DIGITAL IMAGE PROCESSING

Image Enhancement in Spatial Domain : Session1

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Today's Lecture

- **Image Enhancement in Spatial Domain**
    - **Intensity Transform**

Image Enhancement in Spatial Doma

Spatial Domain Vs. Transform Domain

- **Spatial domain:** image plane itself, directly process the intensity values of the image plane

- **Transform domain:** process the transform coefficients, not directly process the intensity values of the image plane

Image Enhancement in Spatial Doma

Spatial Domain Process

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

$f(x, y)$: input image

$g(x, y)$: output image

T: an operator of f defined over a neighborhood of point (x, y).

Image Enhancement in Spatial Domain

Spatial Domain Process

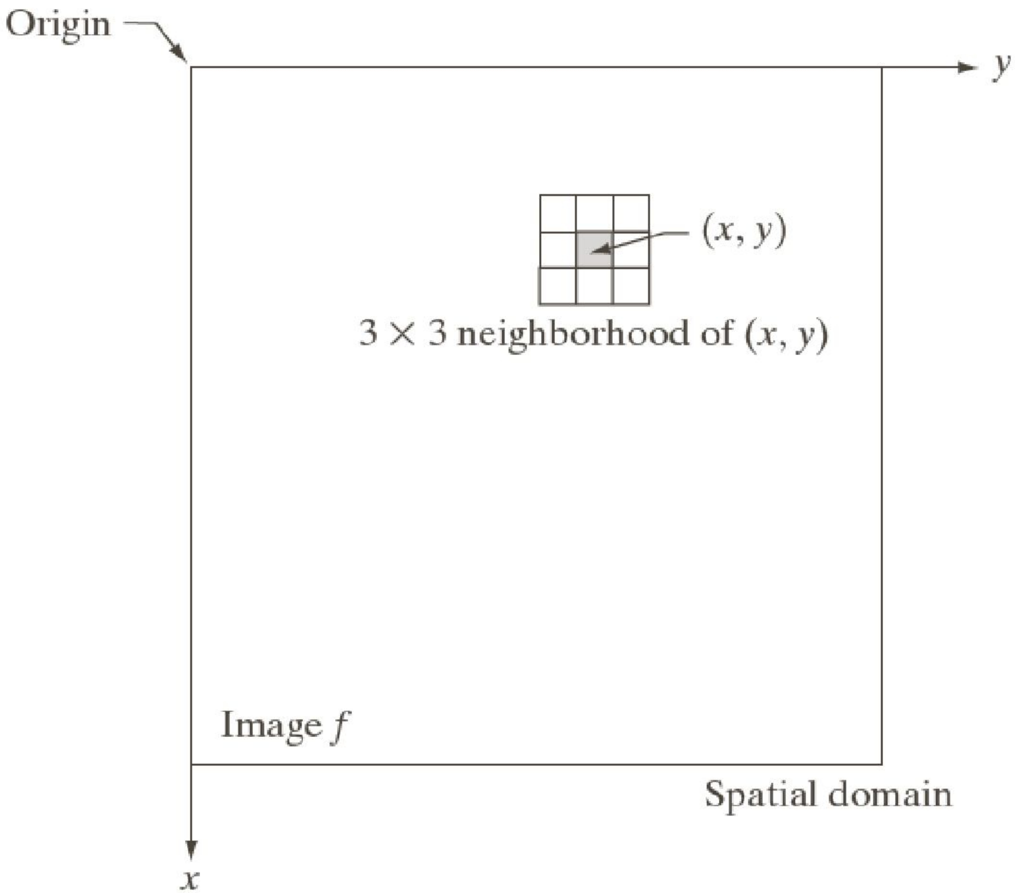
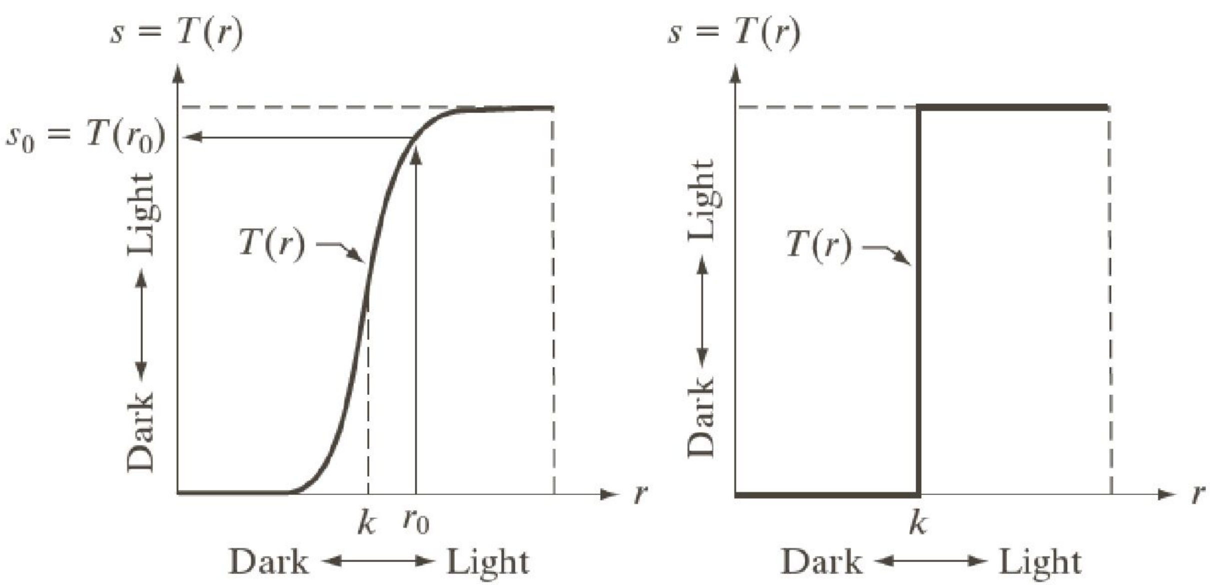


FIGURE 3.1 A 3 × 3 neighborhood about a point (x, y) in an image in the spatial domain. The neighborhood is moved from pixel to pixel in the image to generate an output image.

Image Enhancement in Spatial Domain

Spatial Domain Process

Intensity Transformation Function: $s = T(r)$



a b

FIGURE 3.2 Intensity transformation functions. (a) Contrast-stretching function. (b) Thresholding function.

Image Enhancement in Spatial Doma

Some Basic Intensity Transformation Functions

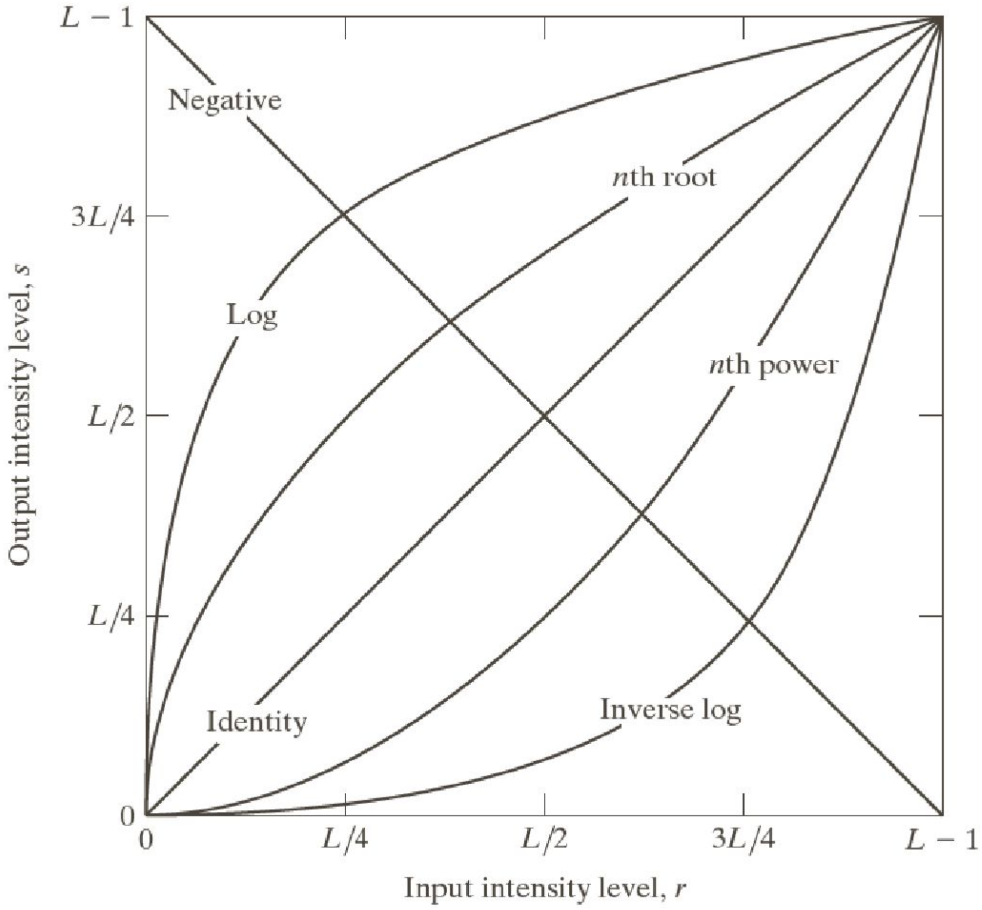


FIGURE 3.3 Some basic intensity transformation functions. All curves were scaled to fit in the range shown.

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Some Basic Intensity Transformation Functions

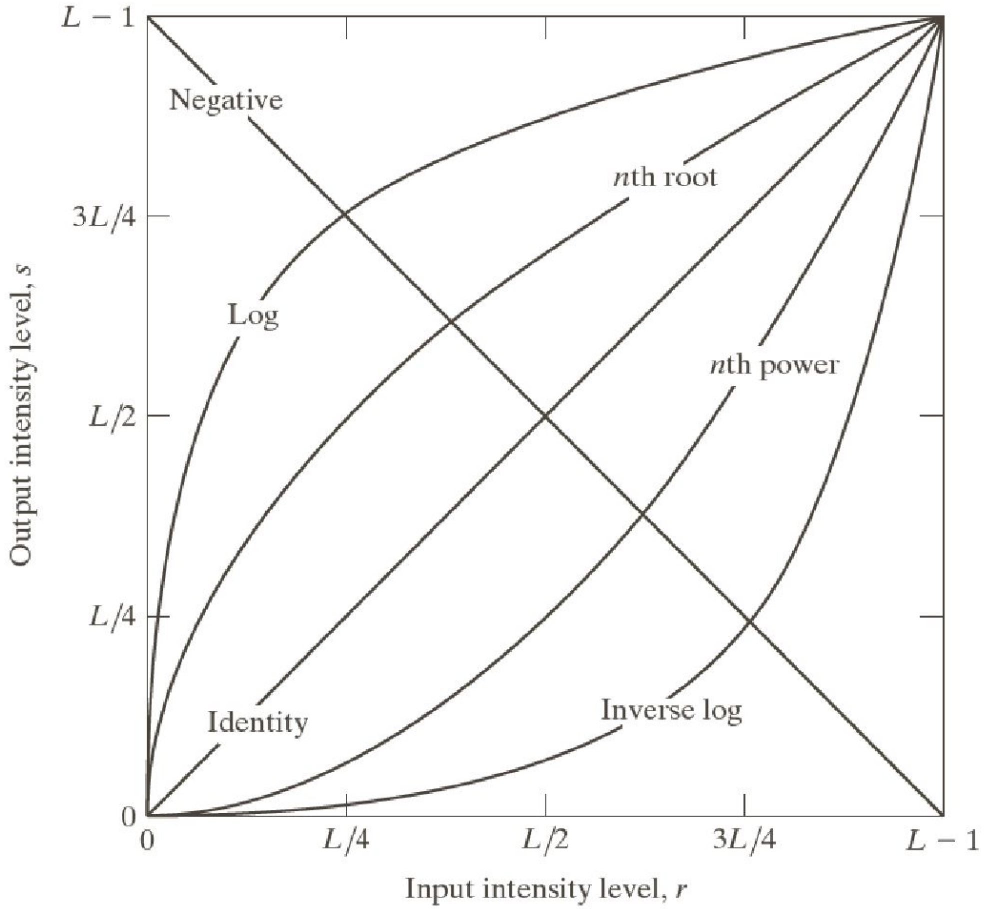


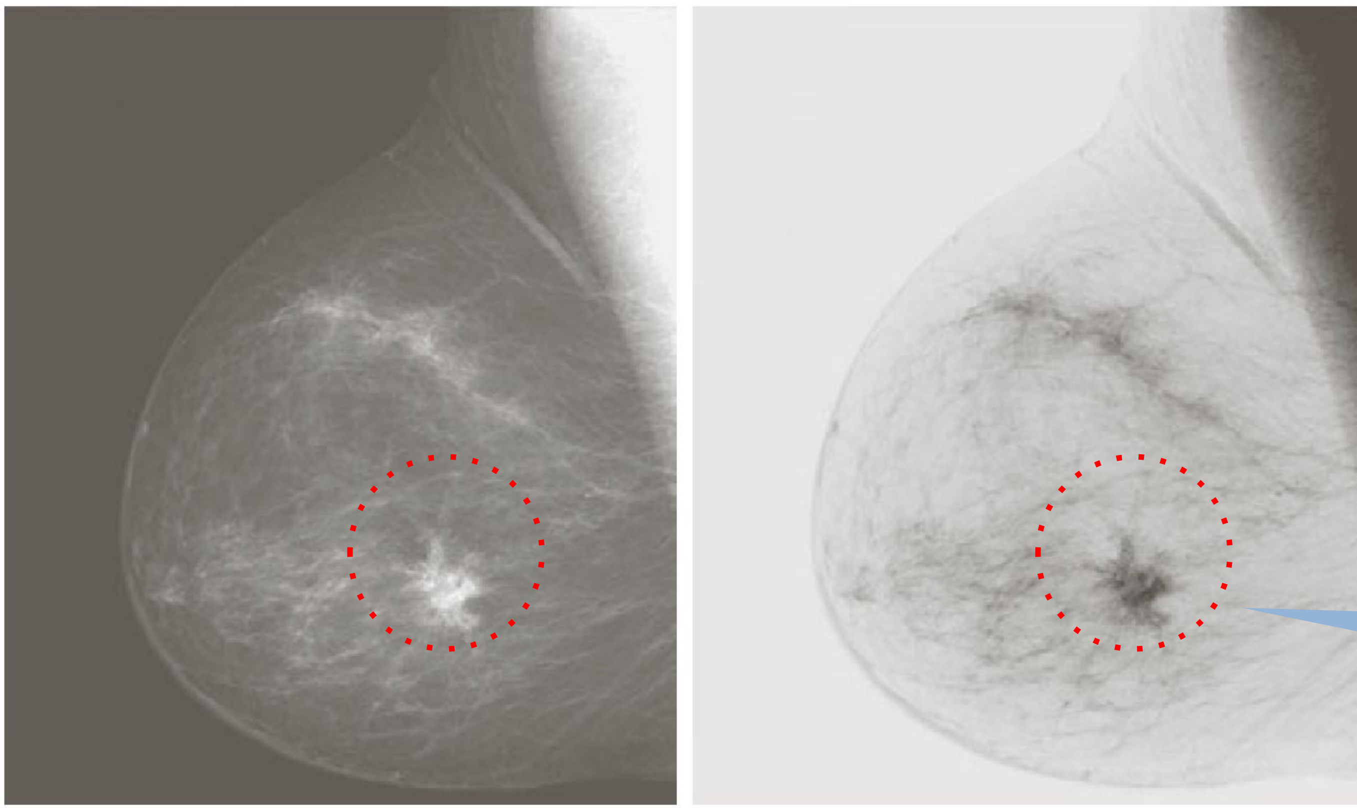
Image negatives

$$s = L - 1 - r$$

Image Enhancement in Spatial Doma

Some Basic Intensity Transformation Functions

Example: Image Negative

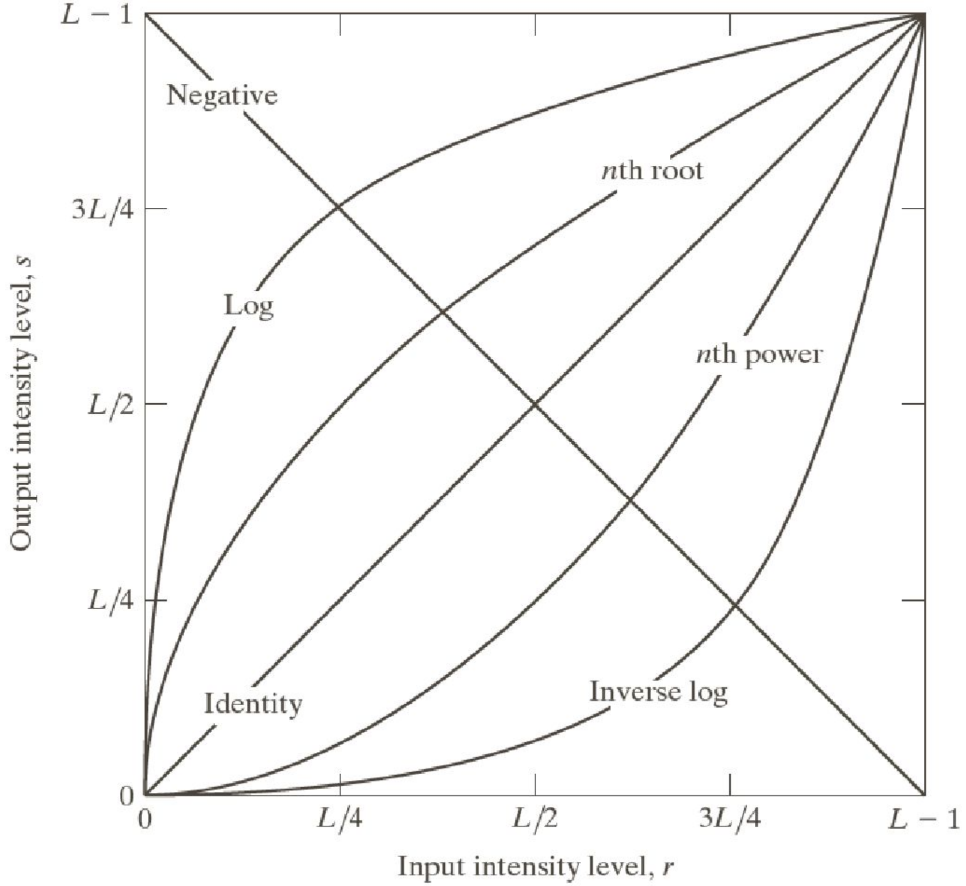


a b

FIGURE 3.4
(a) Original digital mammogram.
(b) Negative image obtained using the negative transformation in Eq. (3.2-1).
(Courtesy of G.E. Medical Systems.)

Image Enhancement in Spatial Doma

Some Basic Intensity Transformation Functions



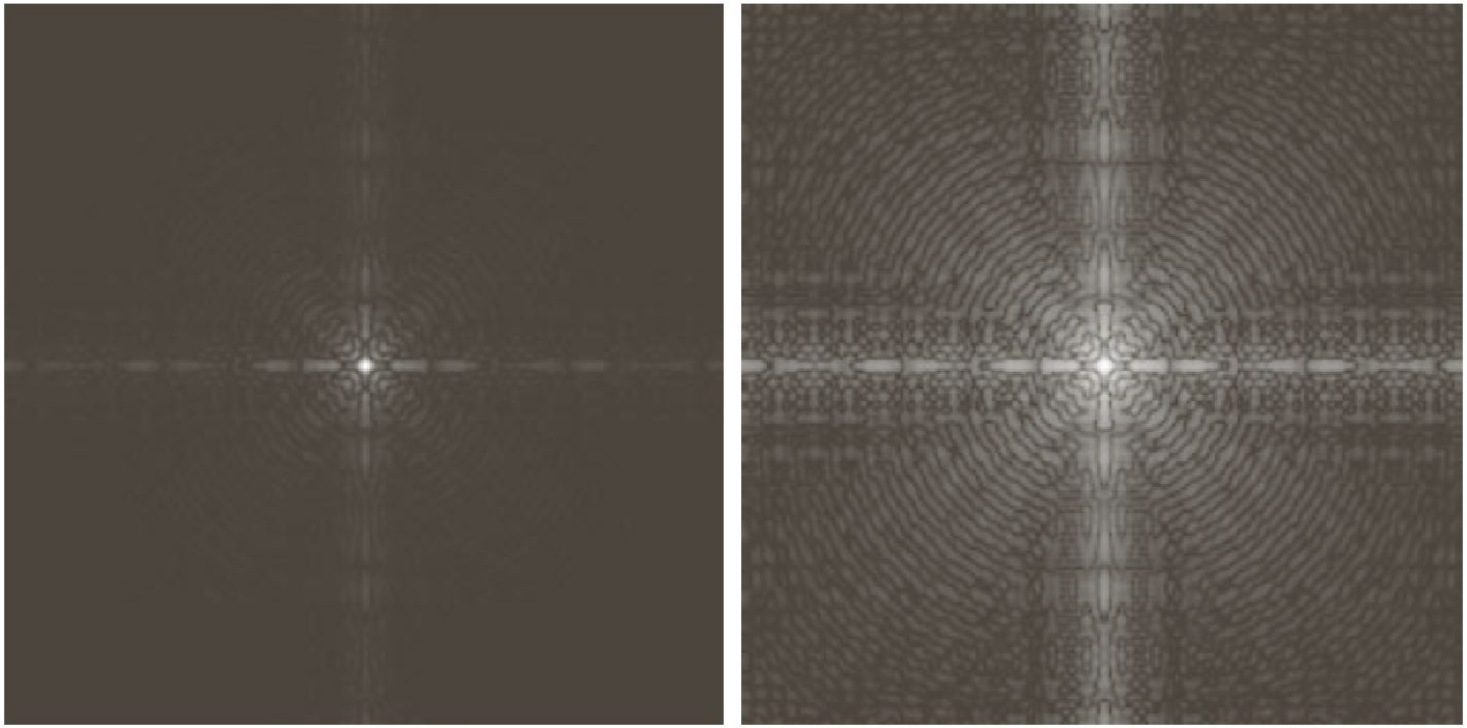
Log Transformations

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

Image Enhancement in Spatial Doma

Some Basic Intensity Transformation Functions

Example: Log Transformations

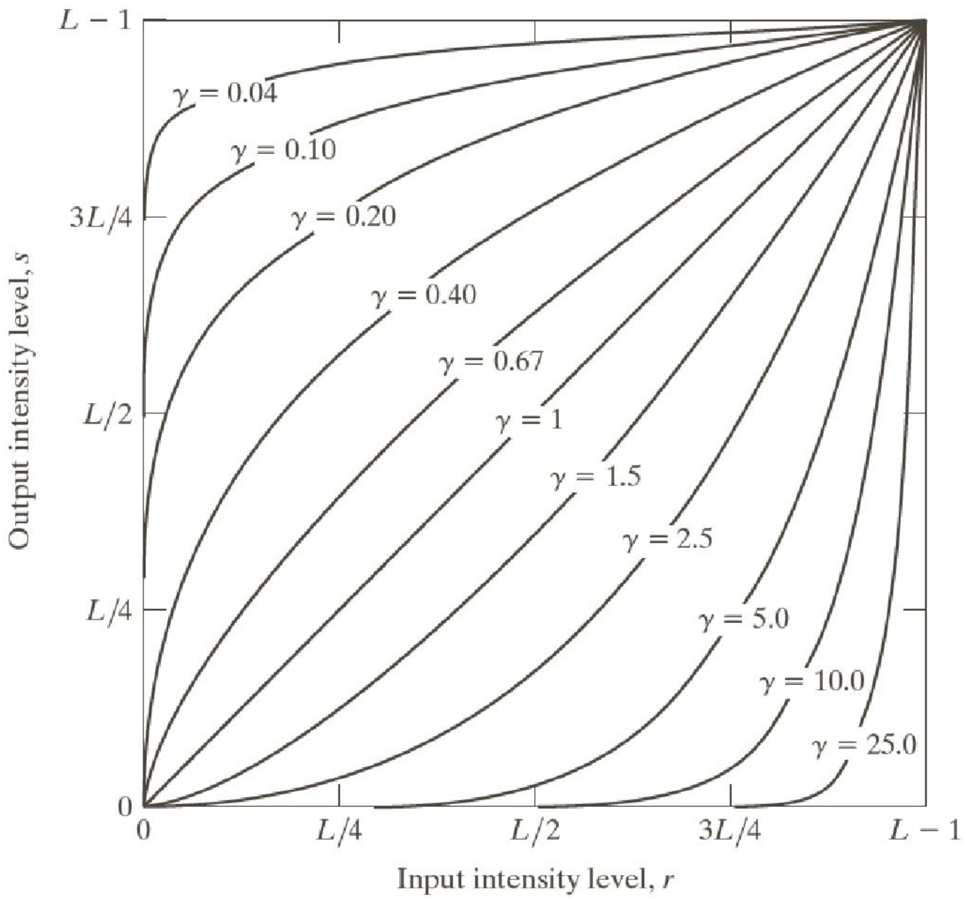


a b

FIGURE 3.5
(a) Fourier spectrum.
(b) Result of applying the log transformation in Eq. (3.2-2) with $c = 1$.

Image Enhancement in Spatial Doma

Some Basic Intensity Transformation Functions



Power-Law (Gamma) Transformations

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

FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases). All curves were scaled to fit in the range shown.

Image Enhancement in Spatial Doma

Some Basic Intensity Transformation Functions

Example: Gamma Transformations

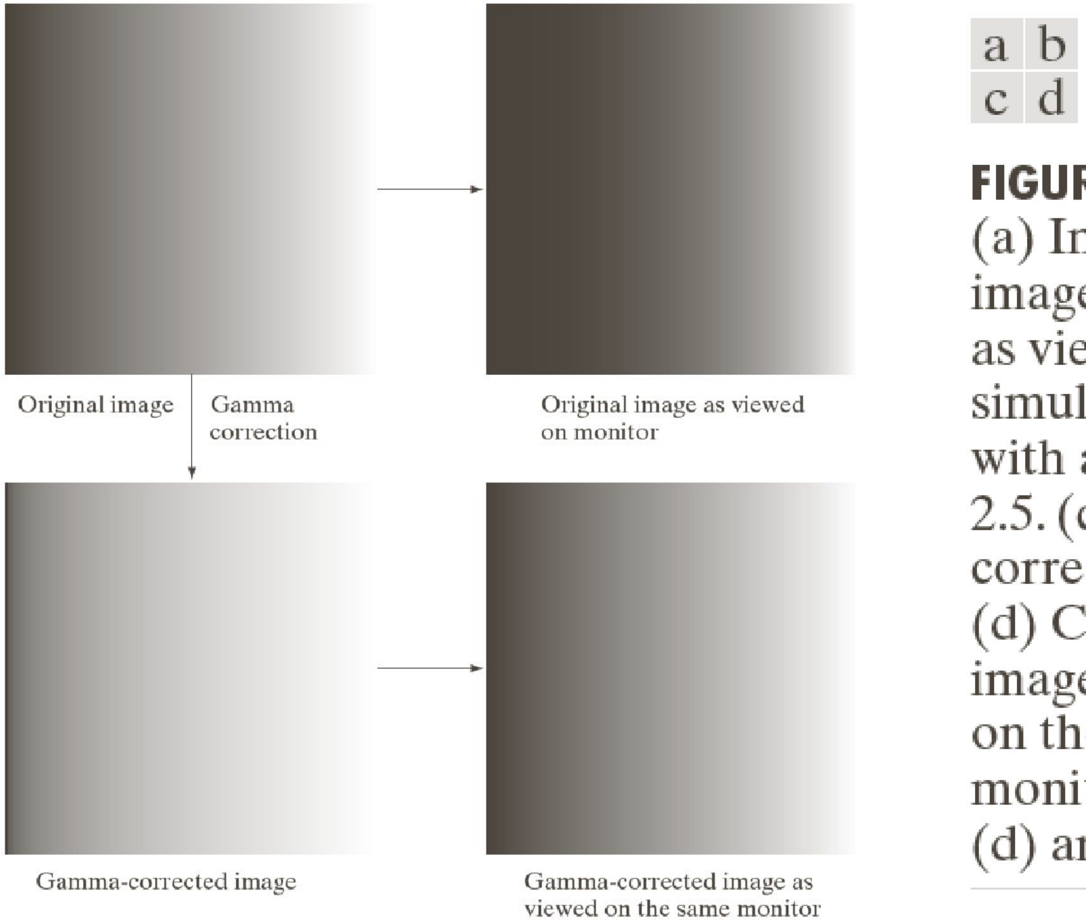
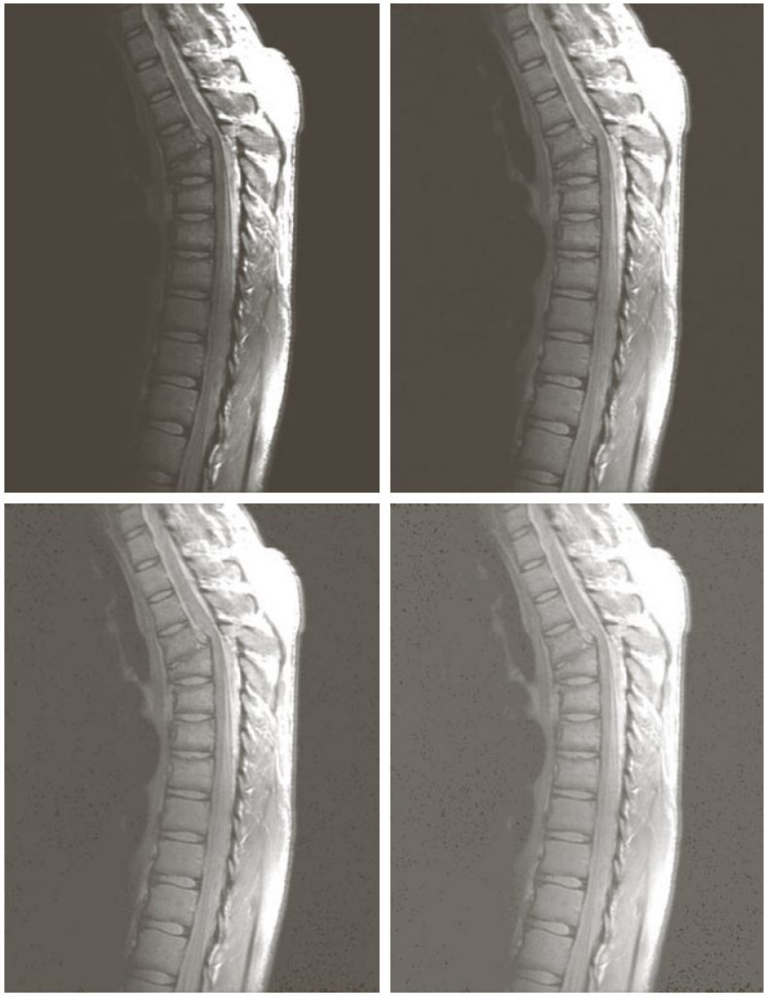


FIGURE 3.7
(a) Intensity ramp image. (b) Image as viewed on a simulated monitor with a gamma of 2.5. (c) Gamma-corrected image. (d) Corrected image as viewed on the same monitor. Compare (d) and (a).

Image Enhancement in Spatial Domain

More Example: Gamma Transformations



a	b
c	d

FIGURE 3.8 (a) Magnetic resonance image (MRI) of a fractured human spine. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 0.6, 0.4,$ and 0.3, respectively. (Original image courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

Image Enhancement in Spatial Doma

More Example: Gamma Transformations

a	b
c	d

FIGURE 3.9 (a) Aerial image. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0, 4.0,$ and 5.0, respectively. (Original image for this example courtesy of NASA.)

Image Enhancement in Spatial Doma

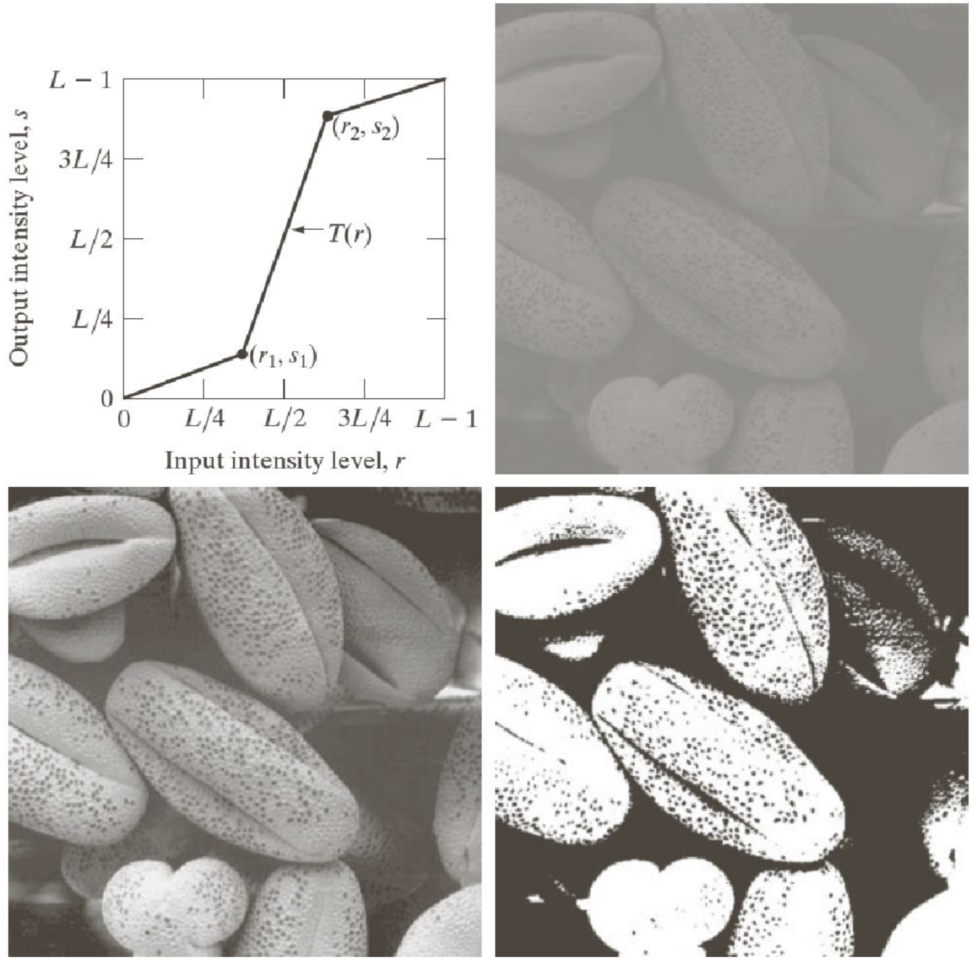
Piecewise-Linear Transformations

- **Contrast Stretching**
  Expands the range of intensity levels in an image so that it spans the full intensity range of the recording medium or display device.

- **Intensity-level Slicing**
  Highlighting a specific range of intensities in an image often is of interest.

Image Enhancement in Spatial Domain

Piecewise-Linear Transformations

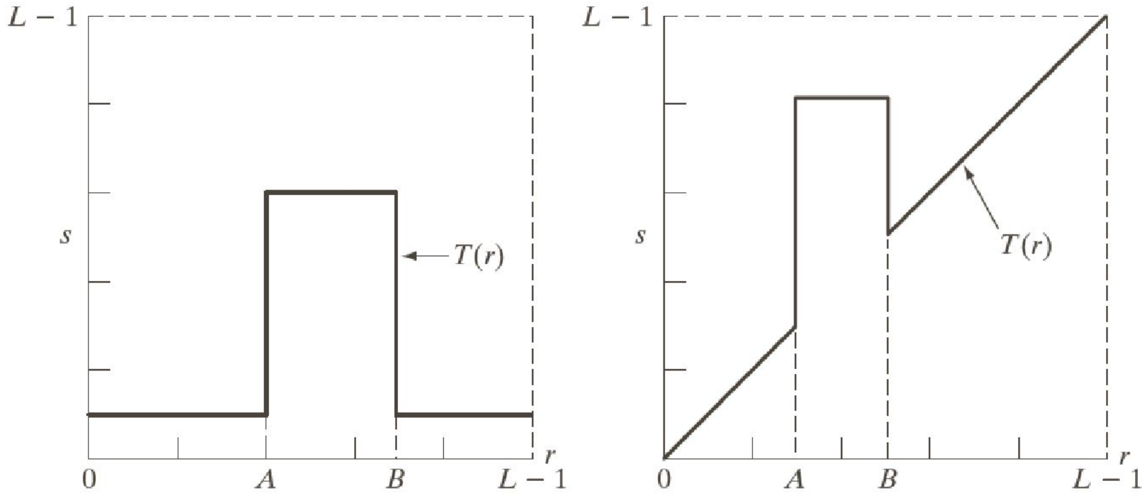


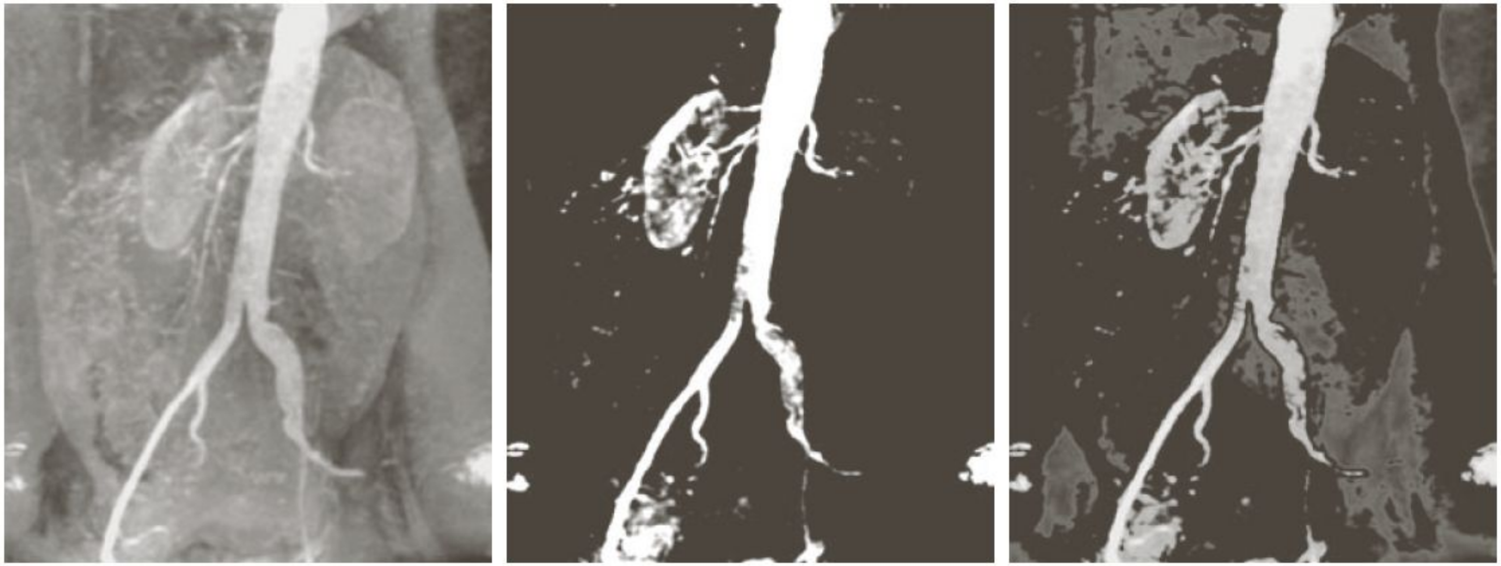
a	b
c	d

FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

a b

FIGURE 3.11 (a) This transformation highlights intensity range [A, B] and reduces all other intensities to a lower level. (b) This transformation highlights range [A, B] and preserves all other intensity levels.





a b c

FIGURE 3.12 (a) Aortic angiogram. (b) Result of using a slicing transformation of the type illustrated in Fig. 3.11(a), with the range of intensities of interest selected in the upper end of the gray scale. (c) Result of using the transformation in Fig. 3.11(b), with the selected area set to black, so that grays in the area of the blood vessels and kidneys were preserved. (Original image courtesy of Dr. Thomas R. Gest, University of Michigan Medical School.)

Image Enhancement in Spatial Doma

Bit-plane Slicing

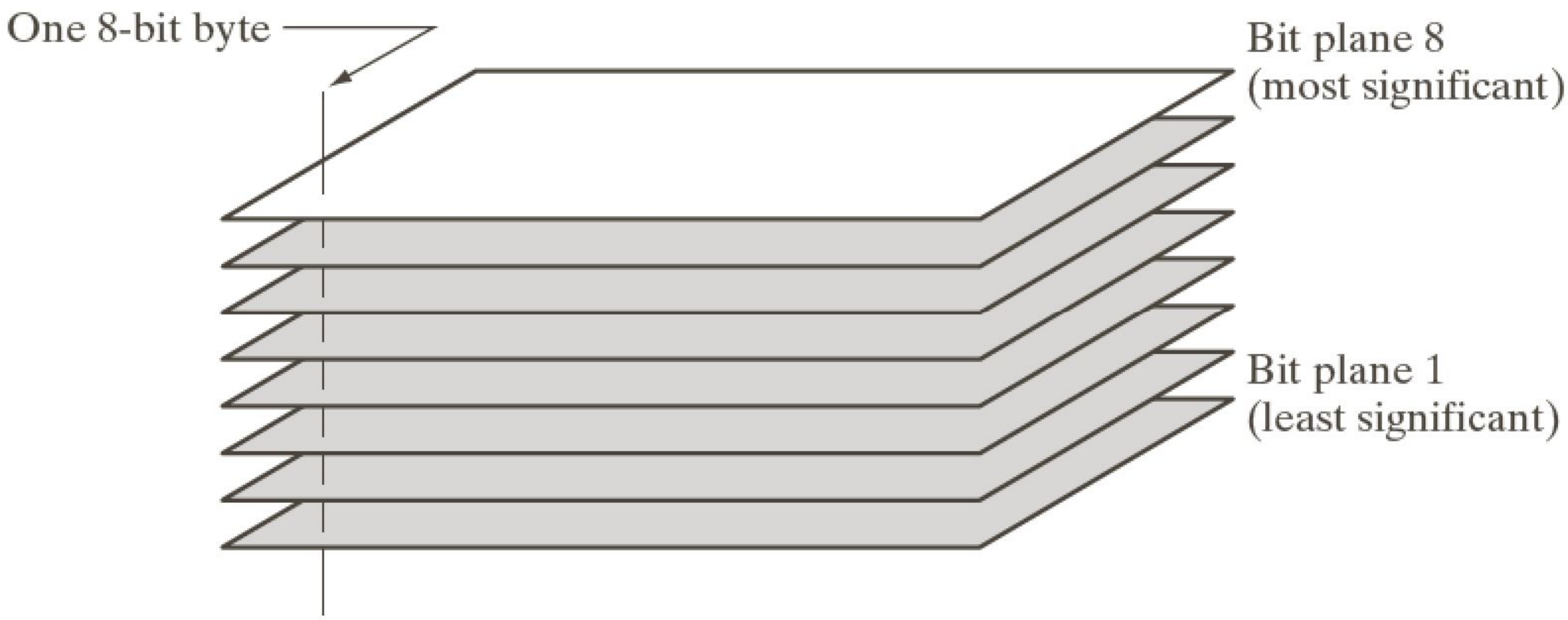


FIGURE 3.13
Bit-plane representation of an 8-bit image.

Image Enhancement in Spatial Doma

Bit-plane Slicing

a b c
d e f
g h i

FIGURE 3.14 (a) An 8-bit gray-scale image of size 500 × 1192 pixels. (b) through (i) Bit planes 1 through 8, with bit plane 1 corresponding to the least significant bit. Each bit plane is a binary image.

Image Enhancement in Spatial Doma

Bit-plane Slicing

a b c

FIGURE 3.15 Images reconstructed using (a) bit planes 8 and 7; (b) bit planes 8, 7, and 6; and (c) bit planes 8, 7, 6, and 5. Compare (c) with Fig. 3.14(a).

Image Enhancement in Spatial Doma

Histogram Processing

- Histogram Equalization
- Histogram Matching
- Local Histogram Processing
- Using Histogram Statistics for Image Enhancement

Image Enhancement in Spatial Doma

Histogram Processing

Histogram $h(r_k) = n_k$

r_k is the k^{th} intensity value

n_k is the number of pixels in the image with intensity r_k

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

n_k: the number of pixels in the image of size $\mathrm{M} \times \mathrm{N}$ with intensity r_k

Image Enhancement in Spatial Doma

Histogram Processing

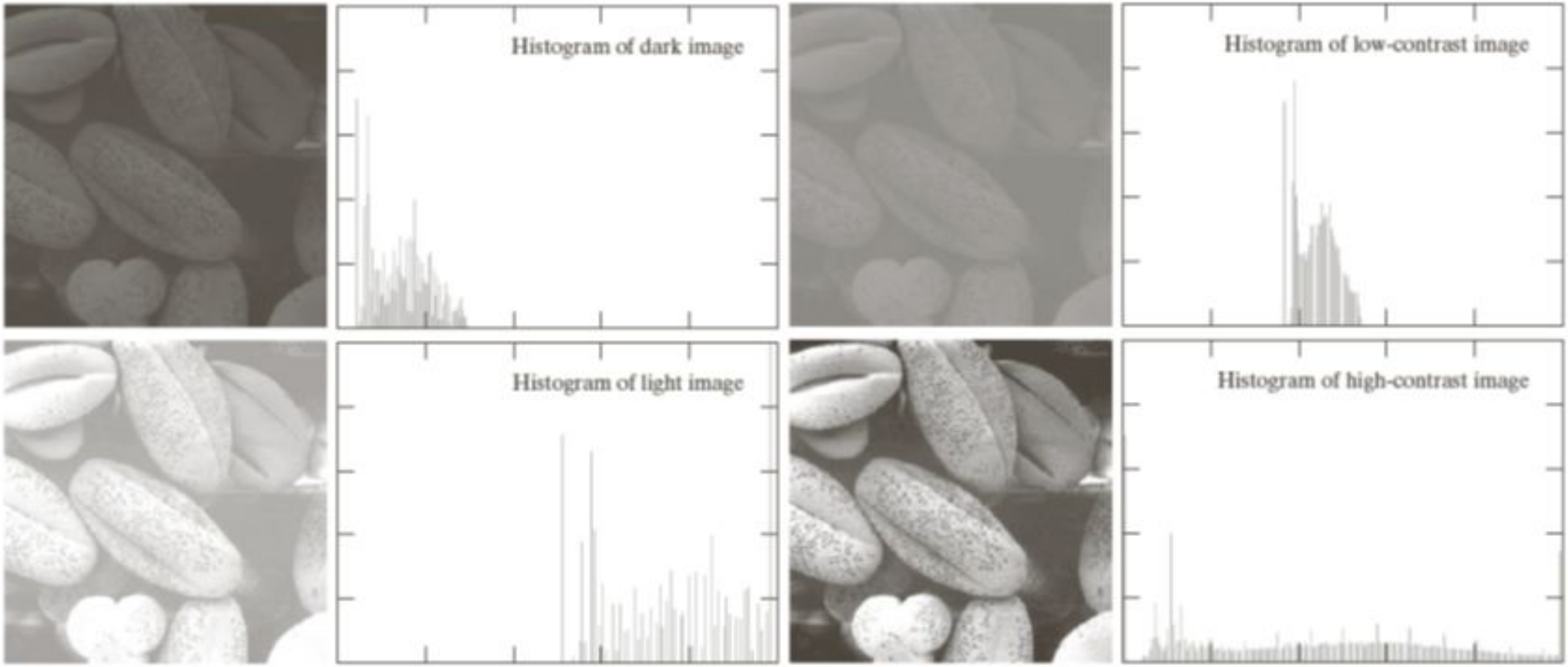
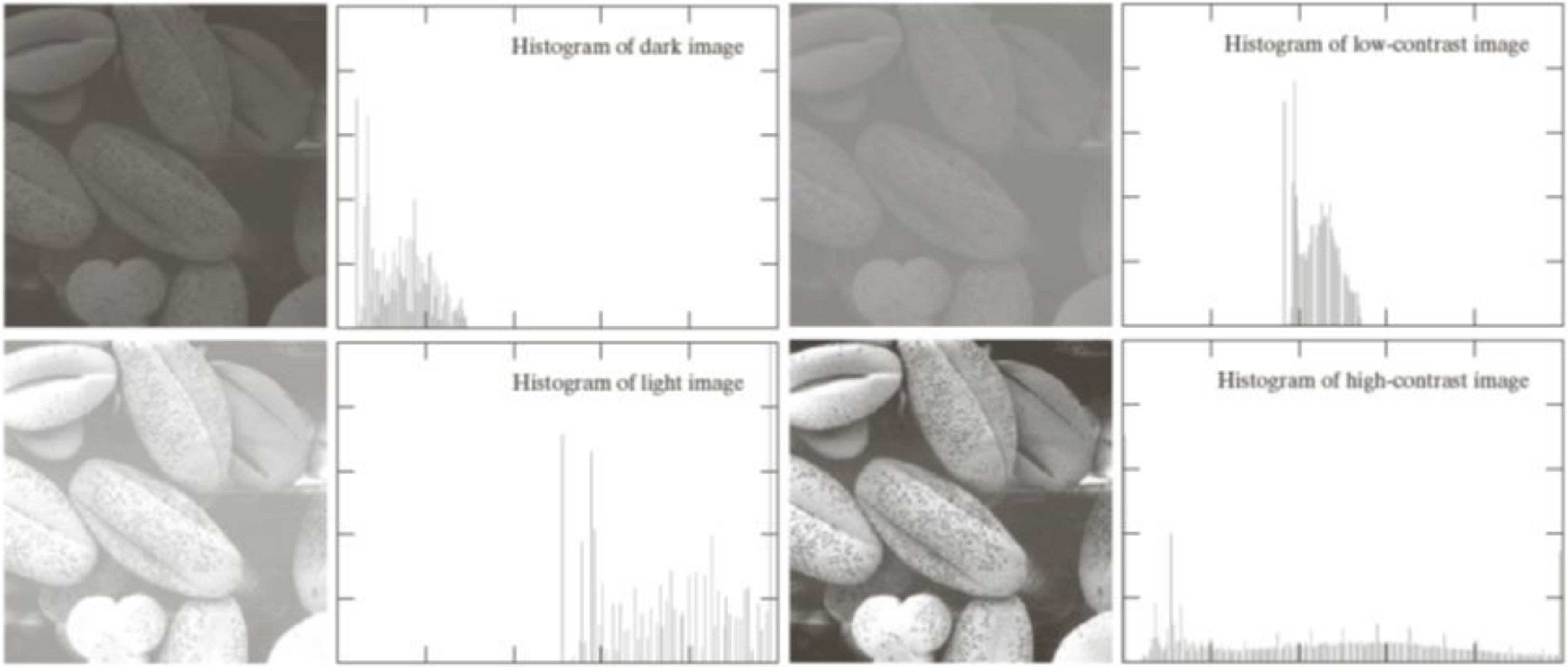


Image Enhancement in Spatial Doma

Histogram Processing



Next Class

- Image Enhancement in Spatial Domain
  - Histogram Equalization
  - Histogram Matching

Thank you:
Question?