Processamento de Imagens

Introdução

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Aula 04:

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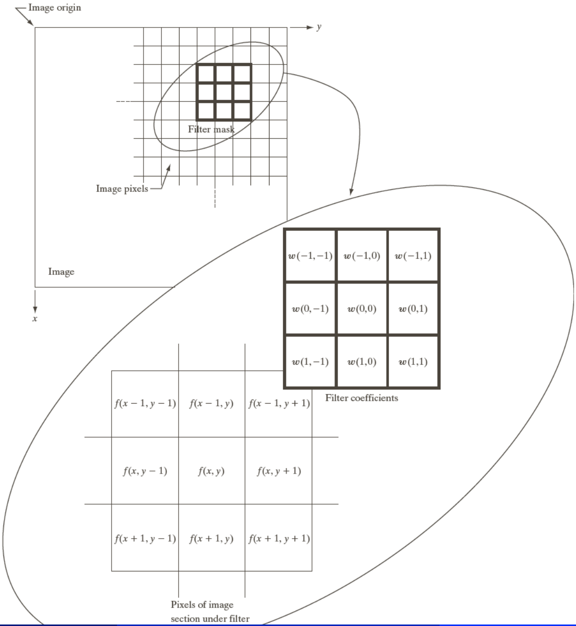
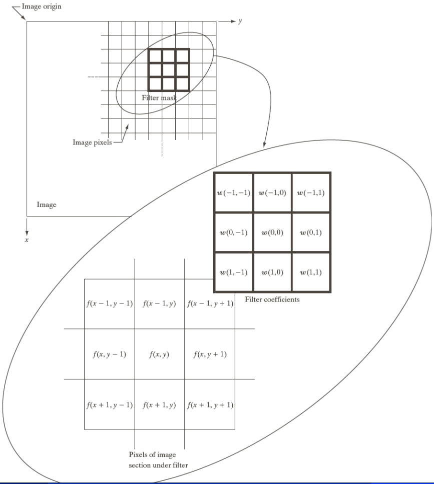
- Filtragem Espacial

Filtragem Espacial



Filtragem Espacial

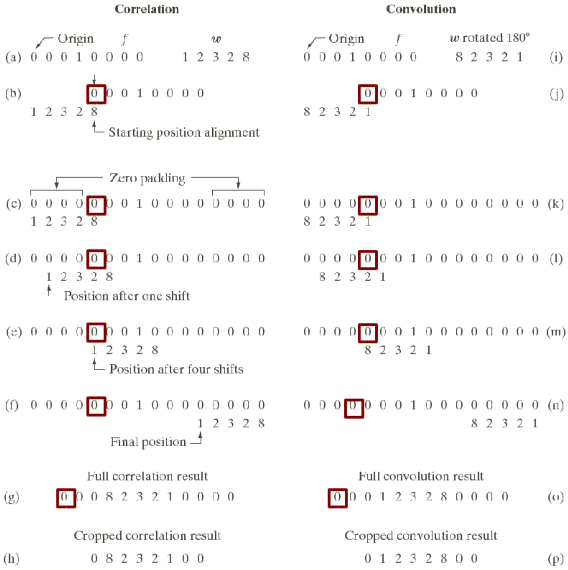
$$g(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)$$

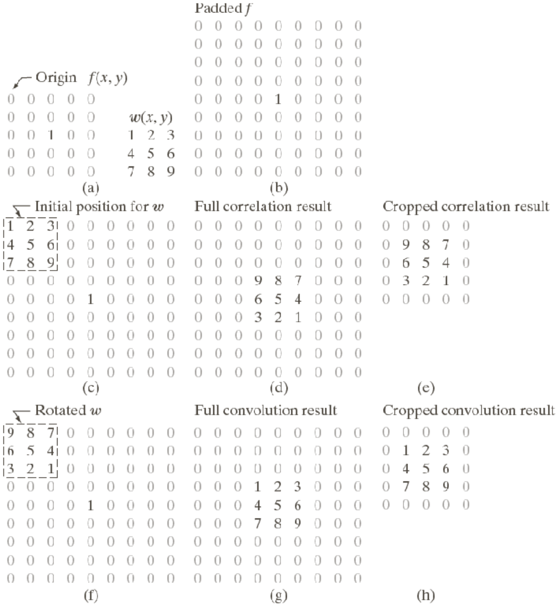


$$R = w(-1,-1)f(x-1,y-1) + w(-1,0)f(x-1,y) + \ldots$$
$$+ w(0,0)f(x,y) + \ldots + w(1,0)f(x+1,y0) + w(1,1)f(x+1,y+1)$$

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

$$R = w_1 z_1 + w_2 z_2 + \ldots w_m n z_m n$$
$$= \sum_{i=1}^{mn} w_i z_i$$


Correlation
Convolution
Origin f w
(a) 0 0 0 1 0 0 0 0 1 2 3 2 8
Origin f w rotated 180°
0 0 0 1 0 0 0 0 8 2 3 2 1 (i)
(b) 0 0 0 1 0 0 0 0
1 2 3 2 8
Starting position alignment
0 0 0 1 0 0 0 0 (j)
8 2 3 2 1
Zero padding
(c) 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
1 2 3 2 8
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 (k)
8 2 3 2 1
(d) 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
1 2 3 2 8
Position after one shift
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 (l)
8 2 3 2 1
(e) 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
1 2 3 2 8
Position after four shifts
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 (m)
8 2 3 2 1
(f) 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
1 2 3 2 8
Final position
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 (n)
8 2 3 2 1
Full correlation result
(g) 0 0 0 8 2 3 2 1 0 0 0 0
Full convolution result
0 0 0 1 2 3 2 8 0 0 0 0 (o)
Cropped correlation result
(h) 0 8 2 3 2 1 0 0
Cropped convolution result
0 1 2 3 2 8 0 0 (p)


Padded f
Origin f(x, y)
w(x, y)
(a)
(b)
Initial position for w
Full correlation result
Cropped correlation result
(c)
(d)
(e)
Rotated w
Full convolution result
Cropped convolution result
(f)
(g)
(h)

Filtragem Espacial

$$R = w(-1,-1)f(x-1,y-1) + w(-1,0)f(x-1,y) + \dots$$
$$+ w(0,0)f(x,y) + \dots + w(1,0)f(x+1,y0) + w(1,1)f(x+1,y+1)$$

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

$$R = w_1 z_1 + w_2 z_2 + \dots w_m n z_m n$$
$$= \sum_{i=1}^{mn} w_i z_i$$

Filtragem Espacial

$\frac{1}{9} \times$

1	1	1
1	1	1
1	1	1

$\frac{1}{16} \times$

1	2	1
2	4	2
1	2	1

$$R = \frac{1}{9} \sum_{i=1}^{mn} z_i$$

ou, genericamente:

$$R = \frac{\sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)}{\sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t)}$$

Filtros: $m = 3, 5, 9, 15,$ e 35.

Eliminando Detalhes

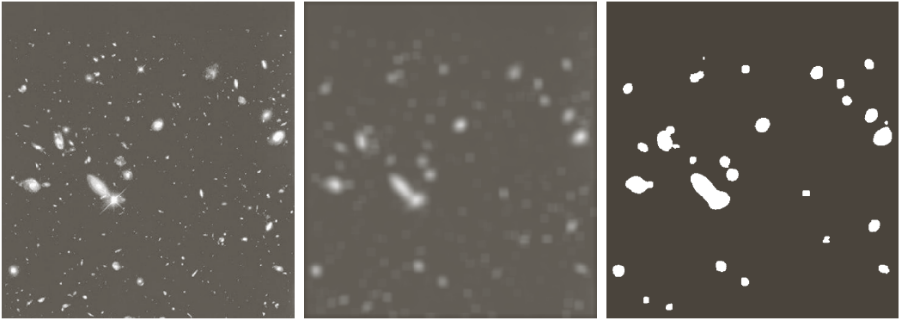
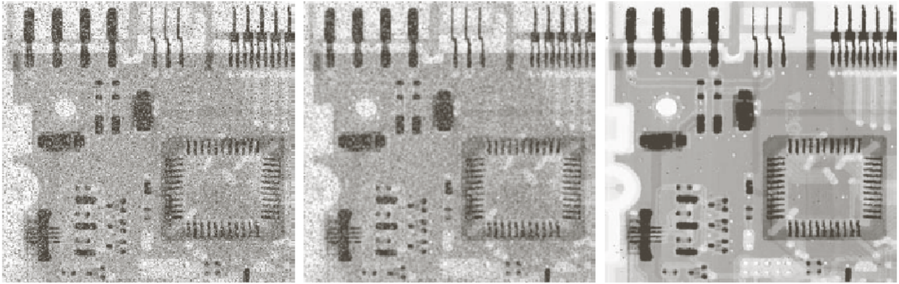


Imagem de 528 x 485. Filtragem com 15x15 seguida de thresholding.

Filtros Estatísticos

- Mediana:
  - Elimina pixels que diferem da sua vizinhança;
  - Áreas isoladas ($< m^2/2$ da vizinhança) são eliminadas
  - Salt and paper
- Max, Min, percentil (genérico)

Mediana



a b c

FIGURE 3.35 (a) X-ray image of circuit board corrupted by salt-and-pepper noise. (b) Noise reduction with a 3×3 averaging mask. (c) Noise reduction with a 3×3 median filter. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)

Filtros de Aguçamento

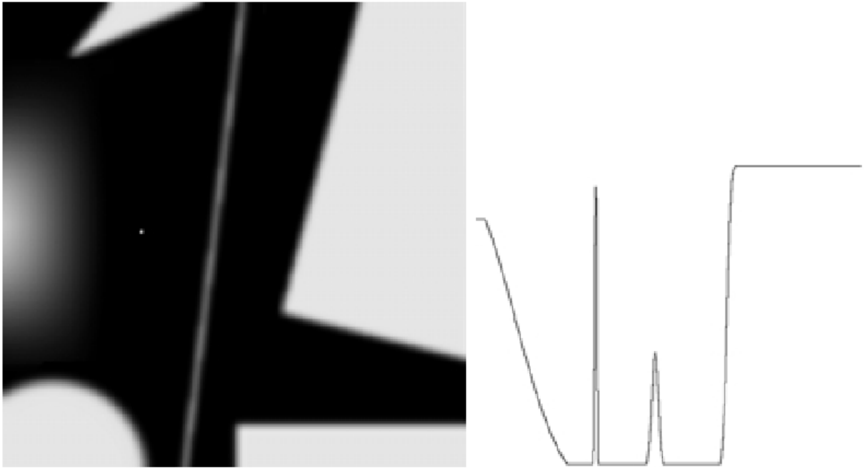
- 1a Derivada (discreta)

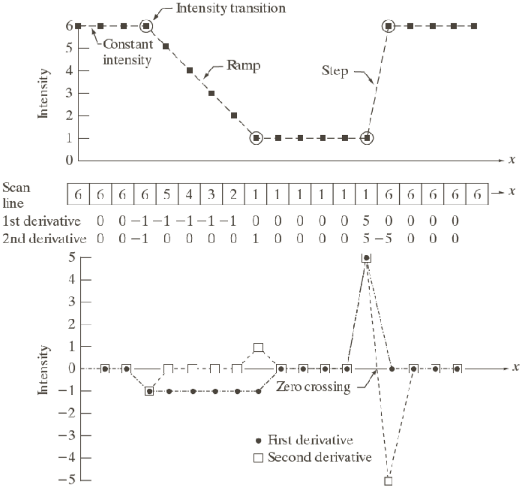
$$\frac{\partial f}{\partial x} = f(x+1) - f(x)$$

- 2a Derivada (discreta)

$$\frac{\partial^2 f}{\partial x^2} = f(x+1) + f(x-1) - 2f(x)$$

Filtros de Aguçamento




Intensity transition
Constant intensity
Ramp
Step
Intensity
x
Scan line
6 6 6 6 5 4 3 2 1 1 1 1 1 1 6 6 6 6 6
1st derivative 0 0 −1 −1 −1 −1 −1 0 0 0 0 0 5 0 0 0 0
2nd derivative 0 0 −1 0 0 0 0 1 0 0 0 0 5 −5 0 0 0
Zero crossing
First derivative
Second derivative

Laplaciano

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

onde

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

e

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

Logo

$$\boxed{\nabla^2 f = [f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1)] - 4f(x, y)}$$

Laplaciano: Máscaras Espaciais

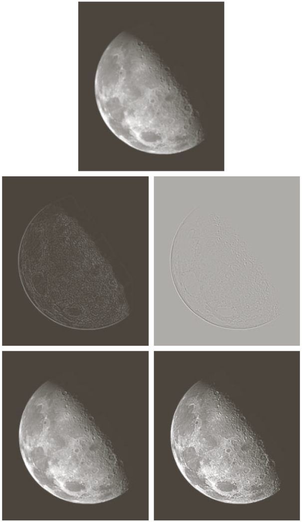
0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

Laplaciano

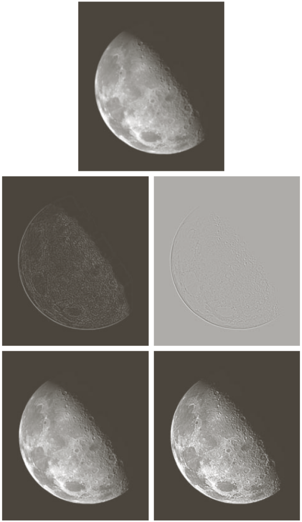


(a) imagem borrada, (b) Laplaciano sem escala, (b) Laplaciano com escalonamento, (c) Laplaciano.

Unsharp Masking

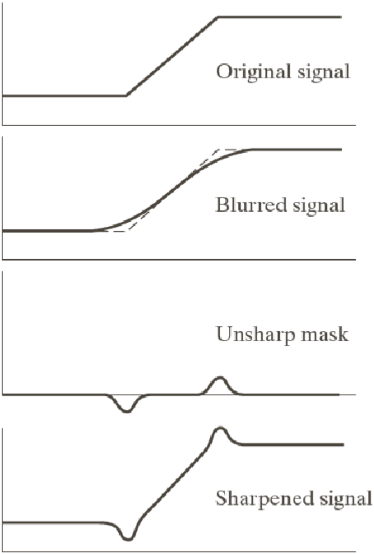
Passos:

1. $\bar{f}(x,y) = \text{conv}(h_{LP}(x,y), f(x,y)) = h_{LP}(x,y) * f(x,y)$
2. $g_{mask} = f(x,y) - \bar{f}(x,y)$
3. $g(x,y) = f(x,y) + k \cdot g_{mask}(x,y)$



(d) Unsharp masking.

Unsharp Masking



High Boost

Passos:

$$f_{hb}(x,y) = Af(x,y) - \bar{f}(x,y)$$

$$f_{hb}(x,y) = (A-1)f(x,y) + f(x,y) - \bar{f}(x,y)$$

$$f_{hb}(x,y) = (A-1)f(x,y) - f_s(x,y)$$

0	−1	0
−1	$A+4$	−1
0	−1	0

−1	−1	−1
−1	$A+8$	−1
−1	−1	−1

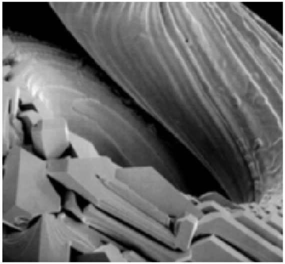
High Boost

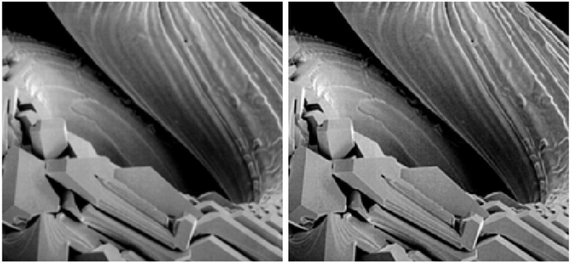
original, borrado com Gaussiano, unsharp mask, resultado do unsharp mask, resultado do high-boost

High Boost

0	−1	0
−1	5	−1
0	−1	0

−1	−1	−1
−1	9	−1
−1	−1	−1





a b c
d e

FIGURE 3.41 (a) Composite Laplacian mask. (b) A second composite mask. (c) Scanning electron microscope image. (d) and (e) Results of filtering with the masks in (a) and (b), respectively. Note how much sharper (e) is than (d). (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)

High Boost

a	b
c	d

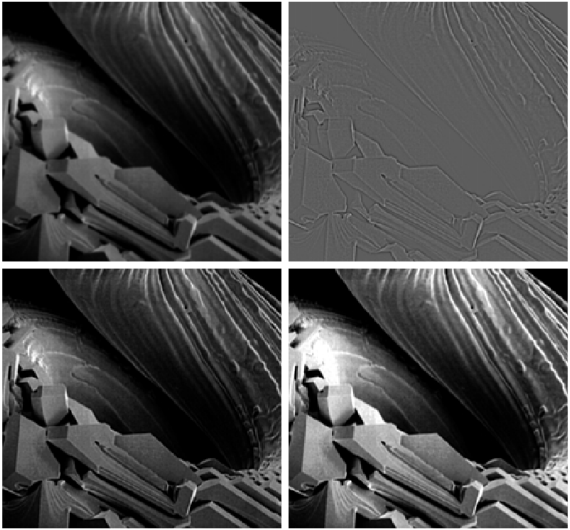


FIGURE 3.43 (a) Same as Fig. 3.41(c), but darker. (a) Laplacian of (a) computed with the mask in Fig. 3.42(b) using $A = 0$. (c) Laplacian enhanced image using the mask in Fig. 3.42(b) with $A = 1$. (d) Same as (c), but using $A = 1.7$.

Passos:

$$\nabla f = \begin{vmatrix} G_x \\ G_y \end{vmatrix} = \begin{vmatrix} \frac{\partial f}{\partial x} \\ \\ \frac{\partial f}{\partial y} \end{vmatrix}$$

$$\begin{aligned} \nabla f &= \text{mag}(\nabla f) \\ &= \left[G_x^2 + G_y^2\right]^{1/2} \\ &= \left[\frac{\partial f}{\partial x}^2 + \frac{\partial f}{\partial y}^2\right]^{1/2} \end{aligned}$$

OU

$$\nabla f \approx |G_x| + |G_y|$$

Roberts & Sobel

(a)

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

(b)

−1	0
0	1

(c)

0	−1
1	0

(d)

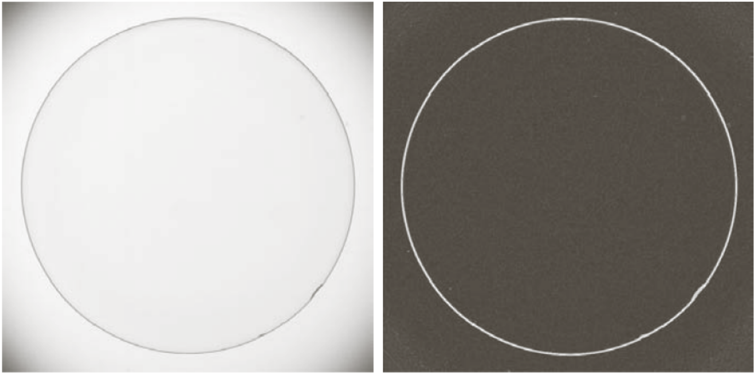
−1	−2	−1
0	0	0
1	2	1

(e)

−1	0	1
−2	0	2
−1	0	1

a
b c
d e

FIGURE 3.41 A 3×3 region of an image (the zs are intensity values). (b)–(c) Roberts cross gradient operators. (d)–(e) Sobel operators. All the mask coefficients sum to zero, as expected of a derivative operator.

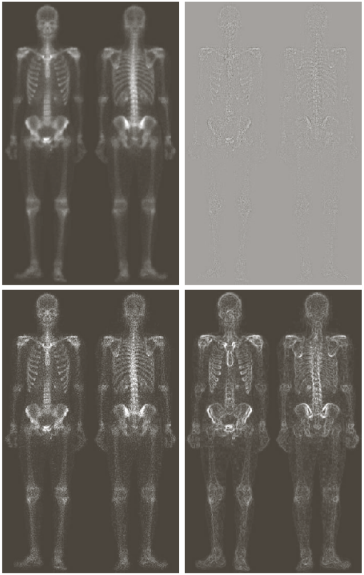


original e Sobel

Roberts & Sobel

original

Laplaciano do original



Original + Laplaciano

Sobel do original

a b
c d

FIGURE 3.43 (a) Image of whole body bone scan. (b) Laplacian of (a). (c) Sharpened image obtained by adding (a) and (b). (d) Sobel gradient of (a).