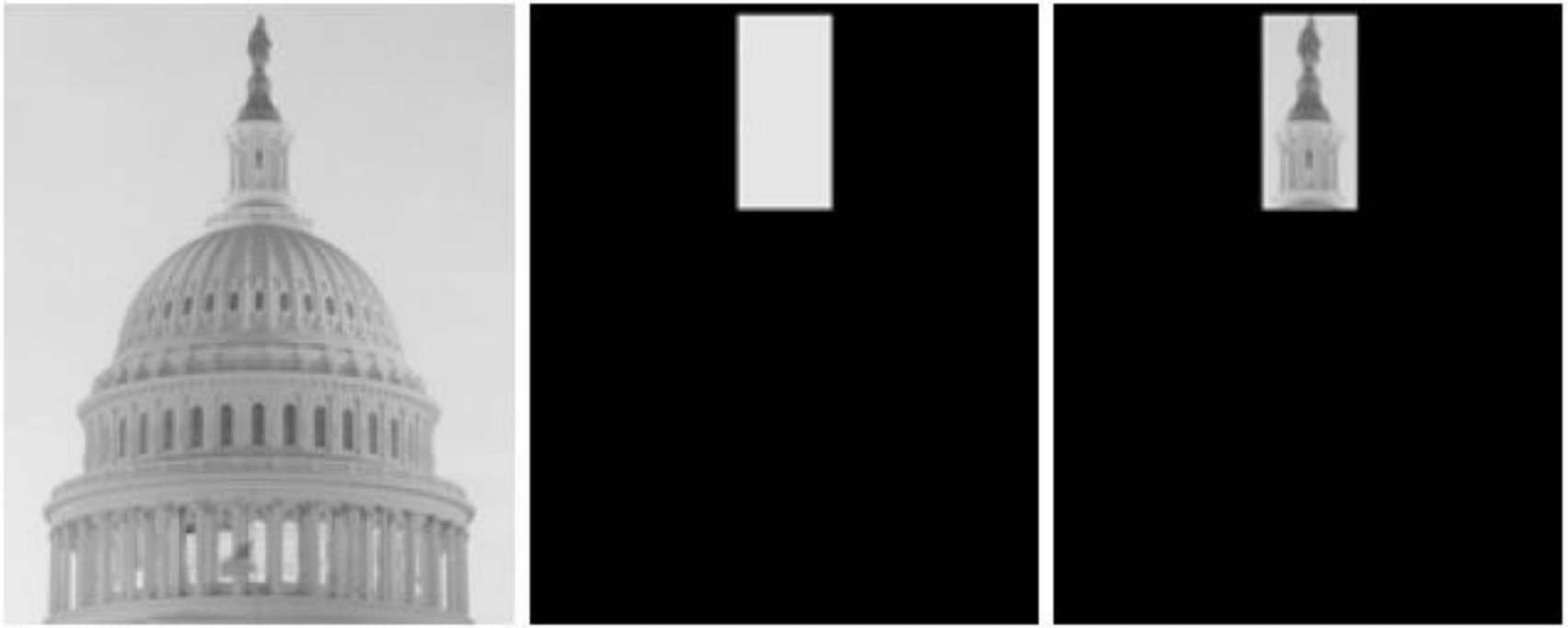



Local Histogram Equalization



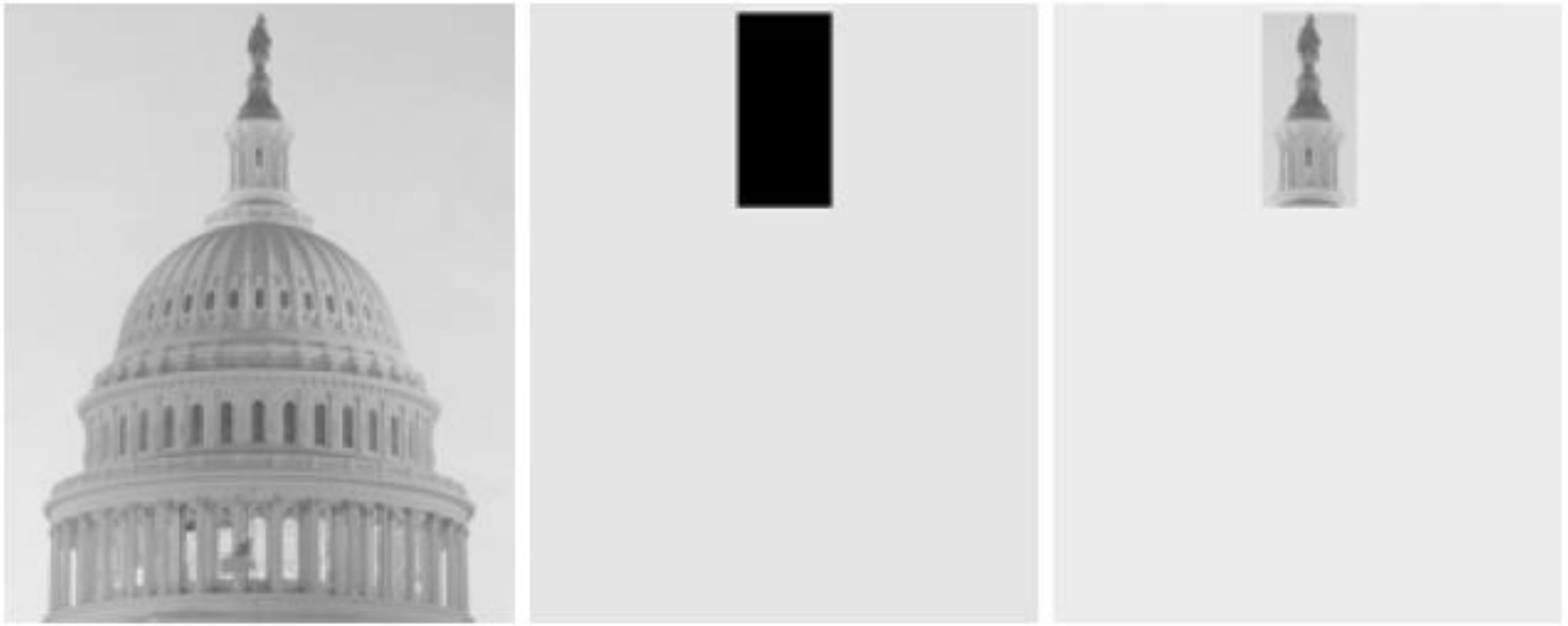
Logical Operations

- Logical AND



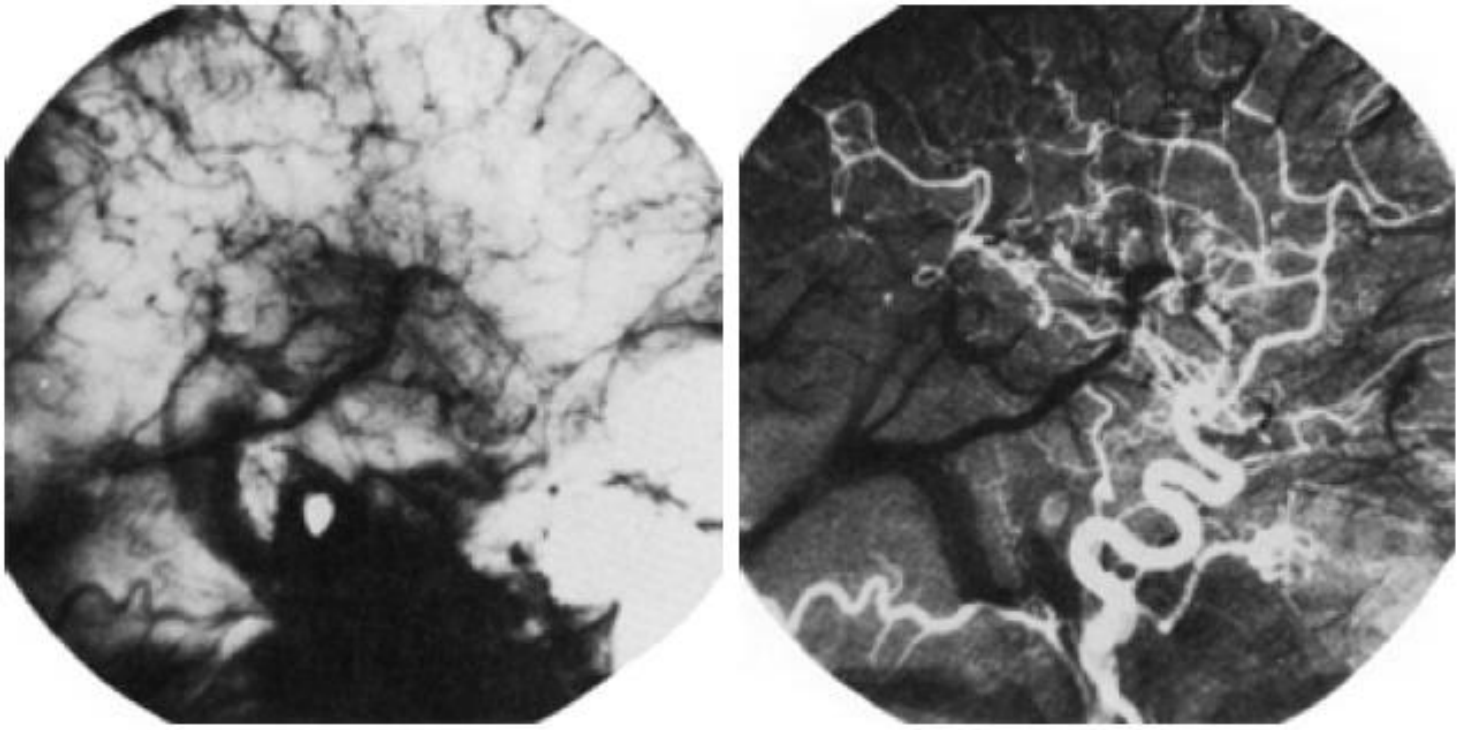
Logical Operations

- Logical OR



Arithmetic Operations

- Image subtraction



Motion Detection by Image Subtraction

Questions?