图像增强

——图像锐化

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图像锐化

锐化目的：

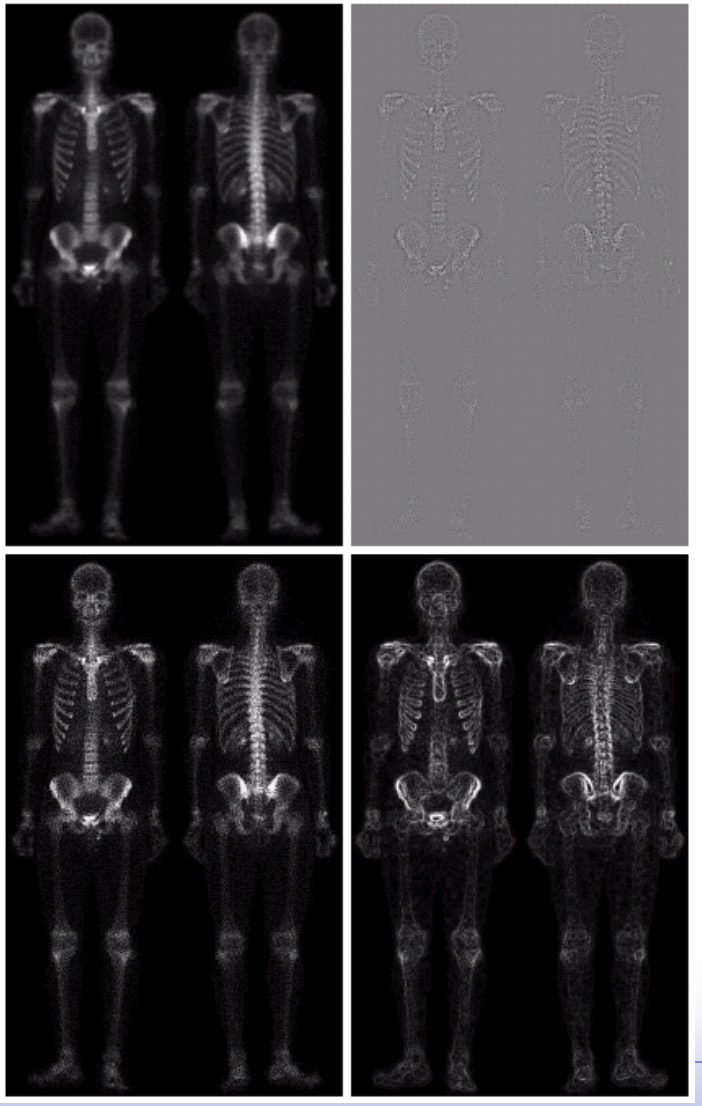
加强图像轮廓，使图像看起来比较清晰

图像锐化

讨论：

图像的轮廓有何特点？

如何加强轮廓？



图像锐化——微分法

最常用的微分方法是**梯度法**。

梯度（*Gradient*）是一个向量，定义为：

$$\mathbf{G}[f(x,y)]=\begin{bmatrix}\partial f/\partial x\\ \partial f/\partial y\end{bmatrix}$$

梯度有幅度和方向

$$G[f(x,y)]=\left[\left(\partial f/\partial x\right)^2+\left(\partial f/\partial y\right)^2\right]^{\frac{1}{2}}$$

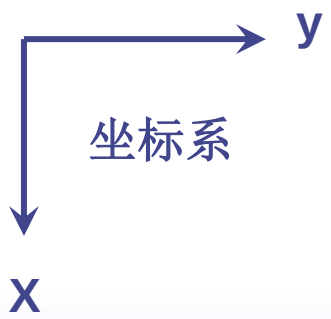
常用的梯度算法

对数字图像，用差分来近似微分

■典型梯度算法

$$G[f(x,y)]=\{[f(x,y)-f(x+1,y)]^2+[f(x,y)-f(x,y+1)]^2\}^{\frac{1}{2}}$$

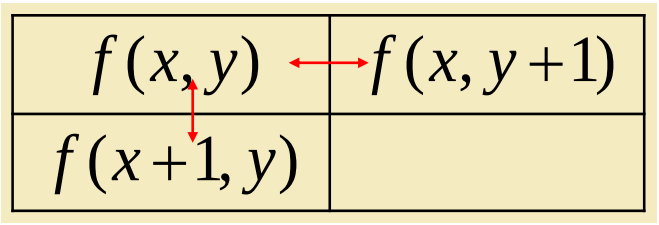
$f(x,y)$	$f(x,y+1)$
$f(x+1,y)$	



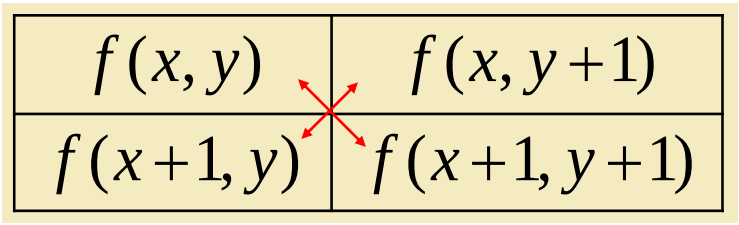
常用的梯度算法

■罗伯茨（Roberts）梯度算法

$$G[f(x,y)]=\{[f(x,y)-f(x+1,y+1)]^2+[f(x+1,y)-f(x,y+1)]^2\}^{\frac{1}{2}}$$



典型梯度算法



罗伯茨梯度算法

常用的梯度算法

■绝对差分算法

$$G[f(x,y)] \approx |f(x,y) - f(x+1,y)| + |f(x,y) - f(x,y+1)|$$

$$G[f(x,y)] \approx |f(x,y) - f(x+1,y+1)| + |f(x+1,y) - f(x,y+1)|$$

常用的梯度算法

说明：

对NxN 数字图像，不可能在最后一行(x=N)和最后一列(y=N)像素上计算梯度值。一种补救办法：用前一行(x=N-1)和前一列(y=N-1)对应像素的梯度值。

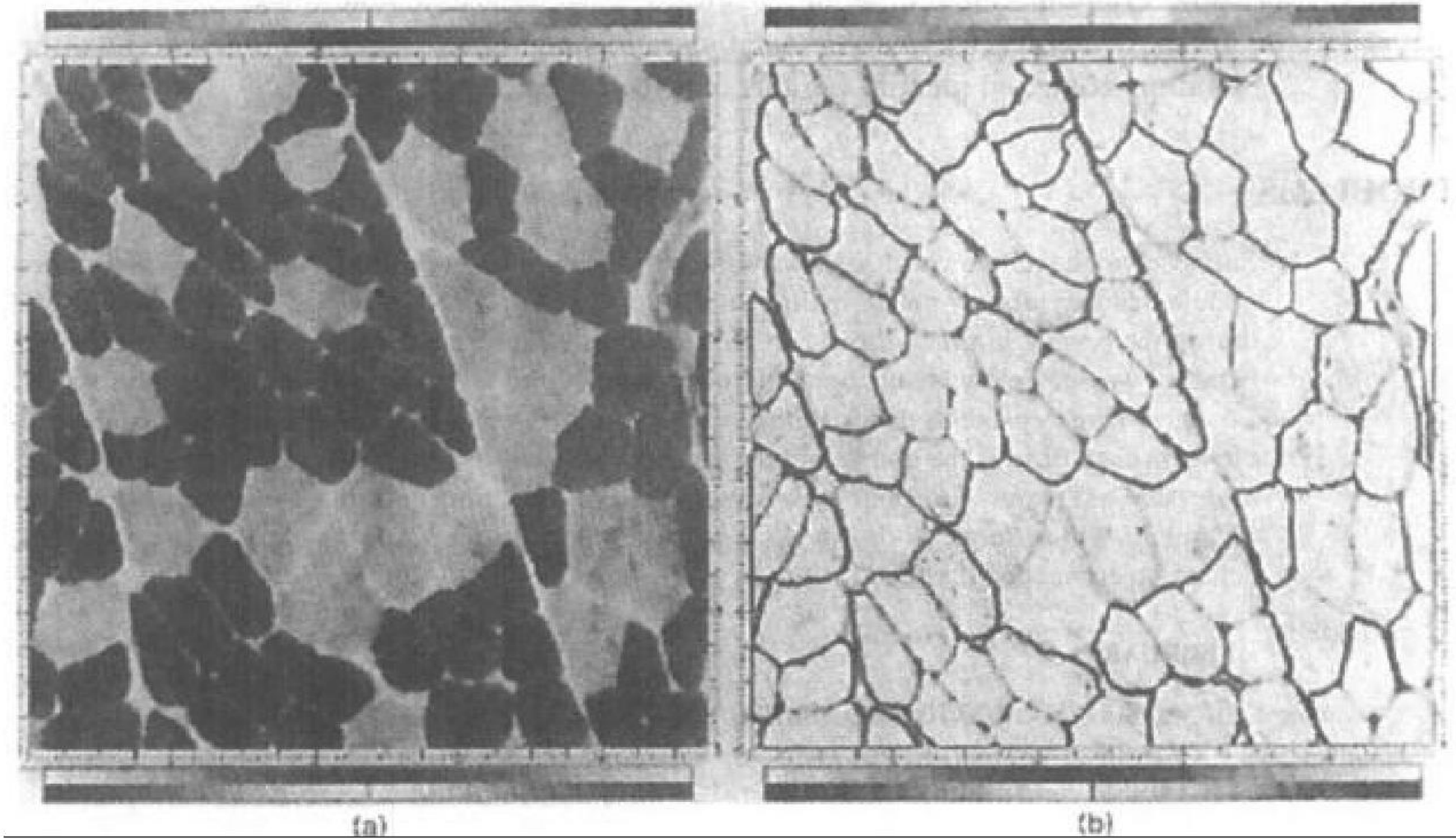


Figure 7–5 A gradient magnitude image: (a) muscle fibers; (b) gradient image

突出图像轮廓的方法

- 梯度图像

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

- 背景保留

$$g(x,y)=\begin{cases}G[f(x,y)] & G[f(x,y)]\geq T\\ f(x,y) & else\end{cases}$$

突出图像轮廓的方法

- 背景保留，轮廓取单一灰度值

$$g(x,y)=\begin{cases} L_G & G[f(x,y)]\geq T \\ f(x,y) & else \end{cases}$$

突出图像轮廓的方法

- **轮廓保留，背景取单一灰度值**

$$g(x,y)=\begin{cases} G[f(x,y)] & G[f(x,y)]\geq T \\ L_B & else \end{cases}$$

L_B：指定的背景灰度值。

突出图像轮廓的方法

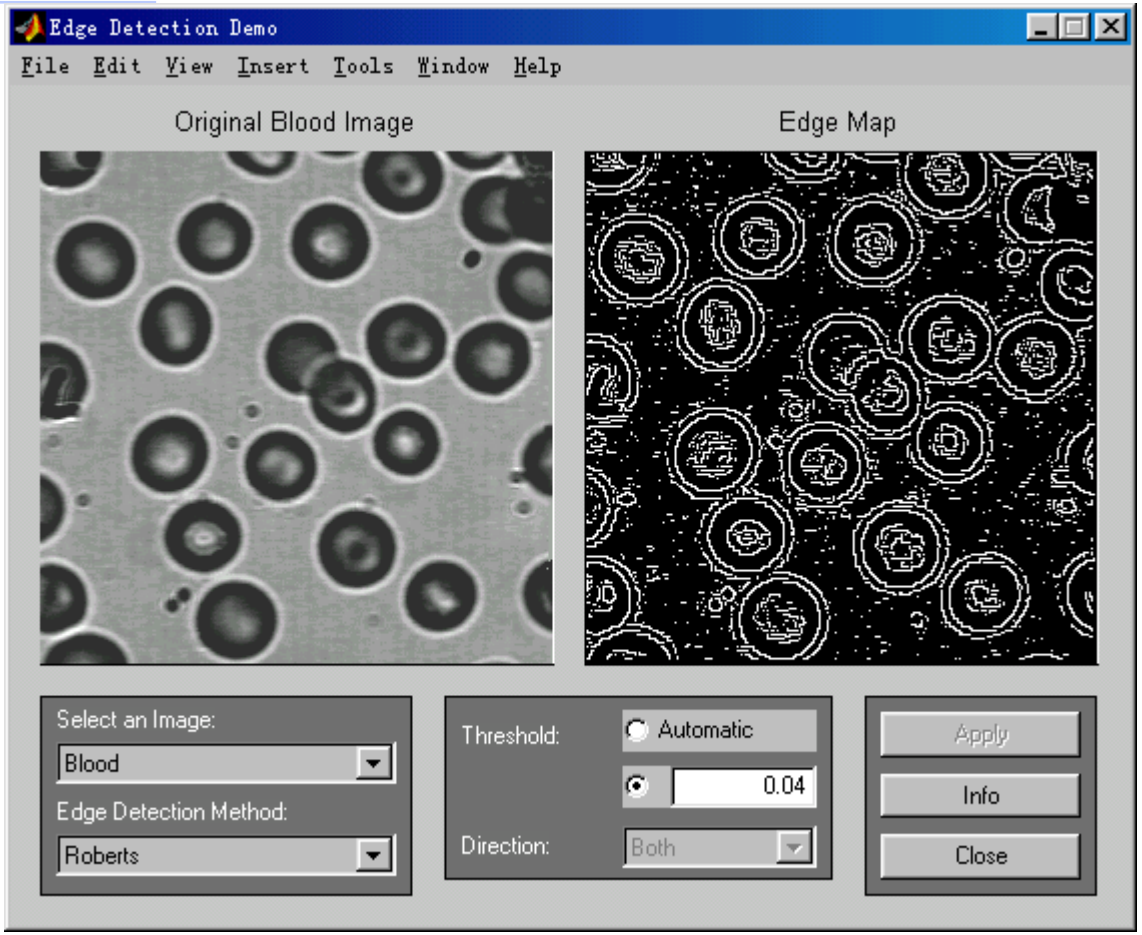
■轮廓、背景分别取单一灰度值

（二值化，只对轮廓感兴趣）

$$g(x,y)=\begin{cases}L_G & G[f(x,y)]\geq T\\ L_B & else\end{cases}$$

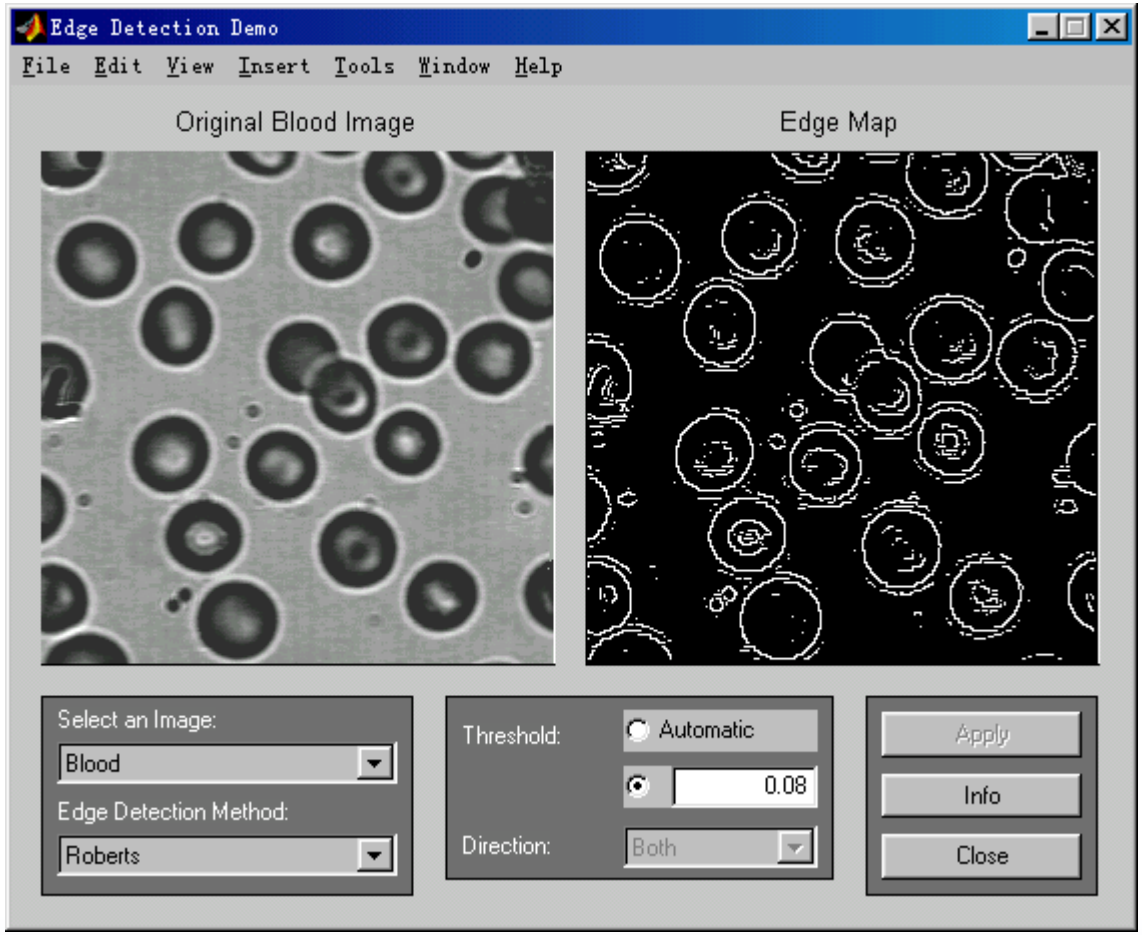
L_G：指定的轮廓灰度值。

L_B：指定的背景灰度值。

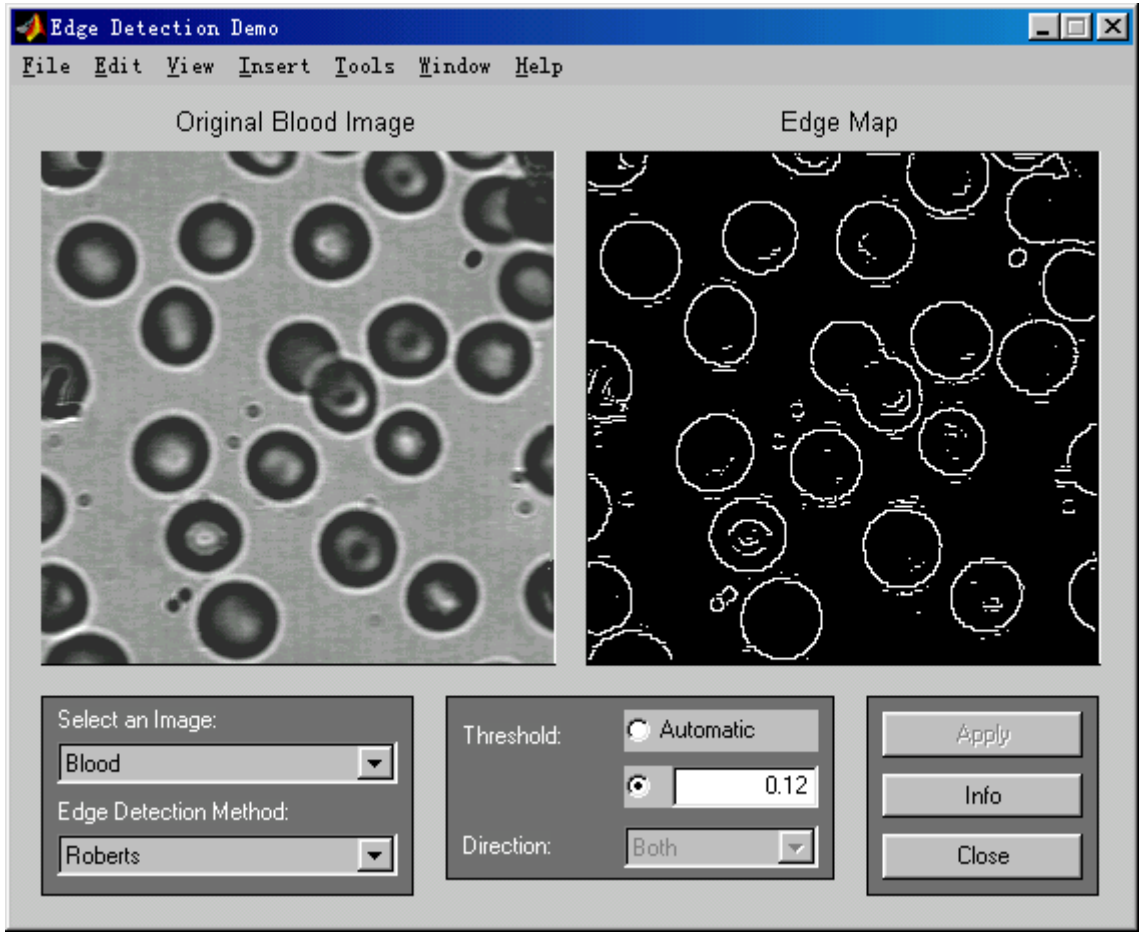


Edge Detection Methods Roberts

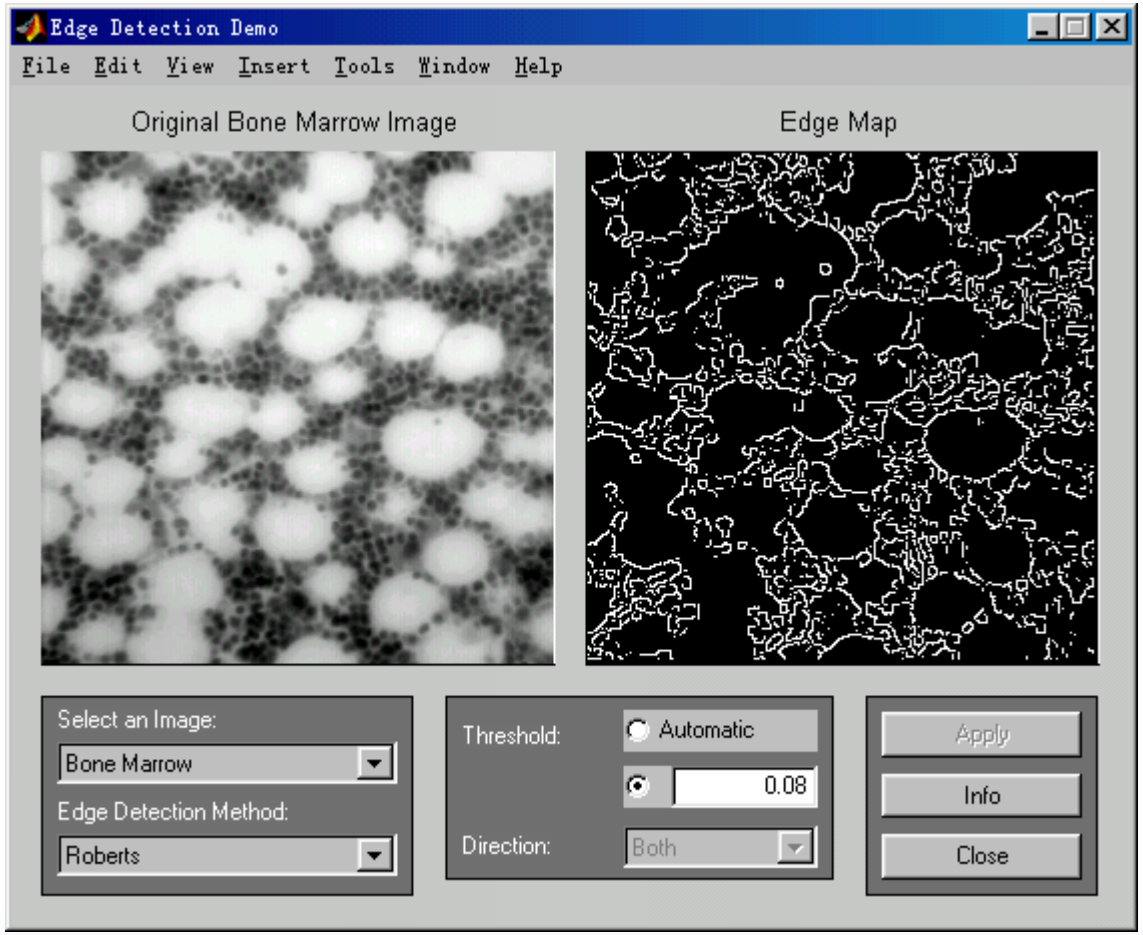
阈值为0.04

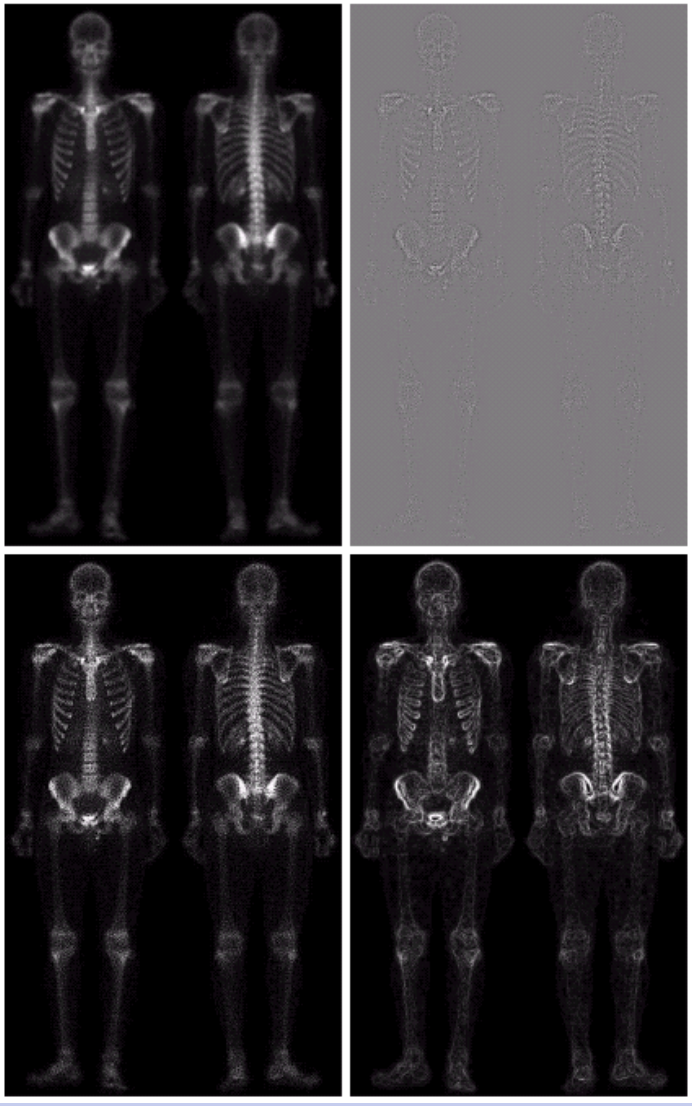


Edge Detection Methods Roberts 阈值为0.08



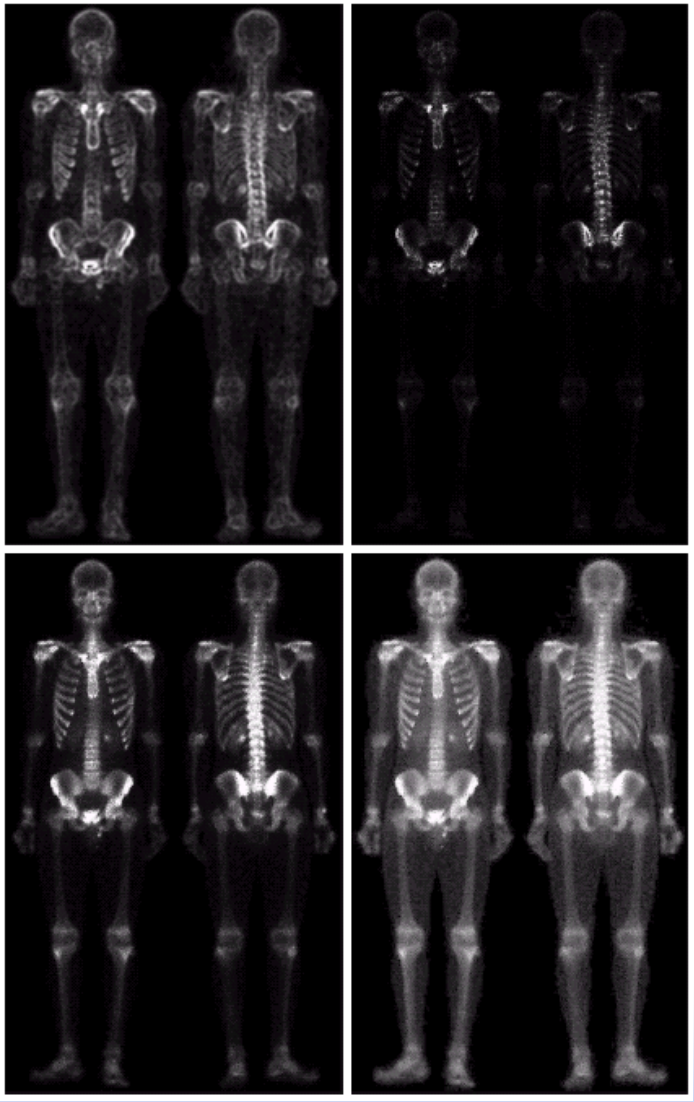
Edge Detection Methods Roberts 阈值为0.12


Edge Detection Demo
File Edit View Insert Tools Window Help
Original Bone Marrow Image
Edge Map
Select an Image:
Bone Marrow
Edge Detection Method:
Roberts
Threshold:
Automatic
0.08
Direction:
Both
Apply
Info
Close



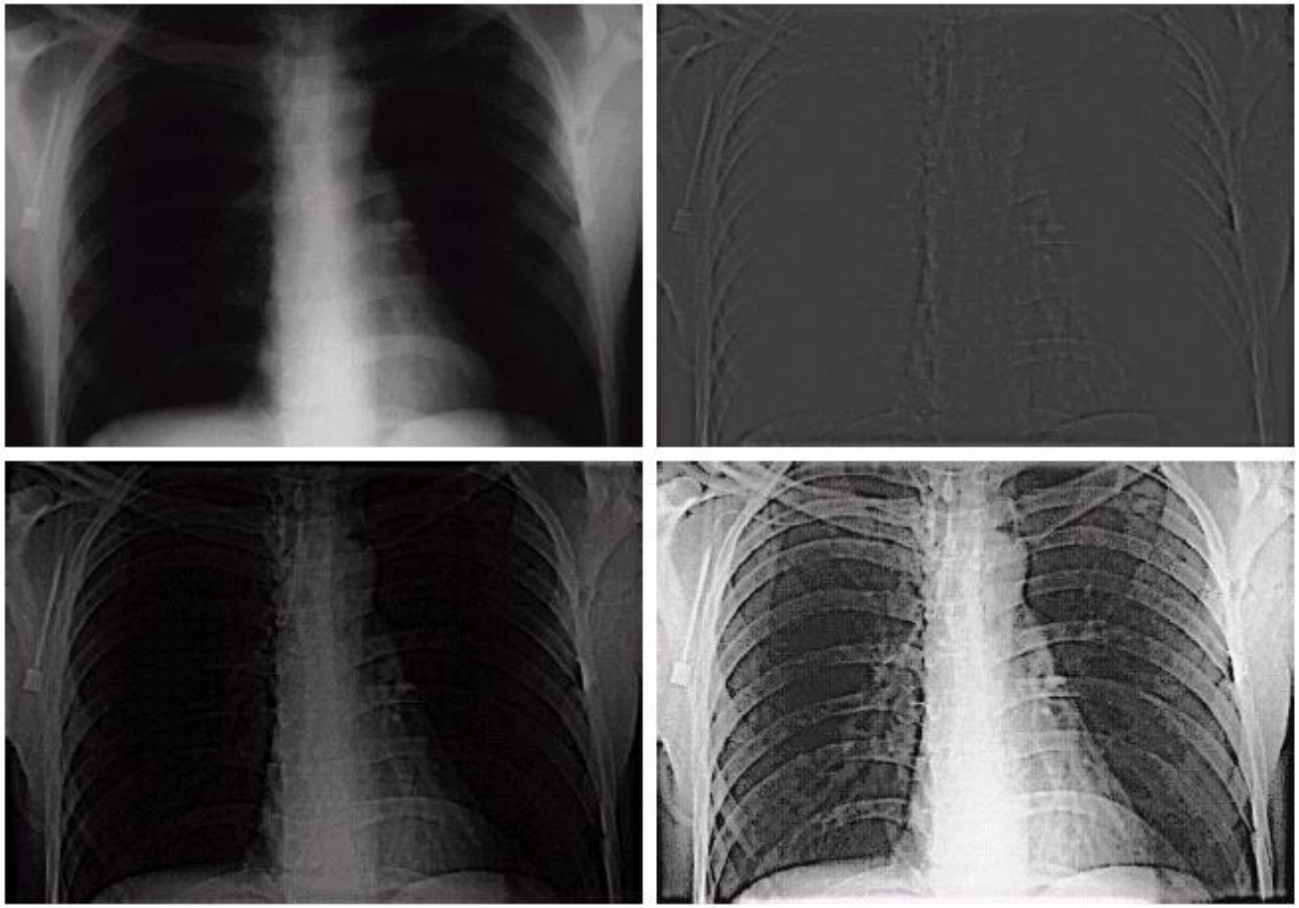
a b
c d

FIGURE 3.46
(a) Image of whole body bone scan.
(b) Laplacian of (a). (c) Sharpened image obtained by adding (a) and (b). (d) Sobel of (a).



e f
g h

FIGURE 3.46
(Continued)
(e) Sobel image smoothed with a 5 × 5 averaging filter. (f) Mask image formed by the product of (c) and (e). (g) Sharpened image obtained by the sum of (a) and (f). (h) Final result obtained by applying a power-law transformation to (g). Compare (g) and (h) with (a). (Original image courtesy of G.E. Medical Systems.)



a b
c d

FIGURE 4.30
(a) A chest X-ray image. (b) Result of Butterworth highpass filtering. (c) Result of high-frequency emphasis filtering. (d) Result of performing histogram equalization on (c). (Original image courtesy Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School.)

反锐化掩模法

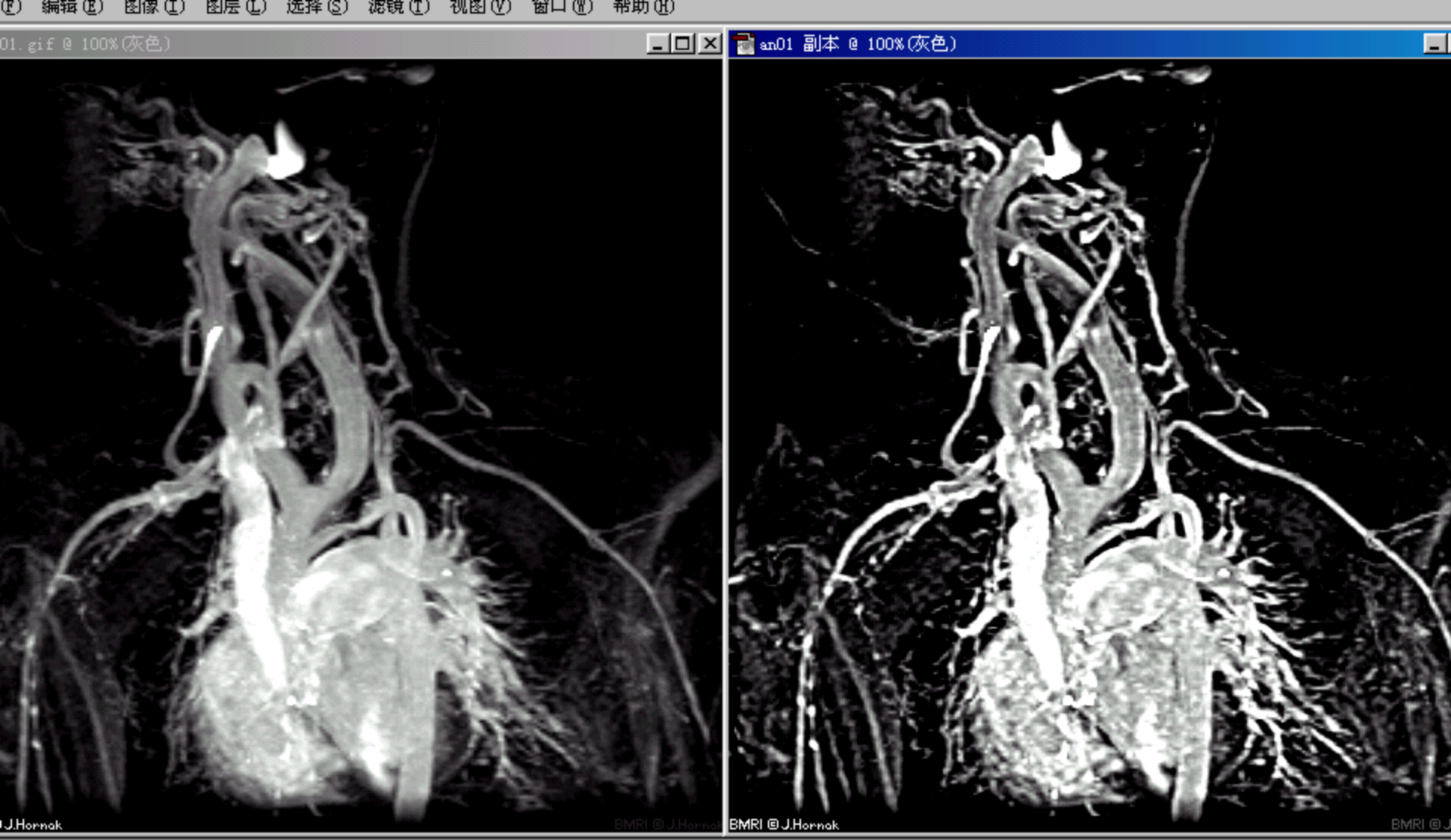
$$g(x,y) = f(x,y) + C[f(x,y) - \overline{f}(x,y)]$$

$\overline{f}(x,y)$ **是模糊化后的图像**

$$\mathbf{W}_1 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 9 & 0 \\ 0 & 0 & 0 \end{bmatrix} - \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

取 **C=9**, 并采用平均模糊图像的方法

$$\mathbf{W} = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$


(E) 编辑(E) 图像(I) 图层(L) 选择(S) 滤镜(T) 视图(V) 窗口(W) 帮助(H)
01.gif @ 100%(灰色)
an01 副本 @ 100%(灰色)
J.Hornak
BMRI © J.Hornak

USM

USM


Adobe Photoshop
文件(F) 编辑(E) 图像(I) 图层(L) 选择(S) 滤镜(T) 视图(V) 窗口(W) 帮助(H)
head1b.gif @ 100%(灰色)
head1b 副本 @ 100%(灰色)

USM

常见的锐化算子

梯度算子

1	
	-1

	1
-1	

Roberts

-1		1
-1		1
-1		1

1	1	1
-1	-1	-1

Prewitt

-1		1
-2		2
-1		1

1	2	1
-1	-2	-1

Sobel

常见的锐化算子

拉普拉斯(Laplacian)算子　二阶微分算子

	-1	
-1	4	-1
	-1	

-1		-1
	4	
-1		-1

-1	-1	-1
-1	8	-1
-1	-1	-1

	-1	
-1	5	-1
	-1	

-1		-1
	5	
-1		-1

-1	-1	-1
-1	9	-1
-1	-1	-1

常见的锐化算子

方向算子

-5	3	3
-5		3
-5	3	3

3	3	3
-5		3
-5	-5	3

3	3	3
3		3
-5	-5	-5

3	3	3
3		-5
3	-5	-5

3	3	-5
3		-5
3	3	-5

3	-5	-5
3		-5
3	3	3

-5	-5	-5
3		3
3	3	3

-5	-5	3
-5		3
3	3	3

Kirsch 算子的8方向3×3模板

常见的锐化算子

-1	-1	-1
0	0	0
1	1	1

0°

-1	-1	0
-1	0	1
0	1	1

45°

-1	0	1
-1	0	1
-1	0	1

90°

0	1	1
-1	0	1
-1	-1	0

135°

Compass operators

模板的讨论

模板的形状：

方形、矩形、线形、圆形

模板的大小：

小模板受局部噪声影响较大

大模板平滑，忽略了细节

模板中的权重：

相同、相异

与位置有关、无关

Terms

Image sharpening: 图象锐化

Contour: 轮廓

Edge: 边界，边缘

Boundary:边界

Deblurring: 去模糊

High frequency enhancement filter: 高频加强滤波器

Terms

Differentiation: 微分

Gradient vector: 梯度向量

Gradient magnitude: 梯度值，梯度

Background: 背景

Object: 物体

Scene: 景物，场景

Unsharp masking: 反锐化掩模

Terms

華中科技大學

Overshoot: 过冲

Ring: 振铃

Step function: 阶跃函数

Unit step function: 单位阶跃函数

Rectangular pulse: 矩形脉冲

Triangular pulse: 三角形脉冲

Gaussian function: 高斯函数

Terms

Impulse: 冲激函数

Dirac delta function: 狄拉克δ函数