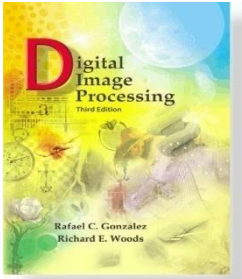
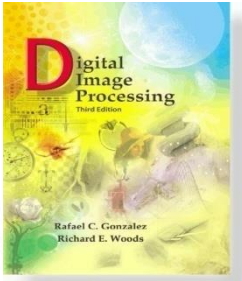


Intensity Transformations and Spatial Filtering

- **Image Enhancement:**
  - No Explicit definition
- **Methods**
  - Spatial Domain:
    - Linear
    - Nonlinear
  - Frequency Domain:
    - Linear
    - Nonlinear



Intensity Transformations and Spatial Filtering

- Spatial Domain Process

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

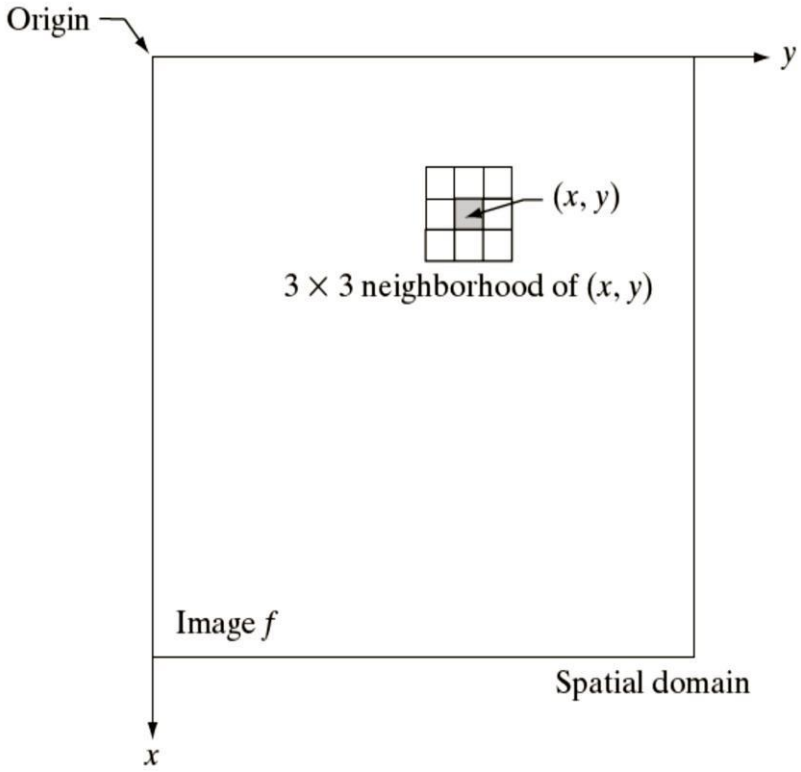
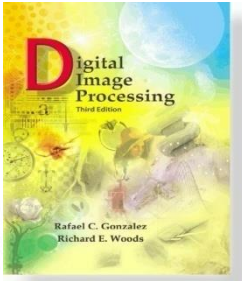
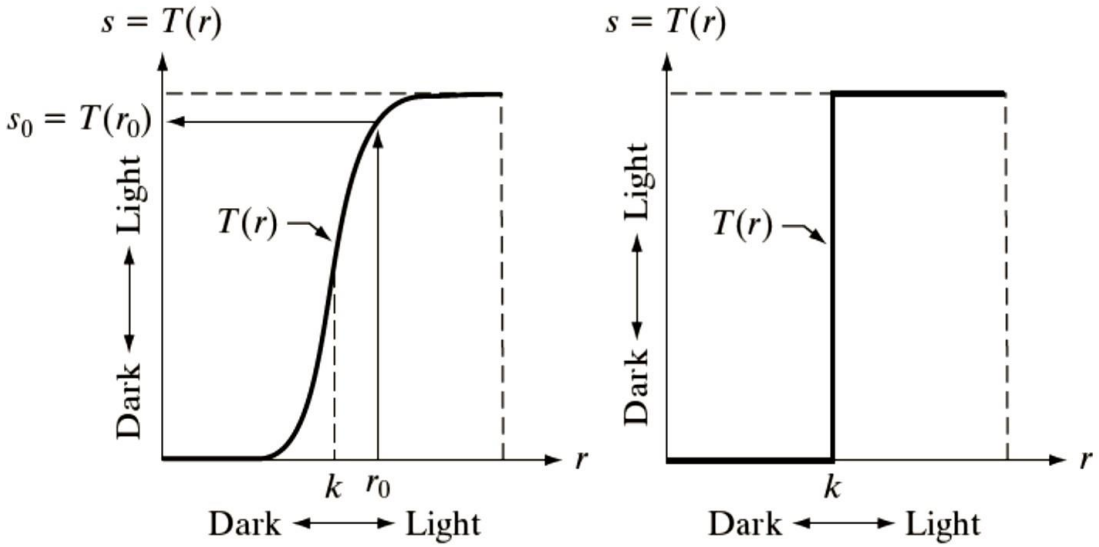


FIGURE 3.1 A 3 × 3 neighborhood about a point (x, y) in an image in the spatial domain. The neighborhood is moved from pixel to pixel in the image to generate an output image.



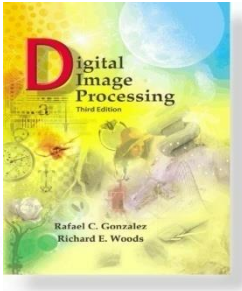
Intensity Transformations and Spatial Filtering

- For 1×1 neighborhood: $s = T(r)$
  - Contrast Enhancement/Stretching/Point Process
- For $w \times w$ neighborhood:
  - Filtering/Mask/Kernel/Window/Template Processing



a b

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



Intensity Transformations and Spatial Filtering

- Intensity Transformation Functions:

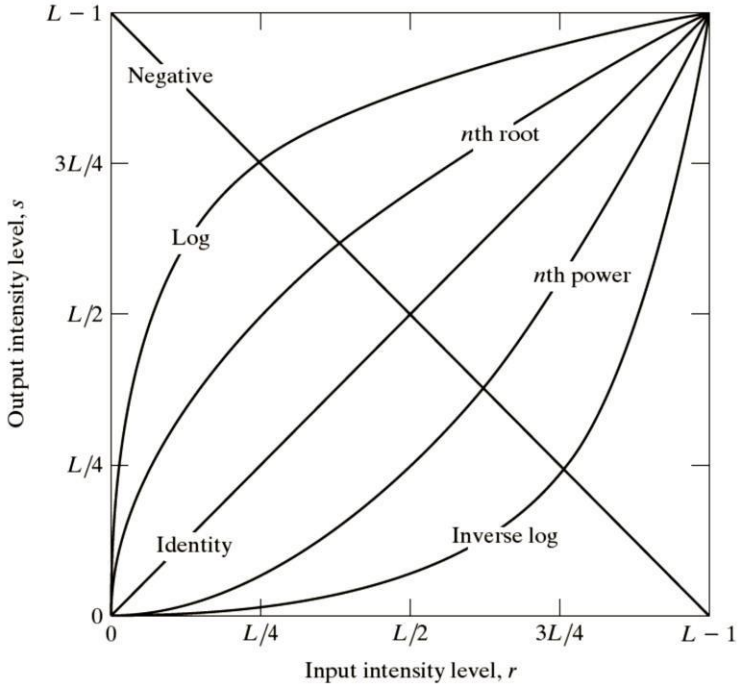
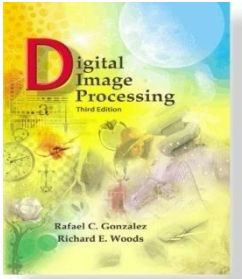


FIGURE 3.3 Some basic intensity transformation functions. All curves were scaled to fit in the range shown.



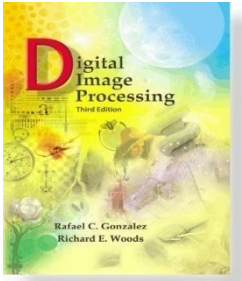
Intensity Transformations and Spatial Filtering

- Image Negatives:

ORIGINAL

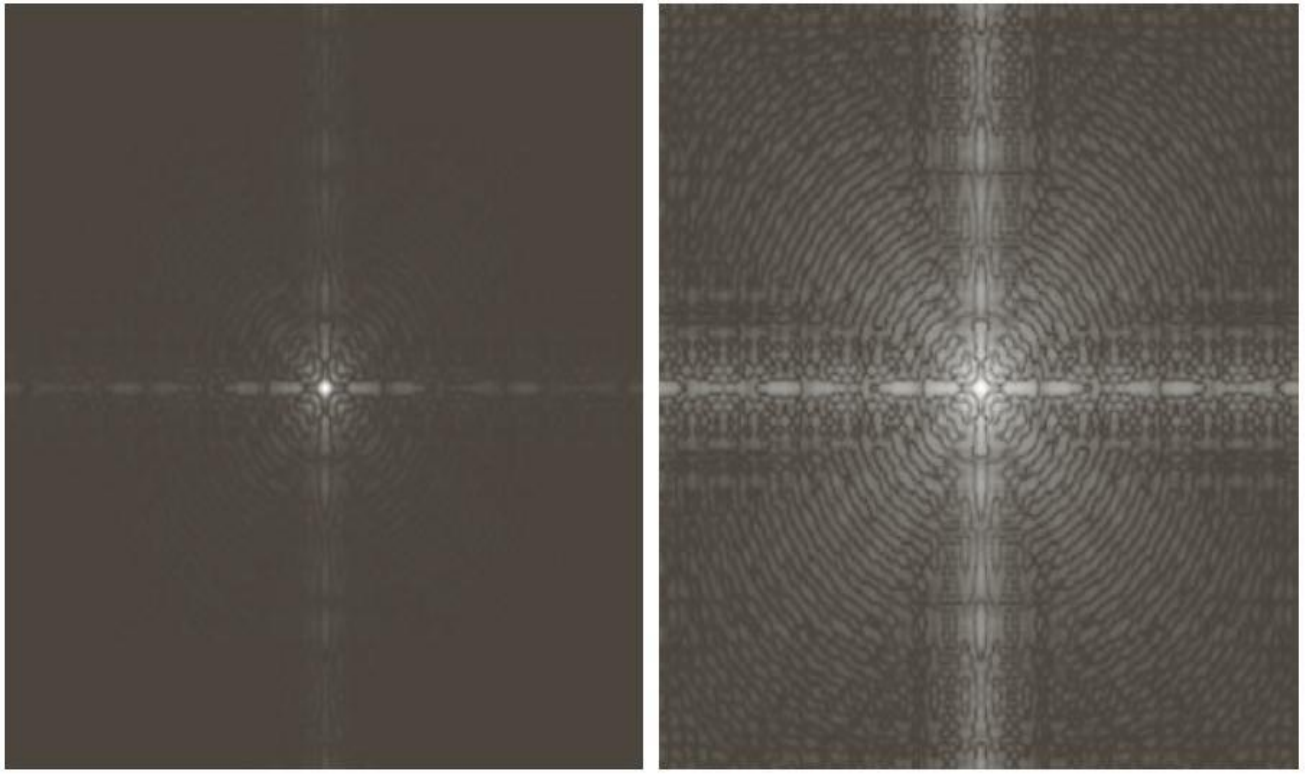
PHOTOGRAPHIC NEGATIVE

$$s = L - 1 - r$$



Intensity Transformations and Spatial Filtering

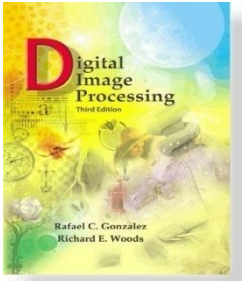
- Log Transform:



a b

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

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



Intensity Transformations and Spatial Filtering

- Power-Law Transform:

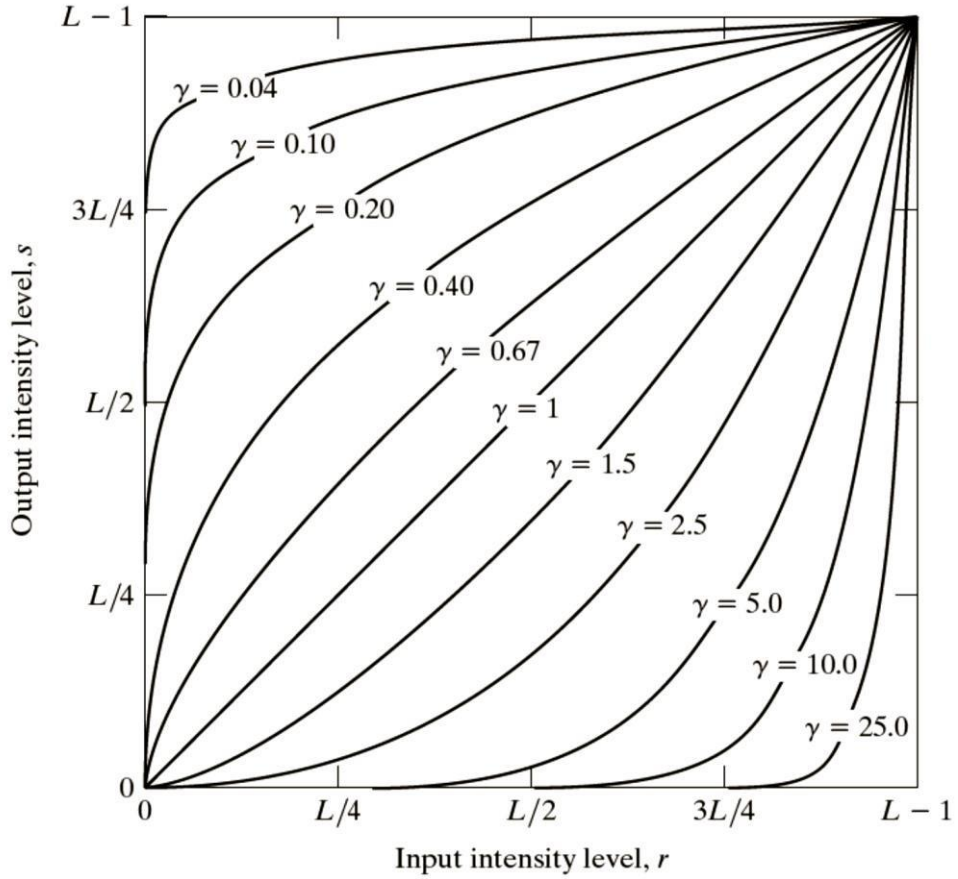
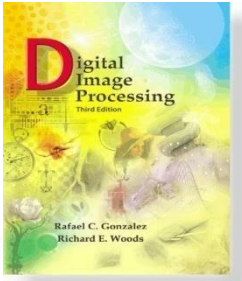


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases). All curves were scaled to fit in the range shown.

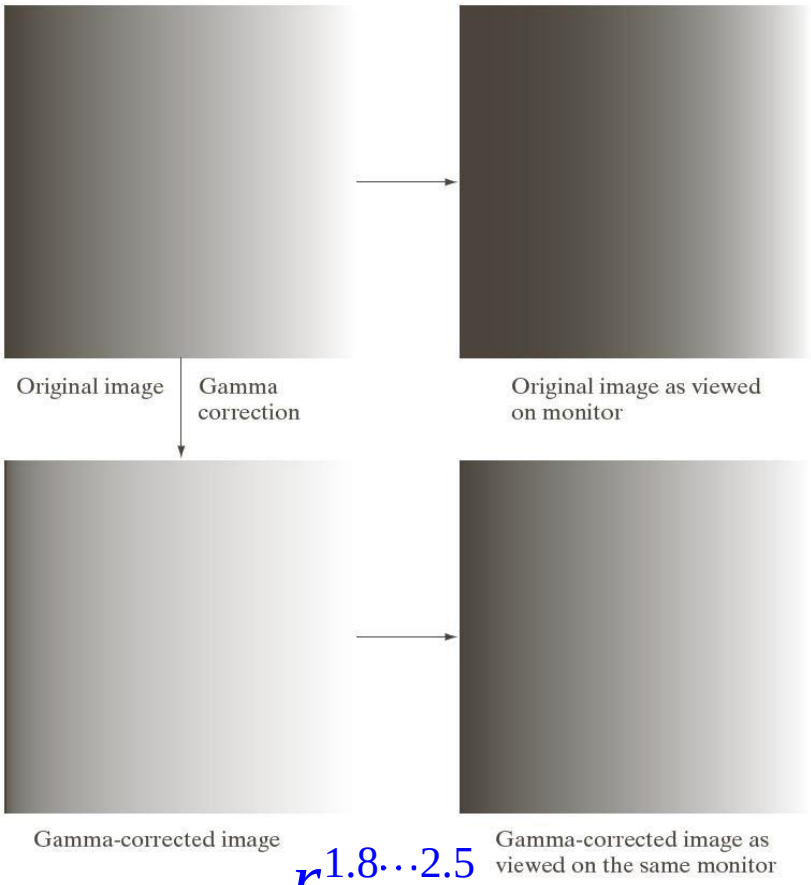
$$s = cr^{\gamma}$$



Intensity Transformations and Spatial Filtering

- Gamma Correction: $r^{1.8\cdots2.5}$

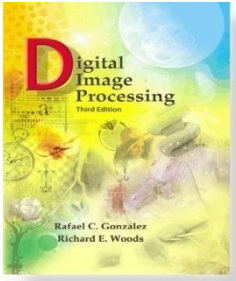
$r^{(1.8\cdots2.5)^{(-1)}}$



$r^{1.8\cdots2.5}$

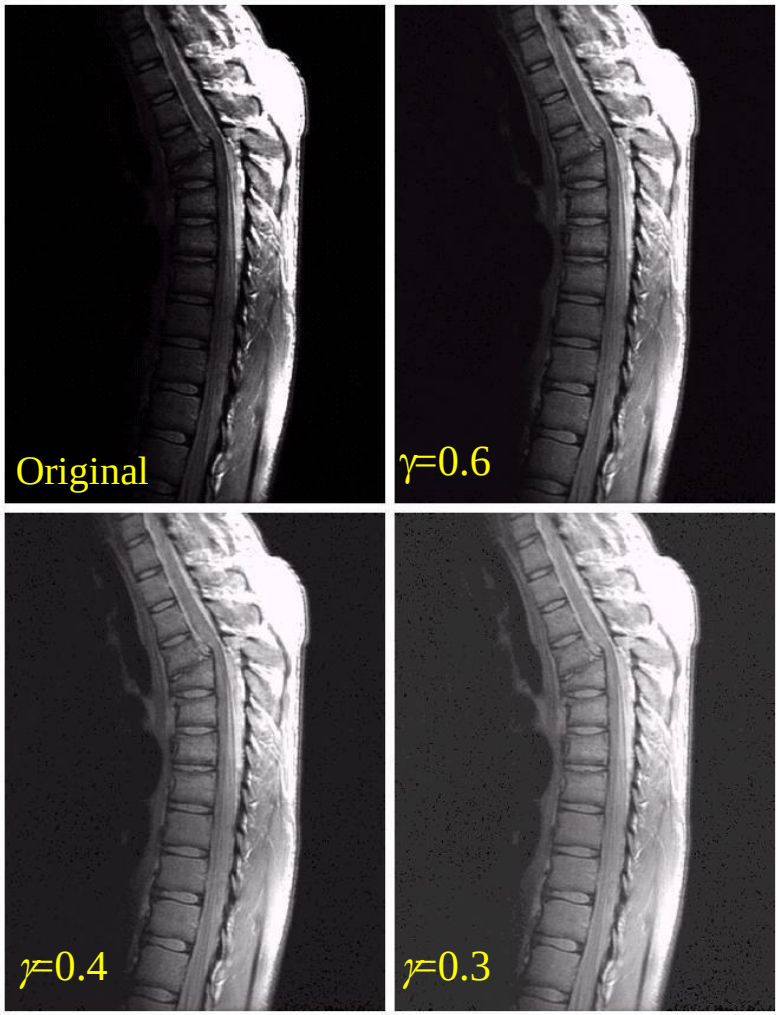
a b
c d

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).



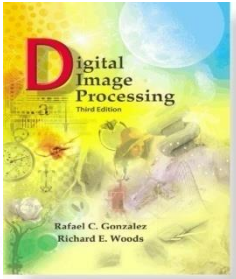
Intensity Transformations and Spatial Filtering

- Gamma Correction
  - Too Dark Image



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.)



Intensity Transformations and Spatial Filtering

- Gamma Correction
  - Too Bright Image

Original

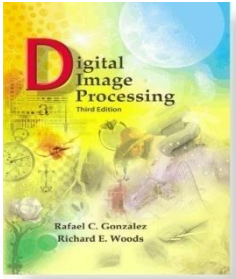
γ=3

γ=4

γ=5

a b
c d

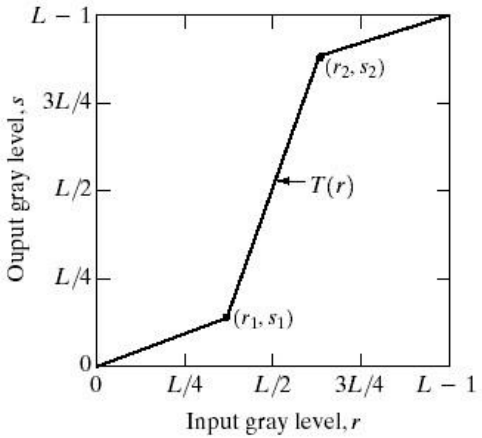
FIGURE 3.9
(a) Aerial image. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0$, 4.0, and 5.0, respectively. (Original image for this example courtesy of NASA.)

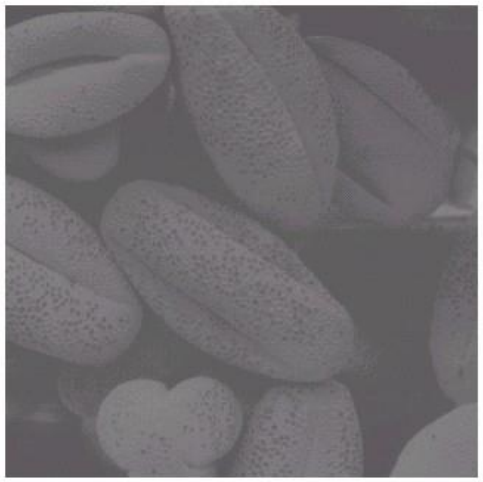


Intensity Transformations and Spatial Filtering

- Contrast Stretching

Original





a b
c d

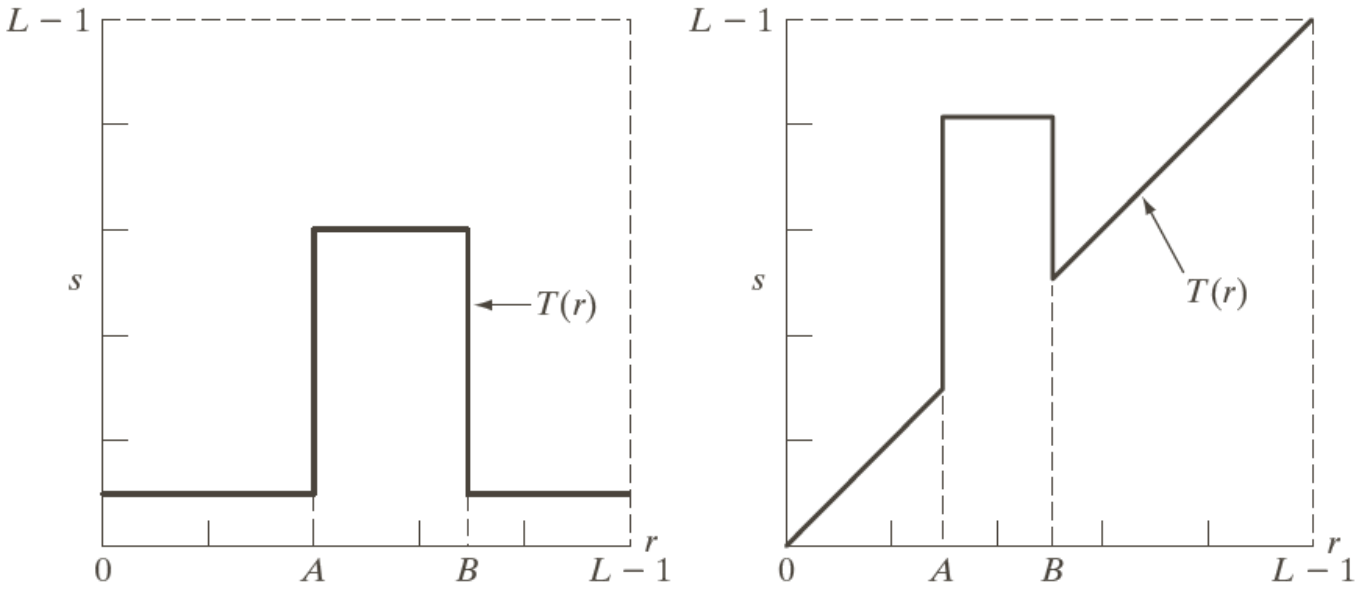
FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

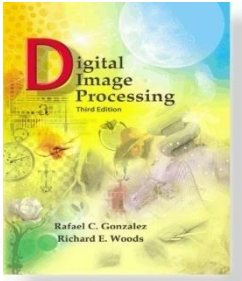
C. S. **THR.**

- Gray Level Slicing

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.

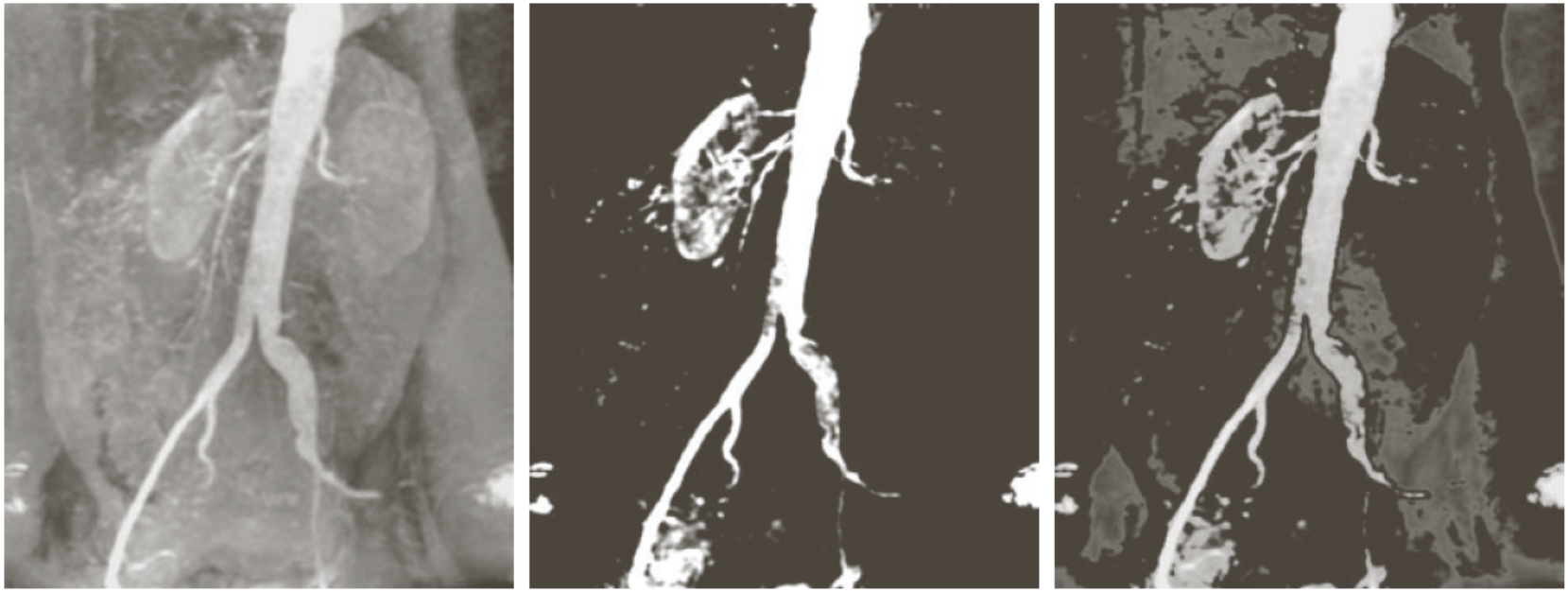




- Example

Using Fig 3.11 (a)

Using Fig 3.11 (b)



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.)

- Bit-Plane Slicing:
  - Highlighting effect of a single bit!

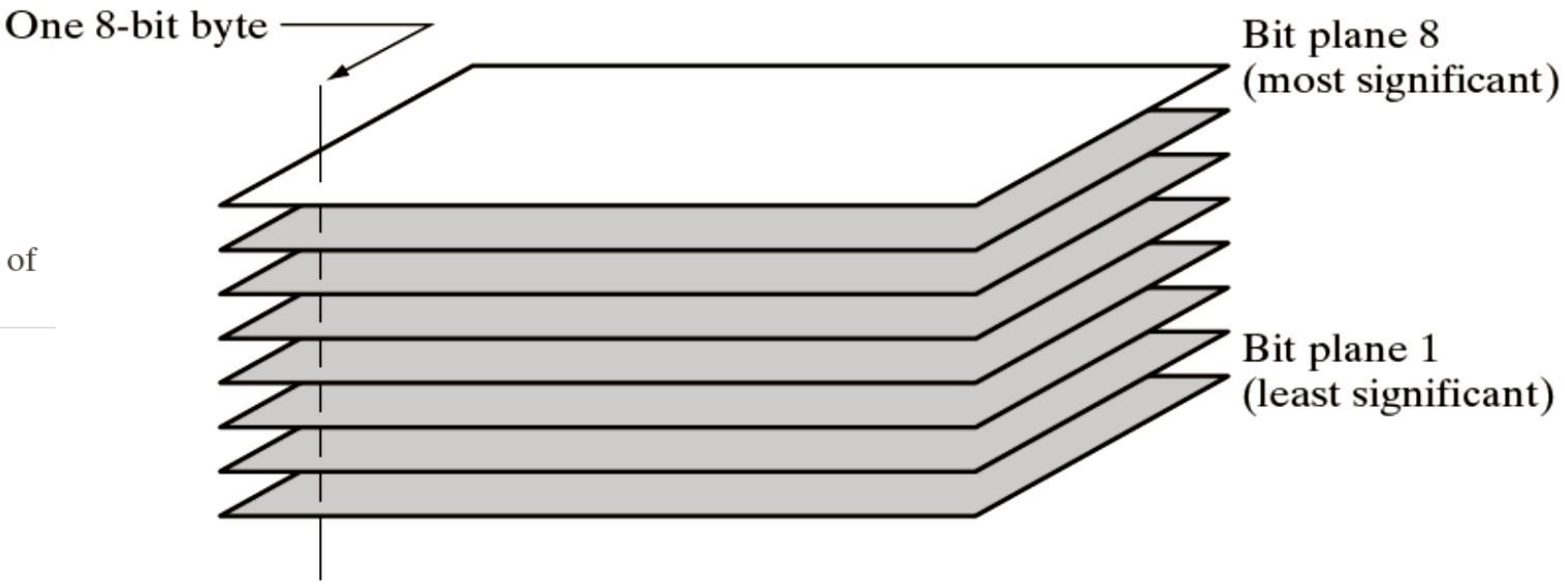
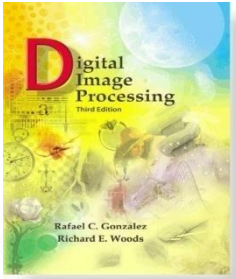


FIGURE 3.13
Bit-plane representation of an 8-bit image.



Intensity Transformations and Spatial Filtering

- Bit-Plane Slicing: 3-bit image example

6	7	6	6	7
0	0	0	1	2
1	1	1	2	3
4	5	5	4	2
6	6	6	7	7

3-bit Image
Graylevels: 0-7

110	111	110	110	111
000	000	000	001	010
001	001	001	010	011
100	101	101	100	010
110	110	110	111	111

Binary Representation

1	1	1	1	1
0	0	0	0	0
0	0	0	0	0
1	1	1	1	0
1	1	1	1	1

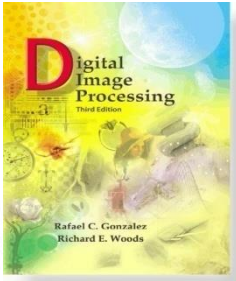
MSB Plane

1	1	1	1	1
0	0	0	0	1
0	0	0	1	1
0	0	0	0	1
1	1	1	1	1

Centre Bit Plane

0	1	0	0	1
0	0	0	1	0
1	1	1	0	1
0	1	1	0	0
0	0	0	1	1

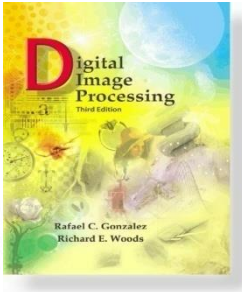
LSB Plane



Intensity Transformations and Spatial Filtering

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 Reconstruction from bit-planes

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).