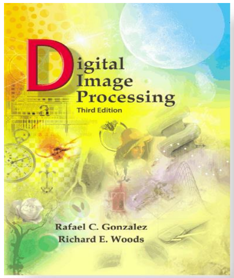
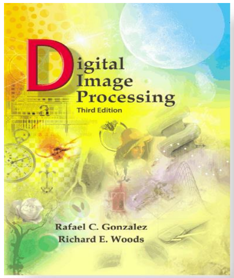


第三章

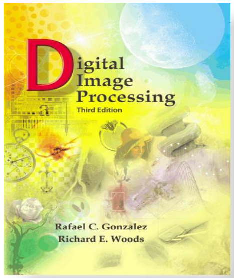
空间域图像增强

第一部分—图像基本运算



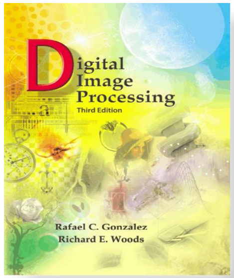
引言

- 图像在系统中成像、复制、传输时，总要产生某些降质。这些降质会使计算机从图像中提取信息时发生错误，因此有必要对降质的图像进行处理改善。



引言

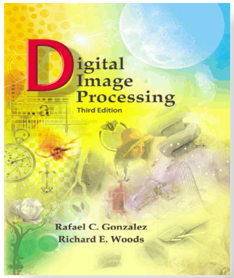
- 改善的方法有两种：
  - 其一是根据降质的原因，设法进行补偿，称之为图像的复原。
  - 其二是不考虑降质的原因，凭借人的感觉和经验，将图像中感兴趣的特征尽量突出出来，而衰减抑制不需要的特征，称之为图像的增强。



图像增强的概念

- 图像增强是采用一系列技术去改善图像的视觉效果,或将图像转换成一种更适合于人或机器进行分析和处理的形式。例如采用一系列技术有选择地突出某些感兴趣的信息，同时抑制一些不需要的信息，提高图像的使用价值。

- 图像增强的首要目标是处理图像，使其比原图像更适合于特定应用。



图像增强的方法

图像增强方法从增强的作用域出发，可分为空间域增强和频率域增强两种。

- 空间域增强方法

  对图像像素进行直接处理

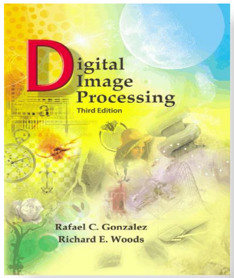
- 频域增强方法

  将图像经傅立叶变换后的频谱成分进行处理，然后逆傅立叶变换获得所需的图像。

*图像增强的通用理论是不存在的

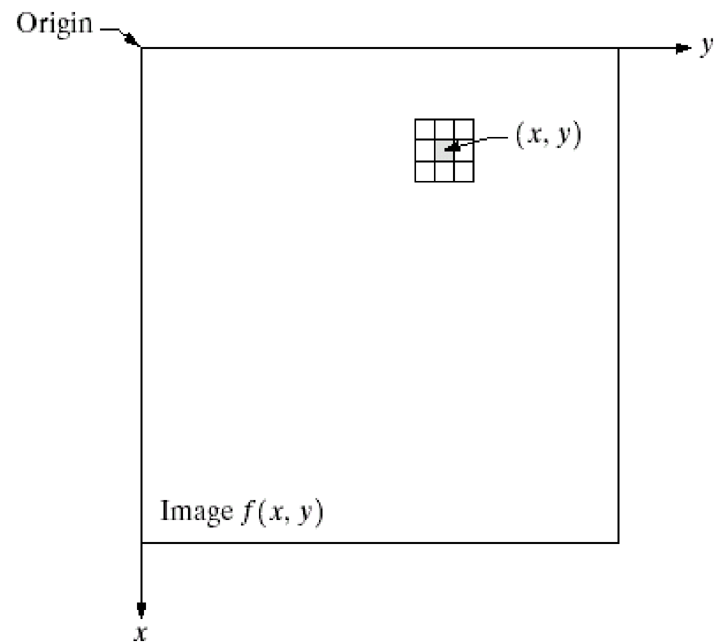
空间域图像增强主要内容

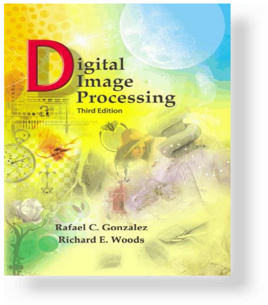
- **3.1 空域运算背景知识**
- **3.2 基本灰度变换**
- **3.3 逻辑运算**
- **3.4算数运算**
- **3.5 几何运算**



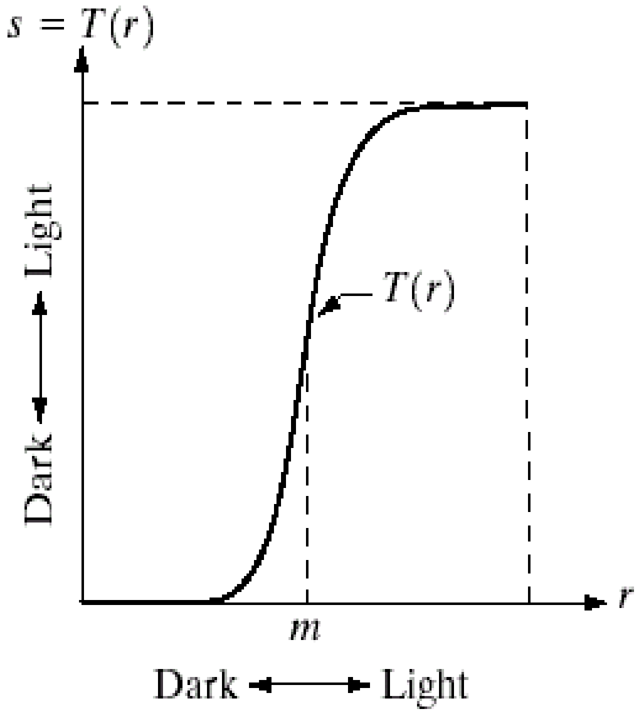
3.1 背景知识

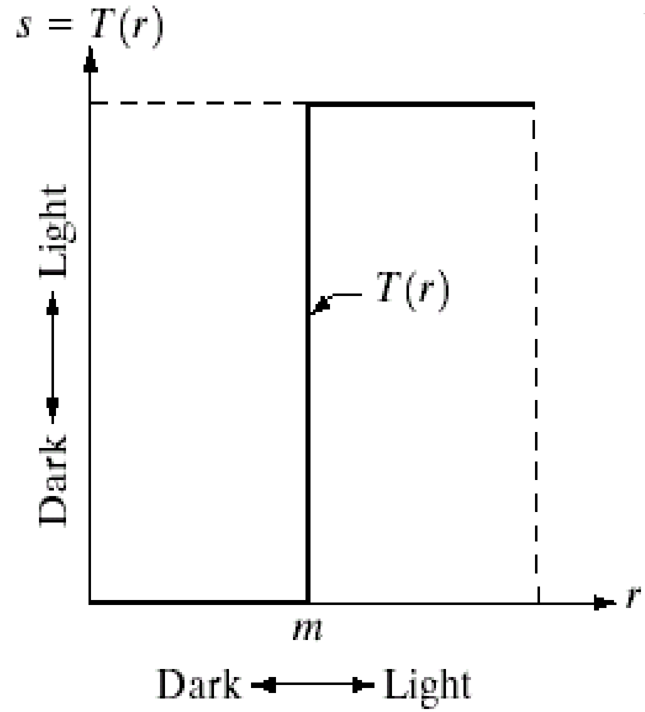
- 空间域操作直接在给定图像的像素上操作。
- 点操作：单像素操作 s=T(r)。图像在任一点的增强仅依赖于该点的灰度
- 邻域操作：g(x,y)=T[f(x,y)]。T是对f的一种操作，其定义在(x,y)的邻域。邻域与预定义的操作一起称为空间滤波器



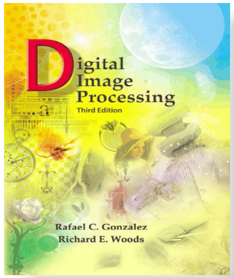


3.1背景知识





- 这种操作会产生比原始图像更高的对比度，灰度级低于m时变暗，高于m时变亮。（对比度扩展）
- 极限情况下产生二值图像，这种情况下的映射称之为**阈值函数**

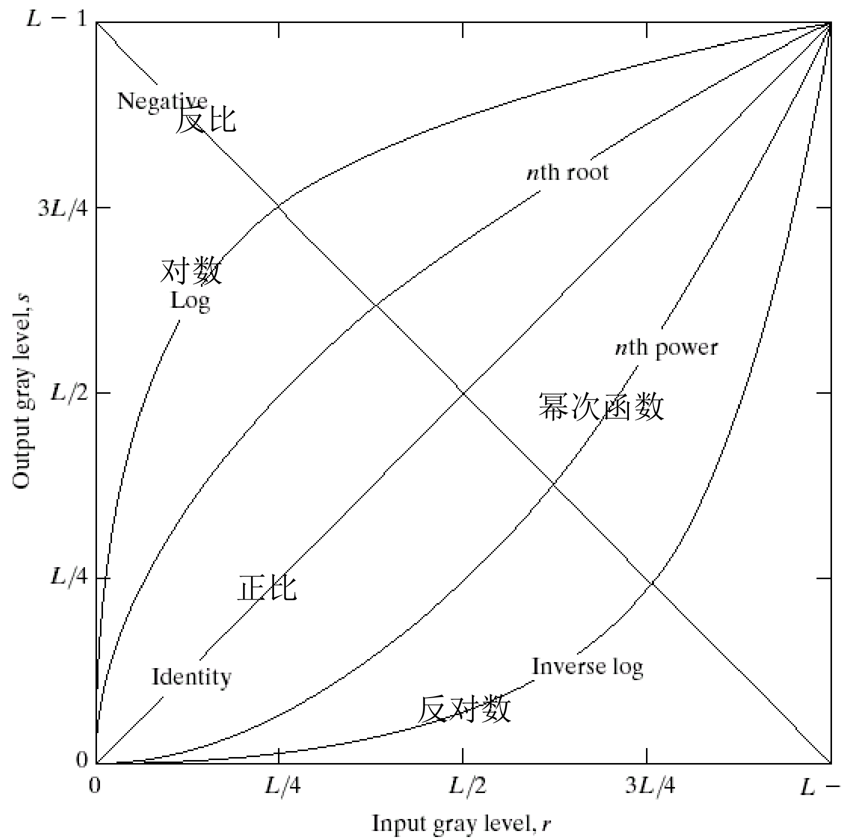


3.2 基本灰度变换

s=T(r)

T把像素值r映射成s

变换T的值通常存储在一个一维阵列中



用于图像增强的某些灰度变换函数

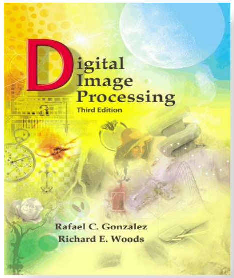
3.2 基本灰度变换

r	…	35	36	37	….	168	169	170	…
S	…	165	166	167	….	236	236	237	…

s=Alog(r+1)　　　A为调整参数

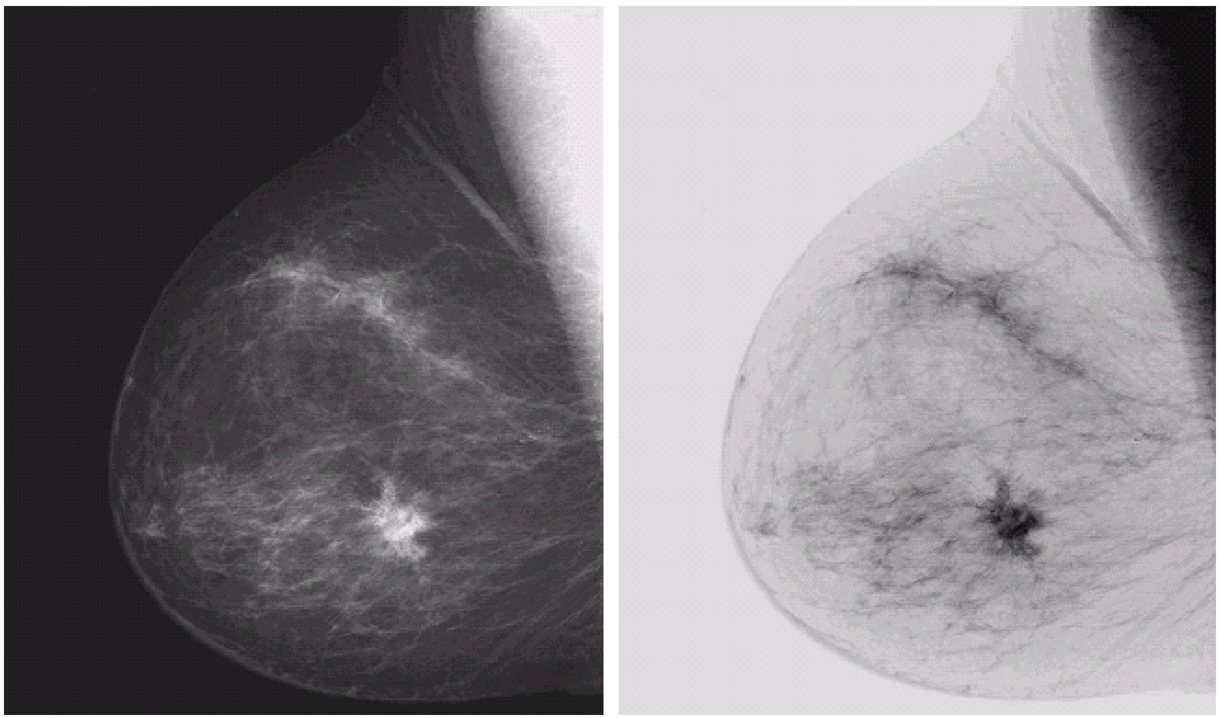
T把像素值r映射成s

变换T的值通常存储在一个一维阵列中



3.2.1 图像反转

- 灰度级范围为[0,L-1]的图像反转可表示为：**s=L-1-r**



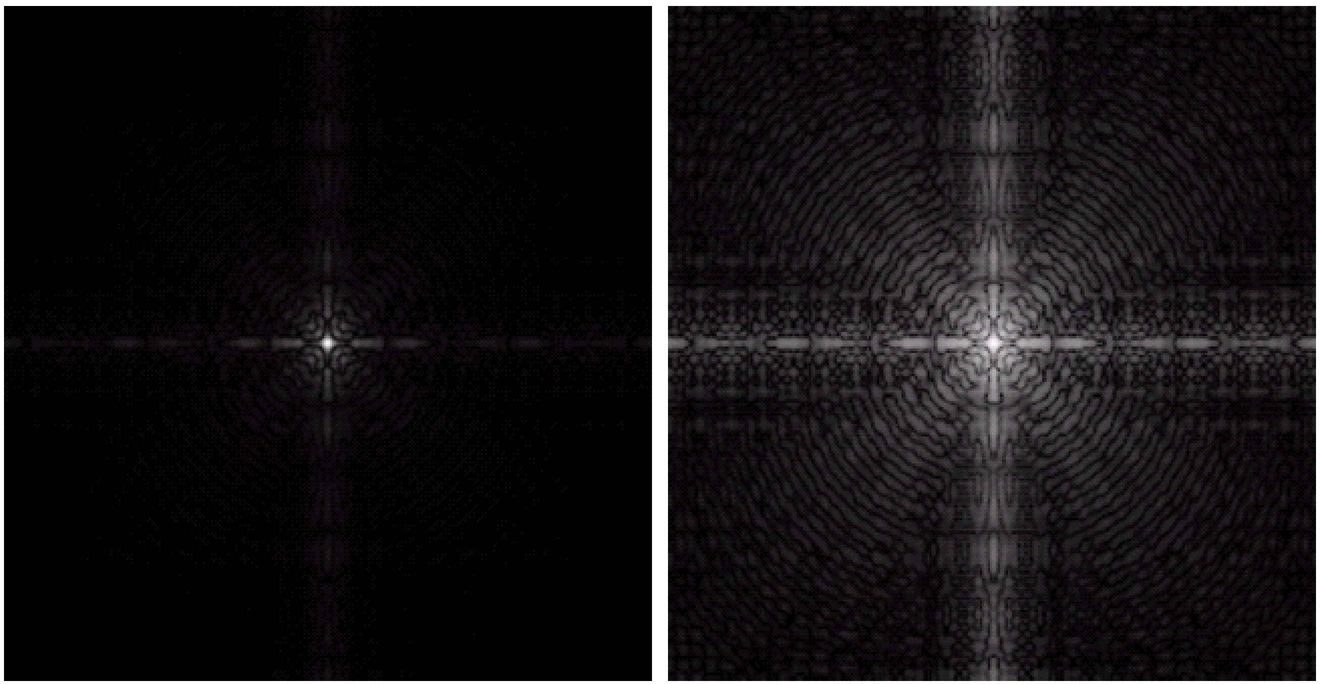
a b

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.)

适用于增强嵌入于图像的暗色区域的白色或灰色细节

3.2.2 对数变换

- 对数变换表达式为：s=c*log(1+r)



- 这种变换使窄带低灰度输入图像值映射为宽带输出值。
- 压缩了图像像素值的动态范围。

3.2.3 幂次变换

幂次变换的基本形式为： $s = cr^{\gamma}$

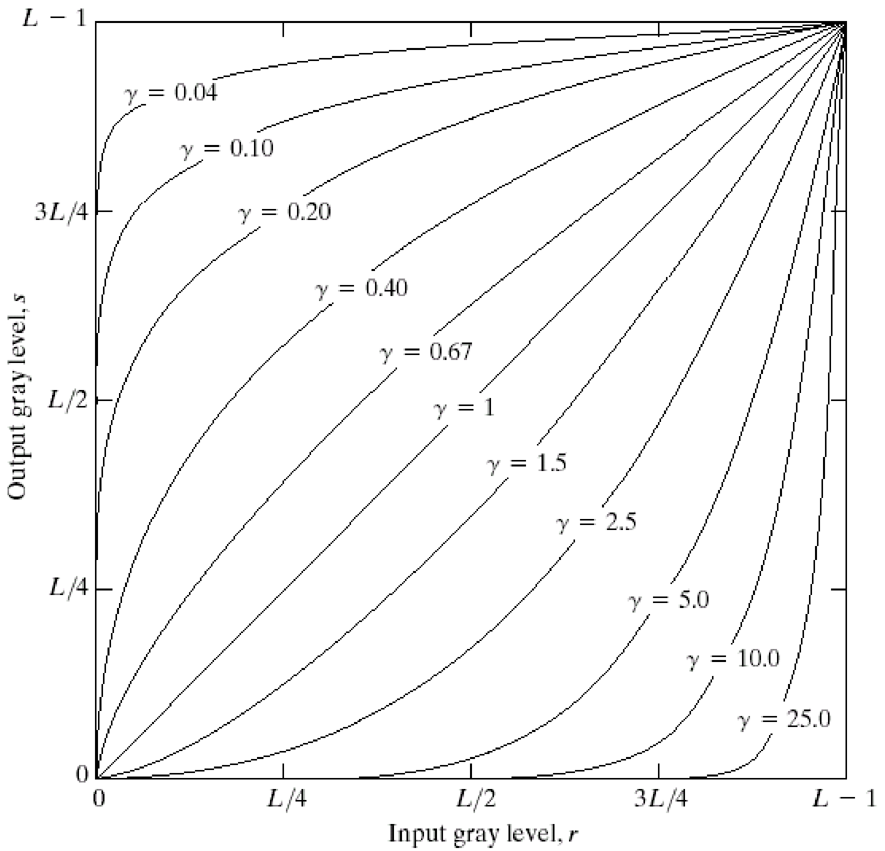
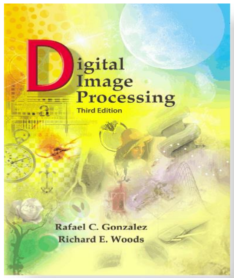


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases).

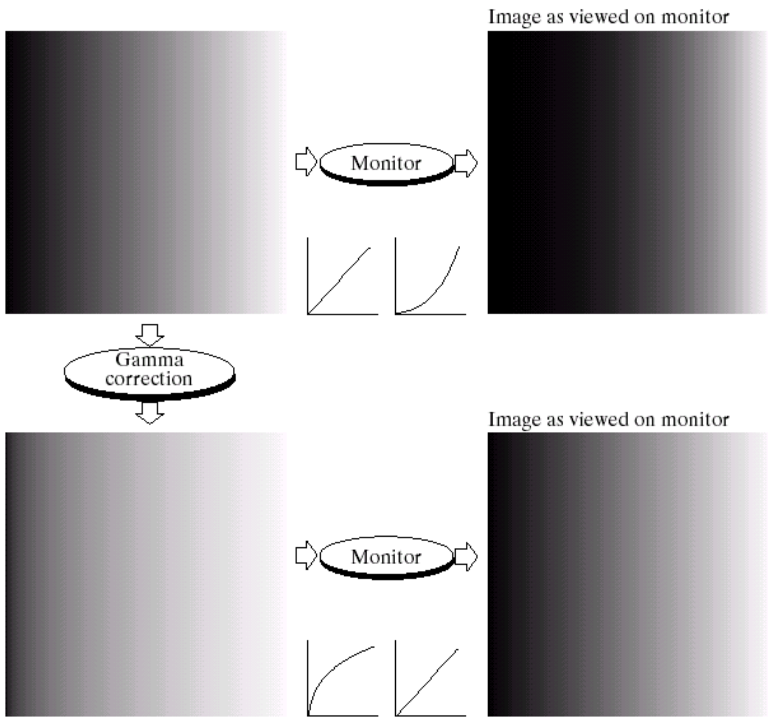


3.2.3 幂次变换

阴极射线管装置的伽马校正

a b
c d

FIGURE 3.7
(a) Linear-wedge gray-scale image.
(b) Response of monitor to linear wedge.
(c) Gamma-corrected wedge.
(d) Output of monitor.

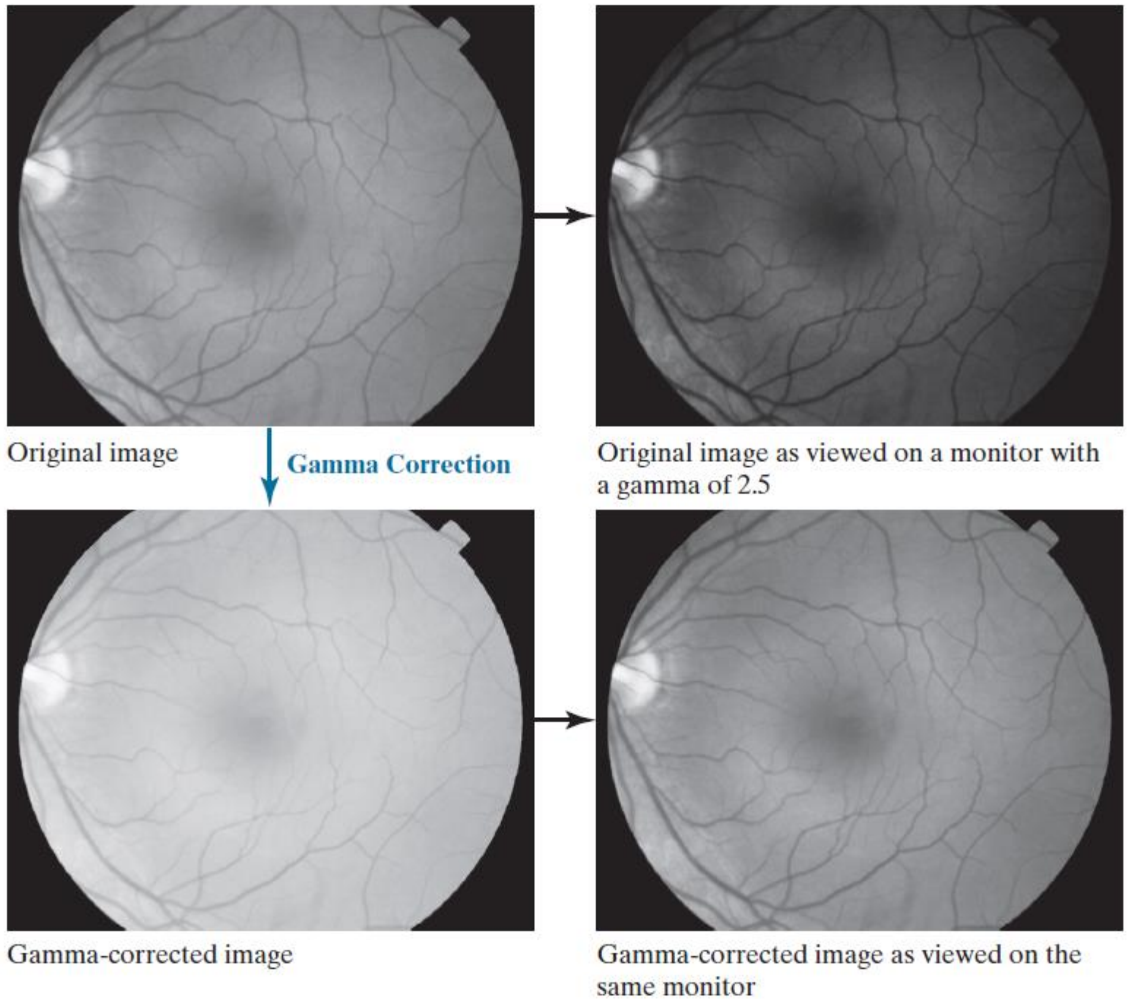


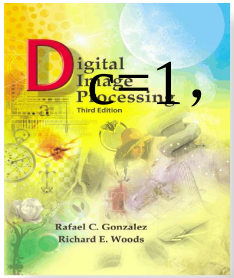
用于修正**幂次响应现象**的过程称为伽马校正

3.2.3 幂次变换

a b
c d

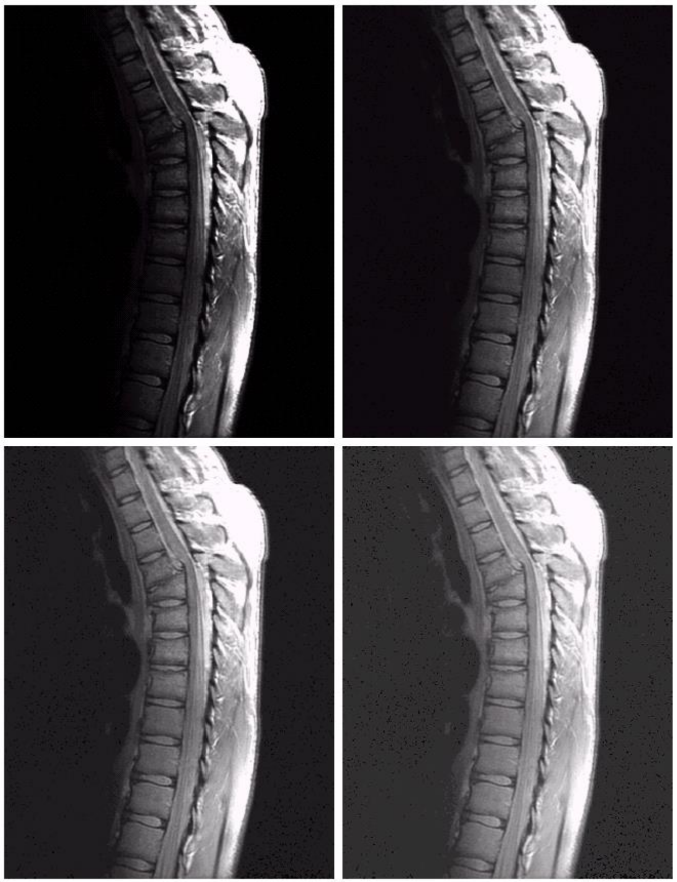
FIGURE 3.7
(a) Image of a human retina. (b) Image as as it appears on a monitor with a gamma setting of 2.5 (note the darkness). (c) Gamma-corrected image. (d) Corrected image, as it appears on the same monitor (compare with the original image). (Image (a) courtesy of the National Eye Institute, NIH)





c=1，

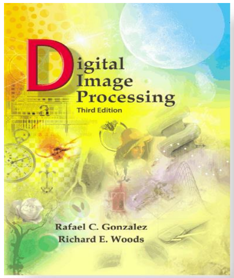
3.2.3 幂次变换



a b
c d

FIGURE 3.8 (a) Magnetic resonance (MR) image 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 for this example courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

人的脊椎骨折的核磁共振图像，b~d图c=1,r=0.6,0.4,0.3

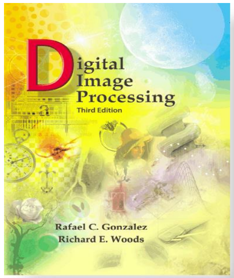


3.2.3 幂次变换

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.)

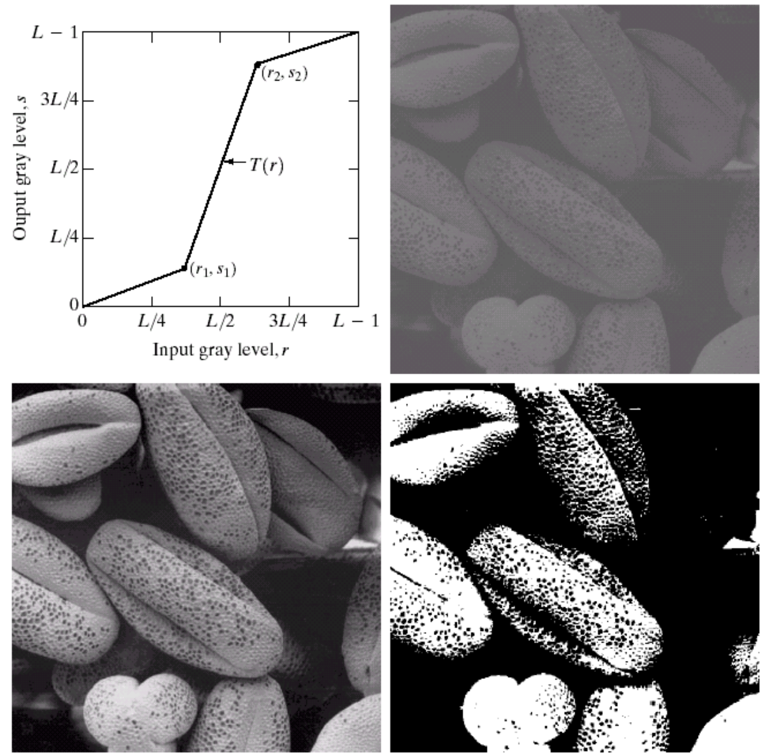
航空图像，
b~d图
c=1,r=3,4,5



3.2.4 分段线性变换函数

对比拉伸

- 最简单的分段线性函数之一是对比拉伸变换。低对比度图像可由照明不足、成像传感器动态范围太小，甚至在图像获取过程中透镜光圈设置错误引起。对比拉伸的思想是提高图像处理时灰度级的动态范围。



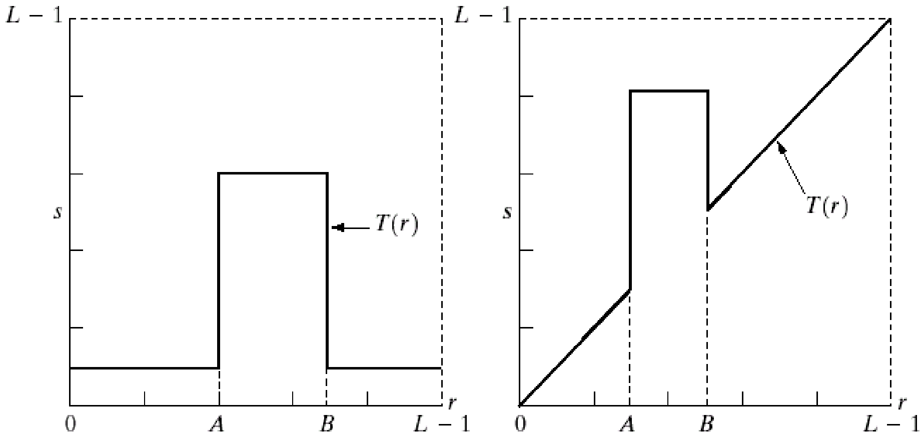
a b
c d

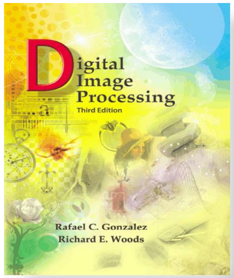
FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

3.2.4 分段线性变换函数

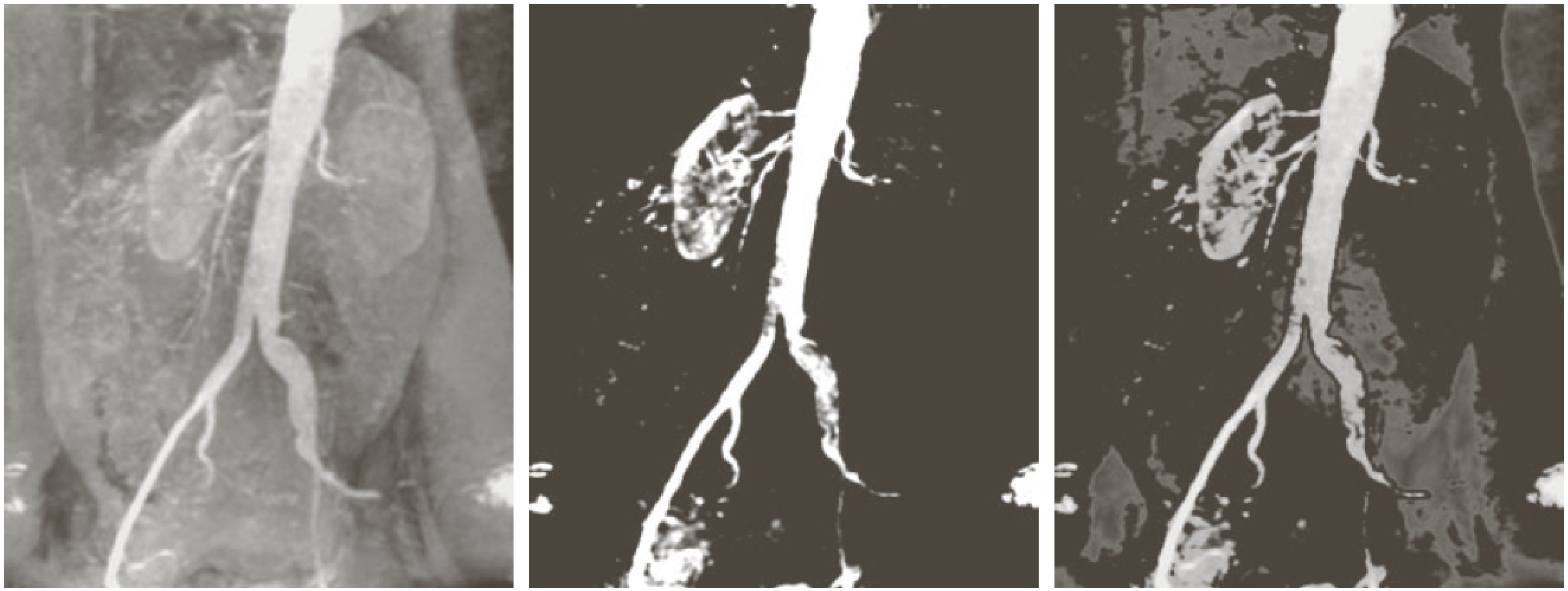
- 灰度分层

- 在图像中提高特定灰度范围的亮度通常是必要的，其应用包括增强特征和增强X射线图中的缺陷。



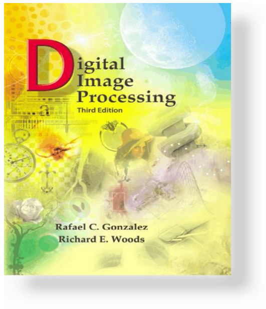


灰度分层



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.)



3.2.4 分段线性变换函数

比特平面分层

- 对任意m比特灰度级的图像可用多项式

$$a_{m-1}2^{m-1}+a_{m-2}2^{m-2}+\ldots+a_1 2+a_0 1$$

表示，图像可分解成m个二值图。即m个位平面。

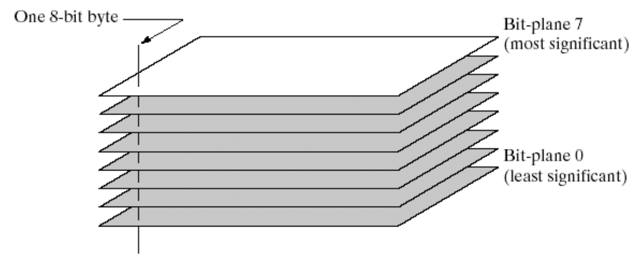


FIGURE 3.12 Bit-plane representation of an 8-bit image.

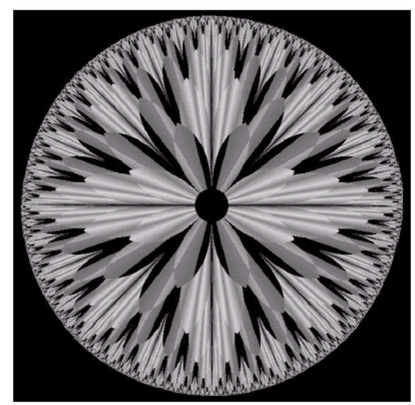
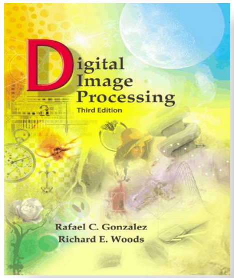


FIGURE 3.13 An 8-bit fractal image. (A fractal is an image generated from mathematical expressions). (Courtesy of Ms. Melissa D. Binde, Swarthmore College, Swarthmore, PA.)



位图切割

高阶比特面包含了视觉的大部分信息，低阶比特面贡献了更精细的图像细节

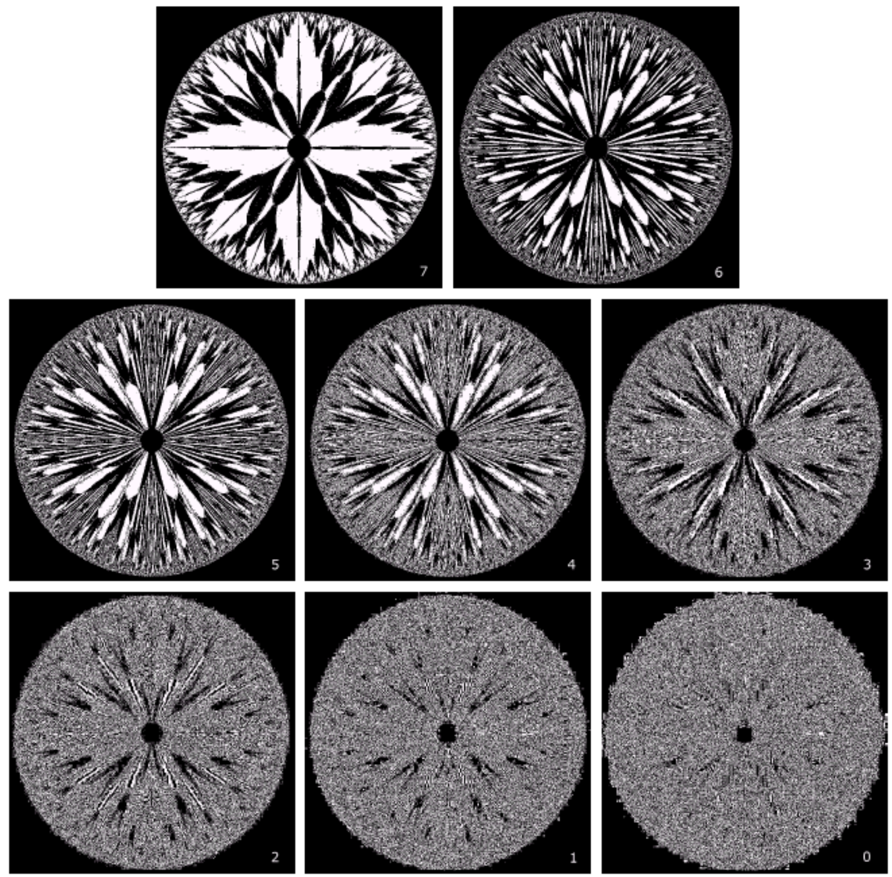
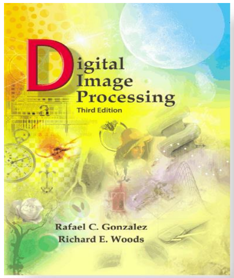


FIGURE 3.14 The eight bit planes of the image in Fig. 3.13. The number at the bottom, right of each image identifies the bit plane.



位图切割

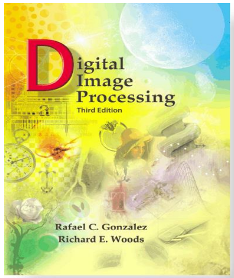
a	b	c
d	e	f
g	h	i

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.

位图切割

a b c

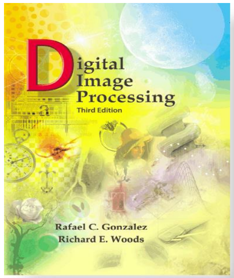
FIGURE 3.15 Images reconstructed using (a) bit planes 8 and 7; (b) bit planes 8, 7, and 6; and (c) bit planes 8, 7, 6, and 5. Compare (c) with Fig. 3.14(a).



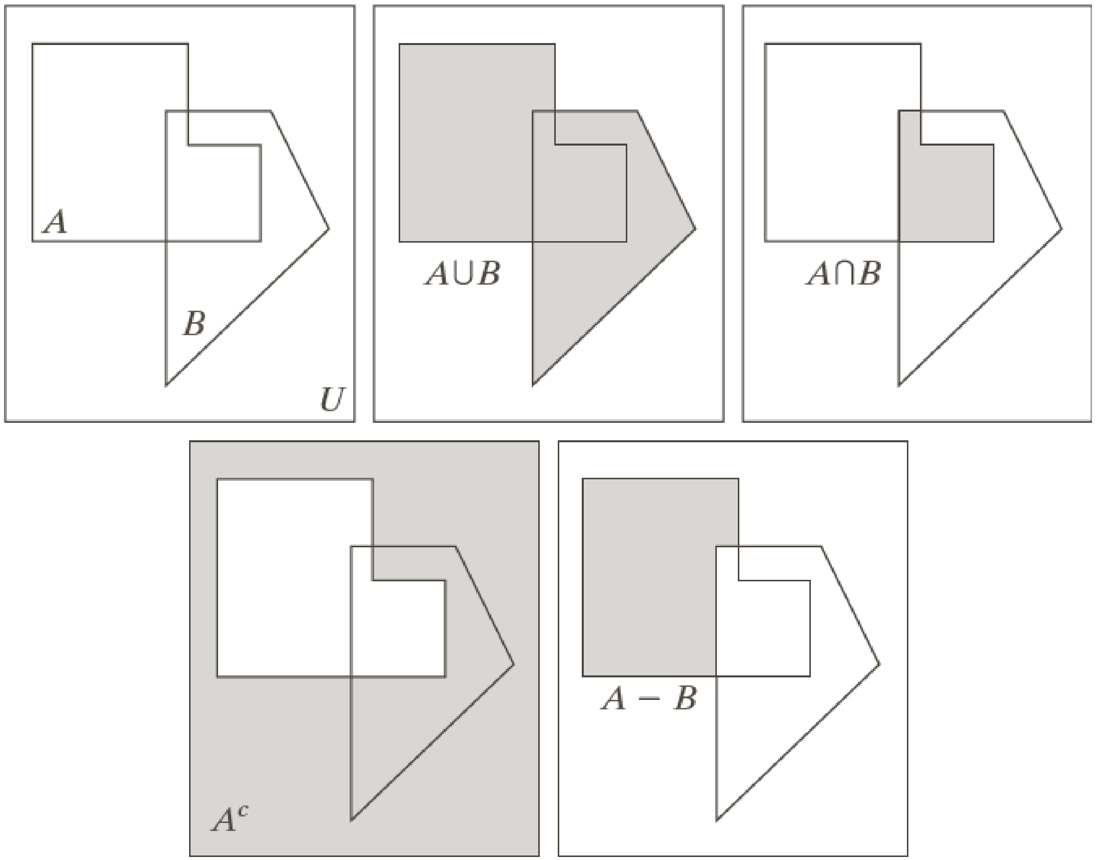
3.3算术/逻辑操作

- 图像中的算术/逻辑操作主要以像素对像素为基础在两幅或多幅图像间进行。

- 逻辑运算：（与、或、非）
- 算术运算：（加、减、乘、除）

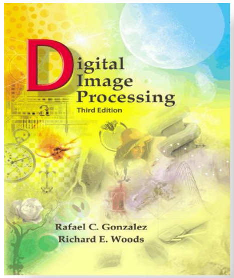


3.3集合与逻辑操作

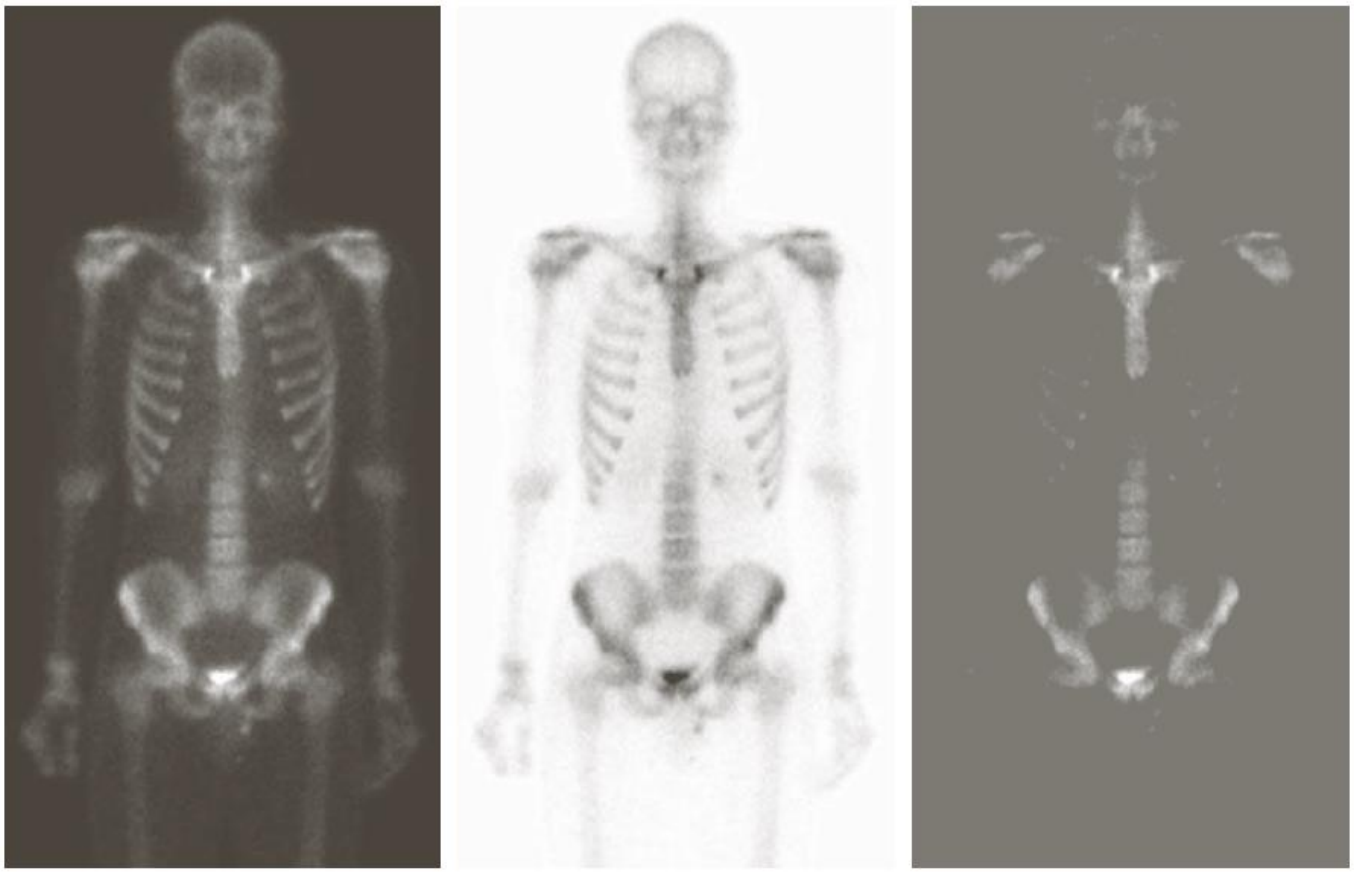


a b c
d e

FIGURE 2.31 (a) Two sets of coordinates, A and B, in 2-D space. (b) The union of A and B. (c) The intersection of A and B. (d) The complement of A. (e) The difference between A and B. In (b)–(e) the shaded areas represent the member of the set operation indicated.



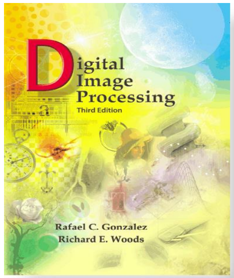
集合运算实例



a b c

FIGURE 2.32 Set operations involving gray-scale images. (a) Original image. (b) Image negative obtained using set complementation. (c) The union of (a) and a constant image. (Original image courtesy of G.E. Medical Systems.)

图像A **A的补集** **A与常数值集合的并集**



3.3集合与逻辑操作

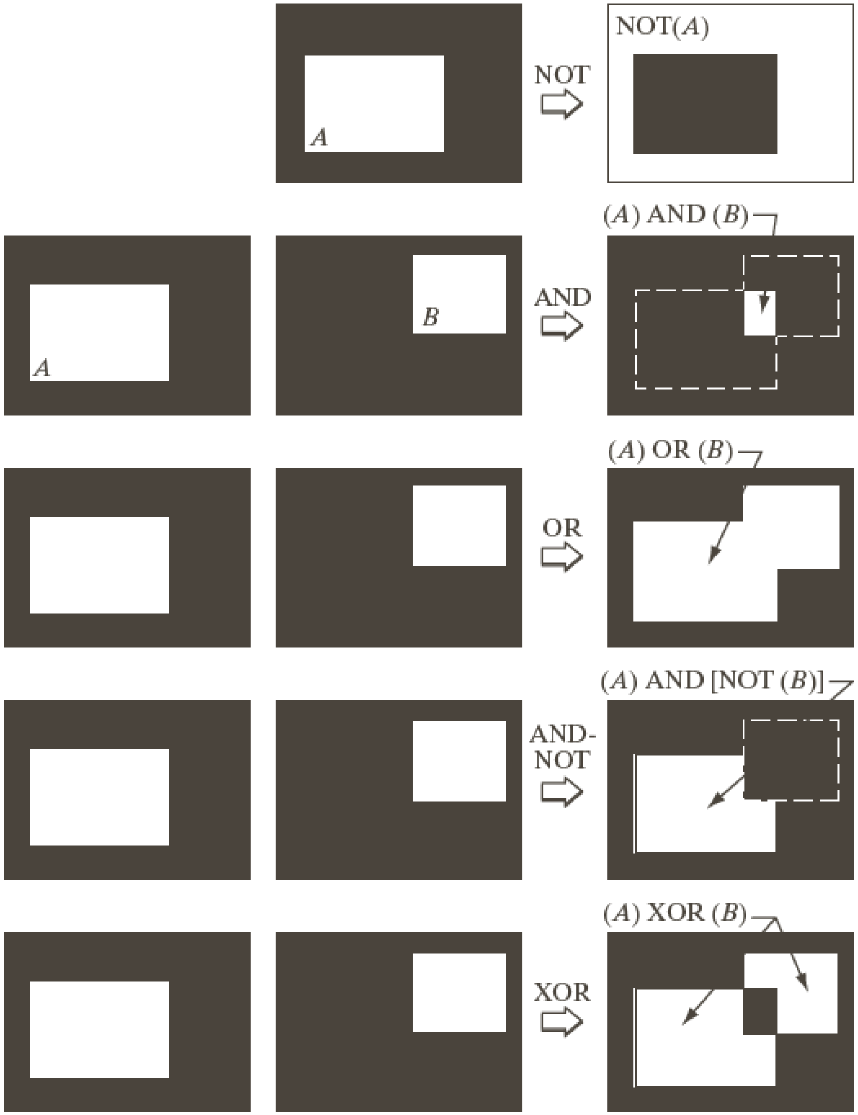
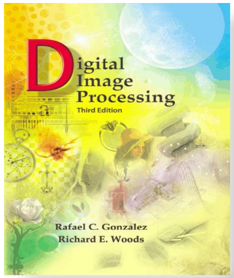


FIGURE 2.33 Illustration of logical operations involving foreground (white) pixels. Black represents binary 0s and white binary 1s. The dashed lines are shown for reference only. They are not part of the result.

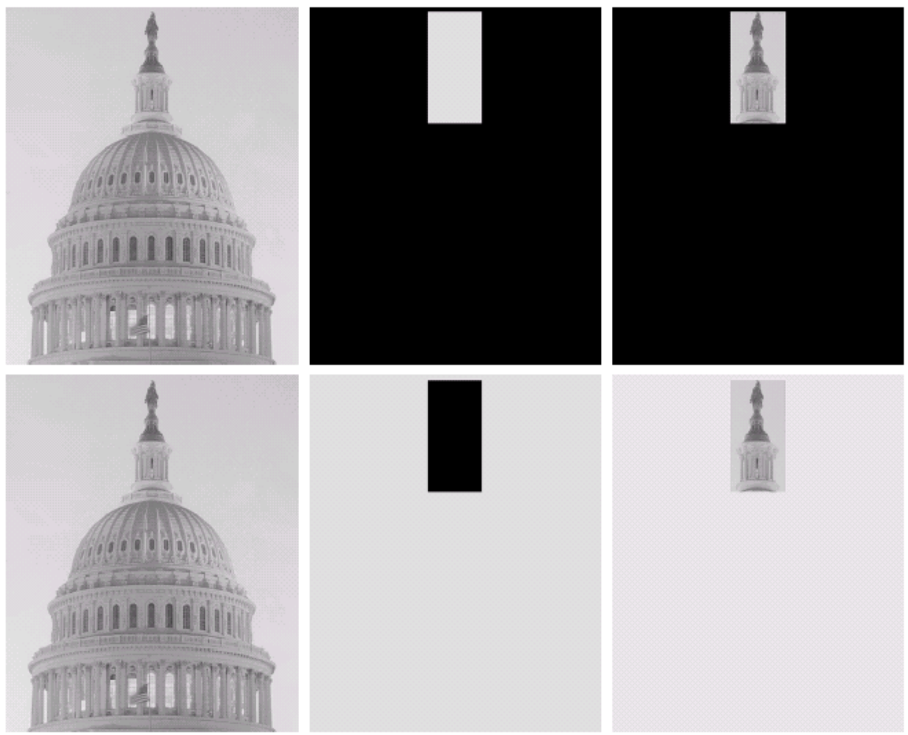


3.3逻辑操作

- 与和或操作通常用做模板，通过这样的操作从一幅图像中提取子图像）

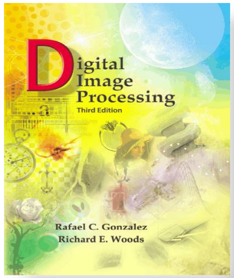
与操作

或操作



a b c
d e f

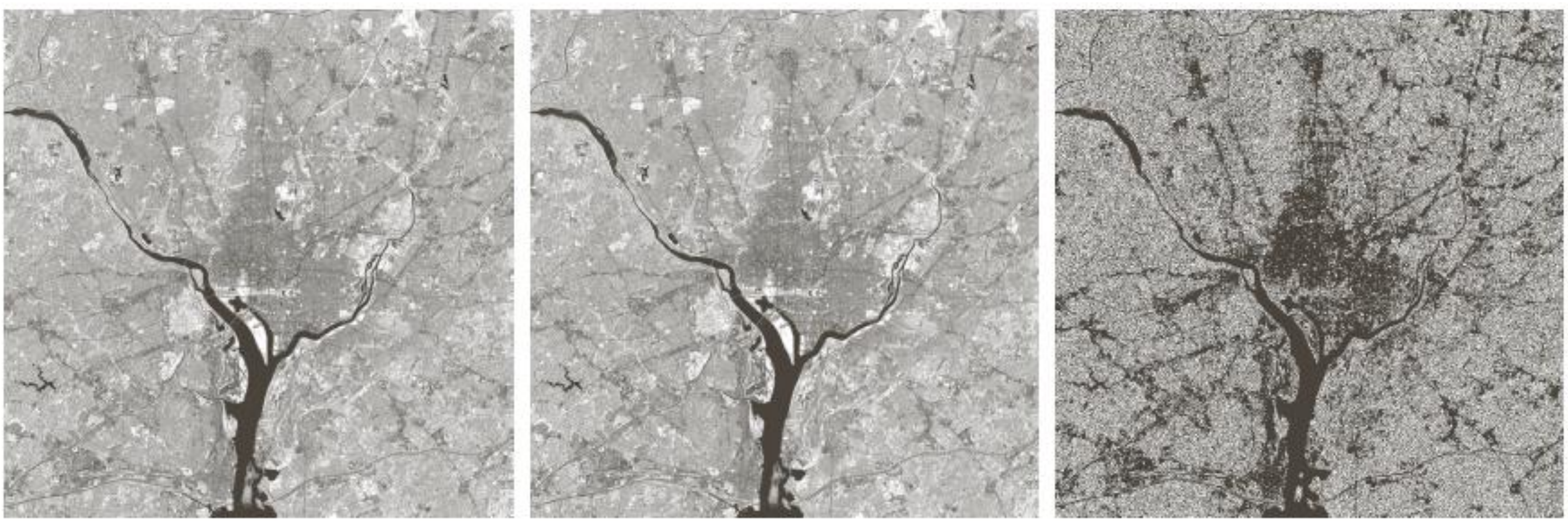
FIGURE 3.27 (a) Original image. (b) AND image mask. (c) Result of the AND operation on images (a) and (b). (d) Original image. (e) OR image mask. (f) Result of operation OR on images (d) and (e).



3.4 算数操作

3.4.1 图像减法操作

- 两幅图像f(x,y)与h(x,y)的差异表示为g(x,y)=f(x,y)-h(x,y)

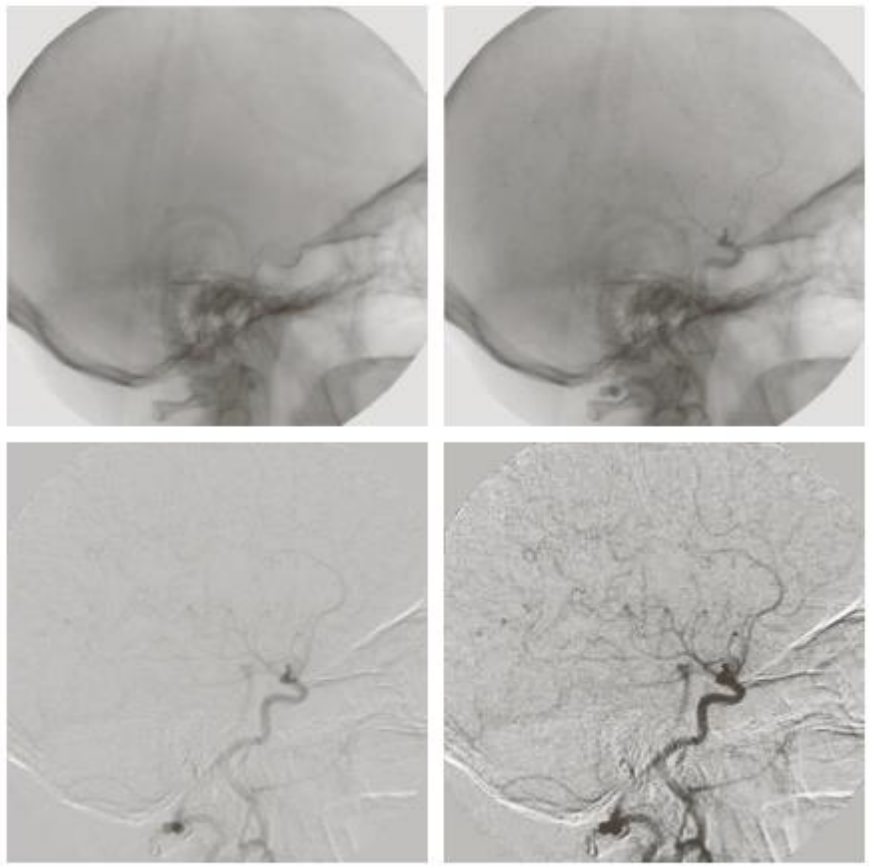


a b c

FIGURE 2.27 (a) Infrared image of the Washington, D.C. area. (b) Image obtained by setting to zero the least significant bit of every pixel in (a). (c) Difference of the two images, scaled to the range [0, 255] for clarity.

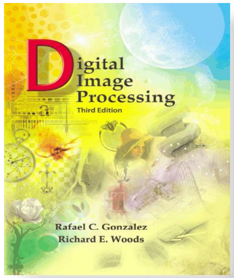
3.4.1 图像减法操作

注入造影剂作为对比介质，可以动态监测对比介质在血管中的运动情况。

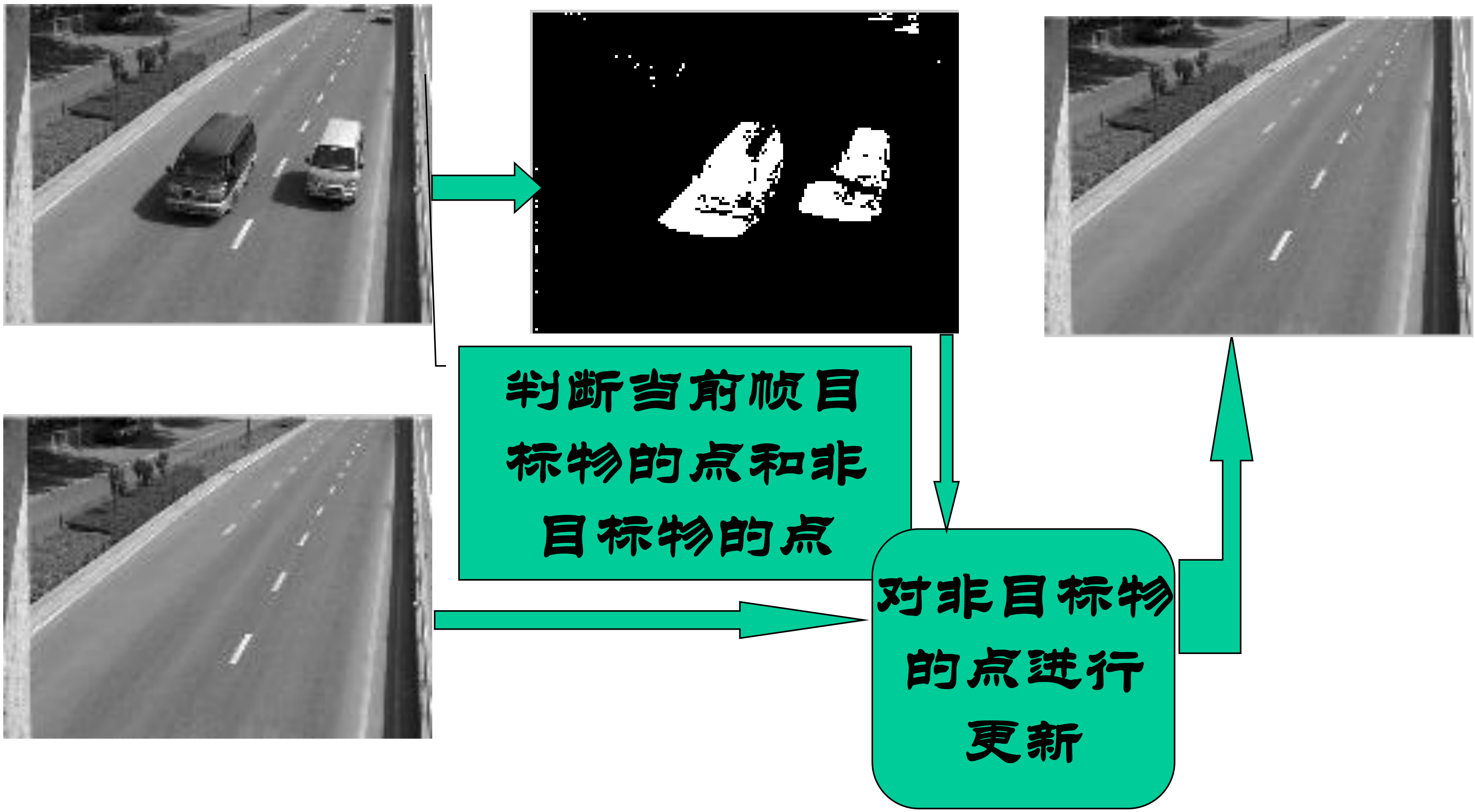


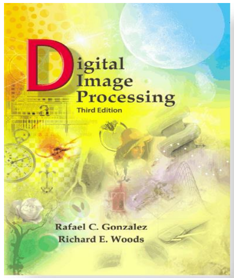
a b
c d

FIGURE 2.28 Digital subtraction angiography. (a) Mask image. (b) A live image. (c) Difference between (a) and (b). (d) Enhanced difference image. (Figures (a) and (b) courtesy of The Image Sciences Institute, University Medical Center, Utrecht, The Netherlands.)


Digital Image Processing
Third Edition
Rafael C. Gonzalez
Richard E. Woods

视频监视 ——车流检测


判断当前帧目标物的点和非目标物的点
对非目标物的点进行更新



图像减法处理

标定技术

- $g(x,y)=f(x,y)-h(x,y)$

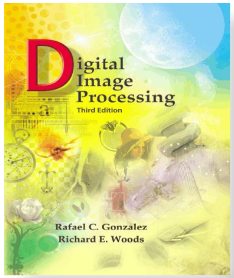
实践中，大多数像素由8位码显示

$0<=f(x,y)<=255$， $0<=h(x,y)<=255$

$->$ $-255<=g(x,y)<=255$

两种方法处理：

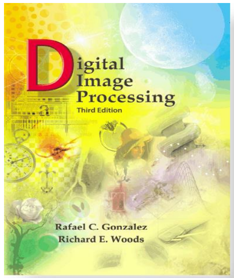
- $g(x,y) = (g(x,y)+255)/2$
- $g(x,y) = (g(x,y)-g_{min})*255/(g_{max}-g_{min})$



3.4.2图像平均处理

- 将噪声$\eta(x,y)$加入到原始图像$f(x,y)$形成带有噪声的图像，即：$g(x,y)=f(x,y)+\eta(x,y)$
- 假设每个坐标点上的噪声不相关且均值为零。则我们处理的目标就是通过加入一系列噪声图像$\{g_i(x,y)\}$来减少噪声。
- 对k幅不同的噪声图像取平均形成图像$\bar{g}(x,y)$

$$\bar{g}(x,y)=\frac{1}{k}\sum_{i=1}^{k}g_i(x,y)$$



3.4.2图像平均处理

$$\overline{g}(x,y)=\frac{1}{k}\sum^{k} g_i(x,y) \qquad g_i(x,y)=f(x,y)+\eta_i(x,y)$$

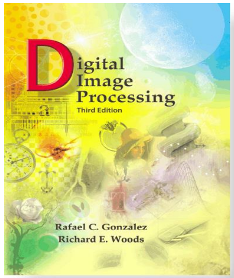
$$E\{\overline{g}(x,y)\}=\tfrac{1}{k}\{\sum_{i=1}^{k}[f(x,y)+\eta_i(x,y)]\}$$

$$=\tfrac{1}{k}\sum_{i=1}^{k} f(x,y)+\tfrac{1}{k}\sum_{i=1}^{k}\eta_i(x,y)$$

$$=f(x,y)$$

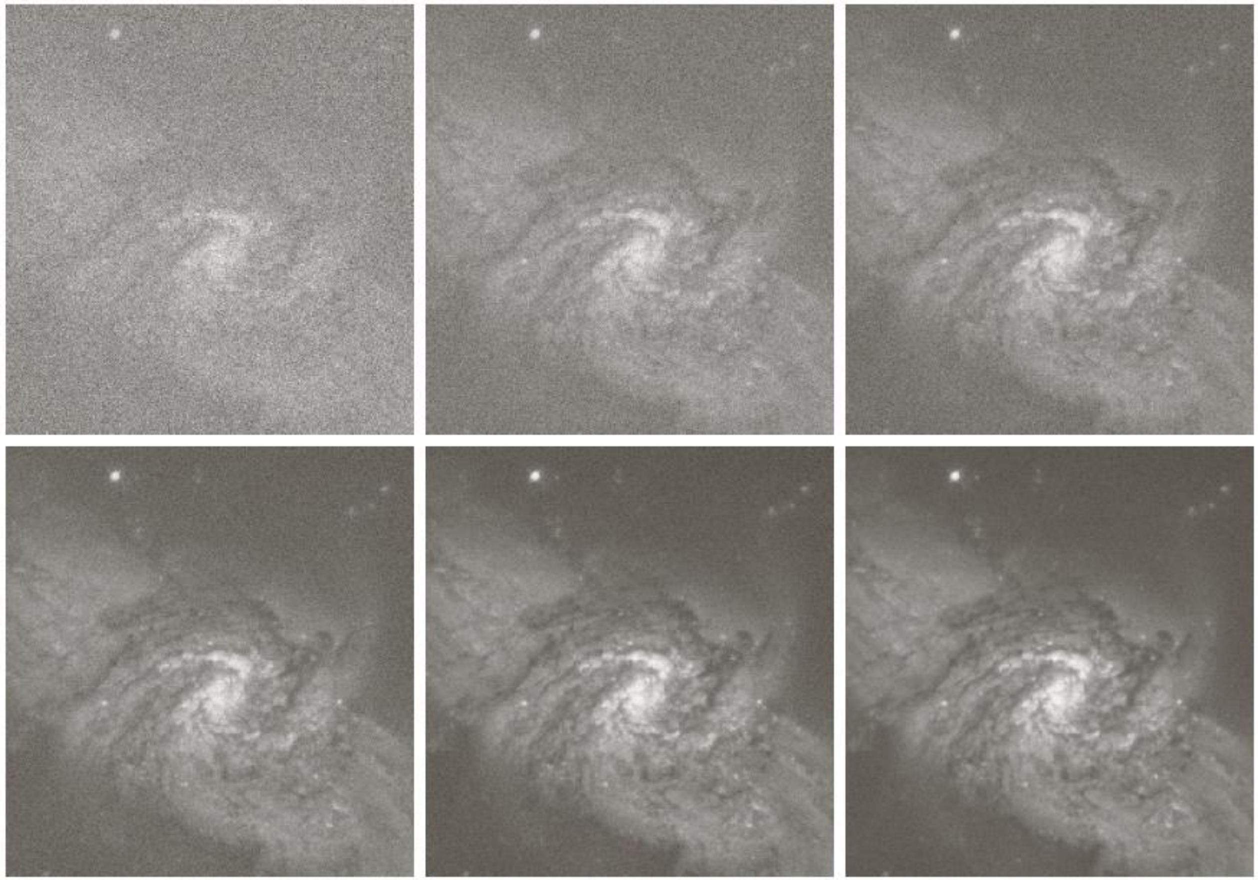
$$\sigma^2_{\overline{g}(x,y)}=\frac{1}{k}\sum_{i=1}^{k}\{g_i(x,y)-E[\overline{g}(x,y)]\}^2$$

$$\delta_{\overline{g}(x,y)}=\frac{1}{\sqrt{k}}\delta_{\eta(x,y)}$$



用图像平均减少噪声

天文学中极低亮度水平成像，引入了传感器噪声 用图像平均减少噪声。



a b c
d e f

FIGURE 2.26 (a) Image of Galaxy Pair NGC 3314 corrupted by additive Gaussian noise. (b)–(f) Results of averaging 5, 10, 20, 50, and 100 noisy images, respectively. (Original image courtesy of NASA.)

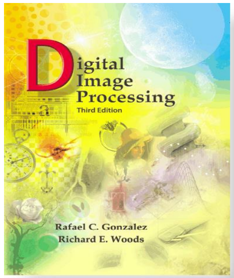
图像乘/除

阴影校正

a b c

FIGURE 2.29 Shading correction. (a) Shaded SEM image of a tungsten filament and support, magnified approximately 130 times. (b) The shading pattern. (c) Product of (a) by the reciprocal of (b). (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)

$$g(x,y)=f(x,y)/h(x,y)$$

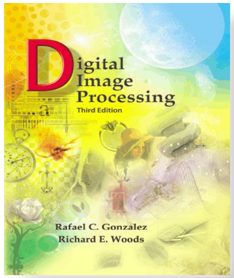


图像乘/除

感兴趣区（ROI）操作

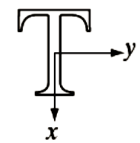
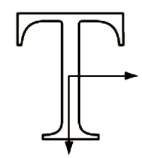
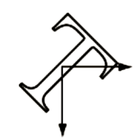
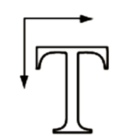
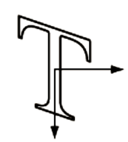
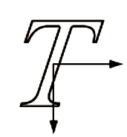
a b c

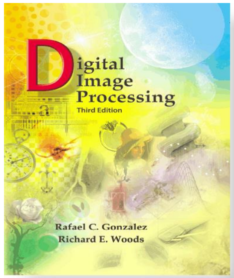
FIGURE 2.30 (a) Digital dental X-ray image. (b) ROI mask for isolating teeth with fillings (white corresponds to 1 and black corresponds to 0). (c) Product of (a) and (b).



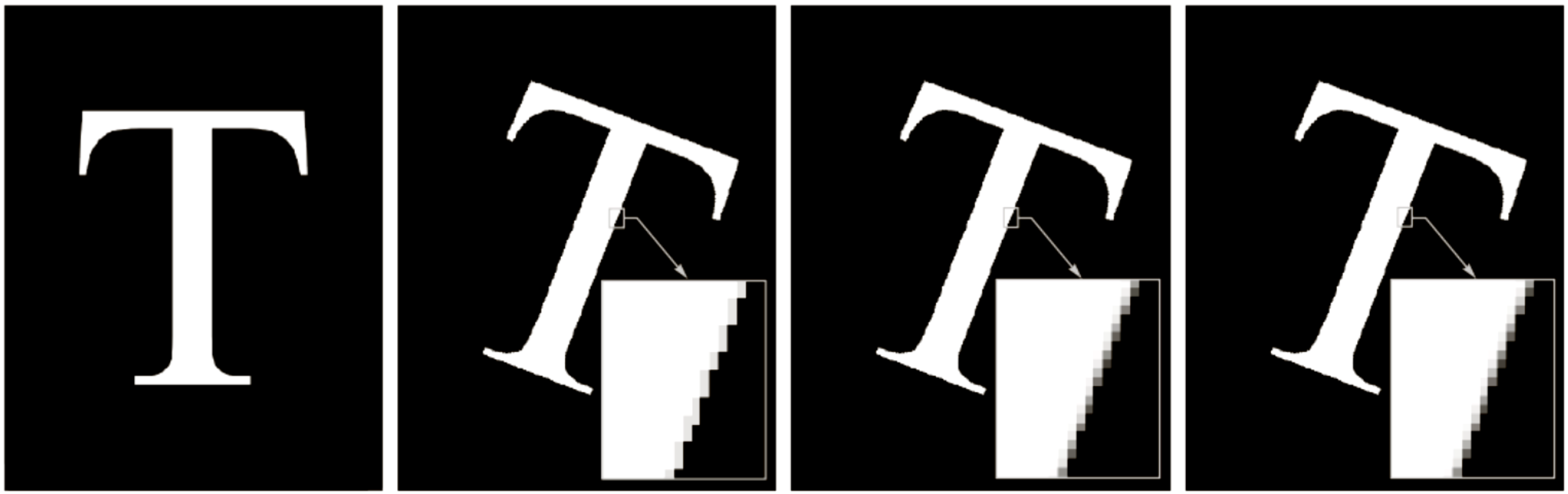
3.5几何运算

TABLE 2.2
Affine transformations based on Eq. (2.6.–23).

Transformation Name	Affine Matrix, T	Coordinate Equations	Example
Identity	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v$ $y = w$	
Scaling	$\begin{bmatrix} c_x & 0 & 0 \\ 0 & c_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = c_x v$ $y = c_y w$	
Rotation	$\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v\cos\theta - w\sin\theta$ $y = v\cos\theta + w\sin\theta$	
Translation	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ t_x & t_y & 1 \end{bmatrix}$	$x = v + t_x$ $y = w + t_y$	
Shear (vertical)	$\begin{bmatrix} 1 & 0 & 0 \\ s_v & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v + s_v w$ $y = w$	
Shear (horizontal)	$\begin{bmatrix} 1 & s_h & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$x = v$ $y = s_h v + w$	



3.5几何运算

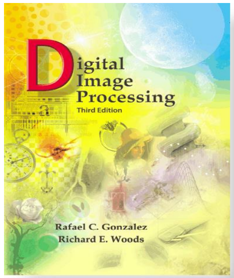


a b c d

FIGURE 2.36 (a) A 300 dpi image of the letter T. (b) Image rotated 21° clockwise using nearest neighbor interpolation to assign intensity values to the spatially transformed pixels. (c) Image rotated 21° using bilinear interpolation. (d) Image rotated 21° using bicubic interpolation. The enlarged sections show edge detail for the three interpolation approaches.

a. 原图 b. 旋转21度（近邻插值法）

b. c.旋转21度（双线性插值）d. 旋转21度（双三次插值）



3.5几何运算

几何校正

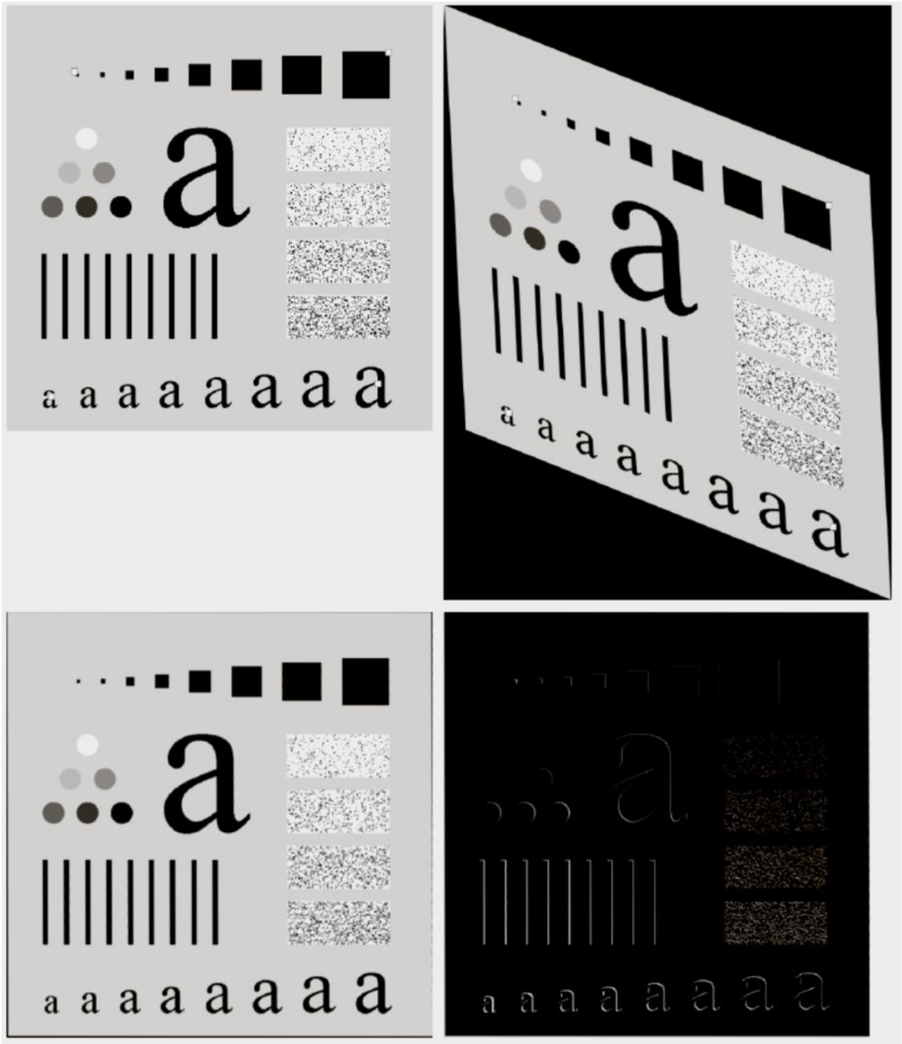


FIGURE 2.37 Image registration. (a) Reference image. (b) Input (geometrically distorted image). Corresponding tie points are shown as small white squares near the corners. (c) Registered image (note the errors in the borders). (d) Difference between (a) and (c), showing more registration errors.