

Realce

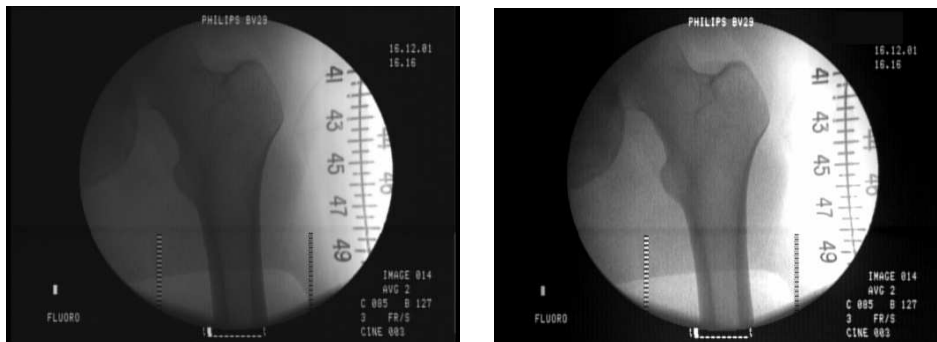
Processamento de imagens objetivando a melhorar a sua qualidade visual



... Aumentar a nitidez

EA978 - 2s2008 - Ting

Realce



... Aumentar o contraste

EA978 - 2s2008 - Ting

Realce



... Realçar a borda

EA978 - 2s2008 - Ting

Realce



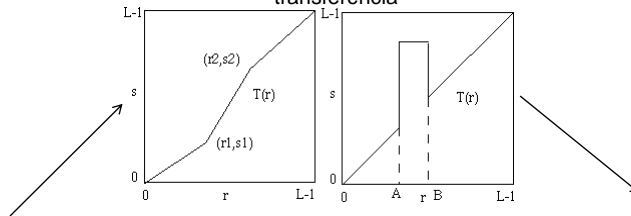
Imagem Original +
Imagem com borda
realçada

EA978 - 2s2008 - Ting

Realce

Métodos no Domínio Espacial

Alterar função de transferência



Aumentar contraste

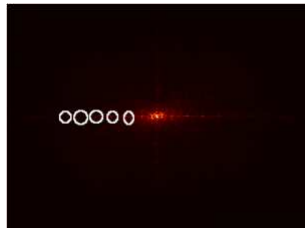


EA978 - 2s2008 - Ting

<http://www.cs.ru.nl/~ths/rt2/col/h4/4verbeteringenENG.html>

Realce

Métodos no Domínio da Frequência

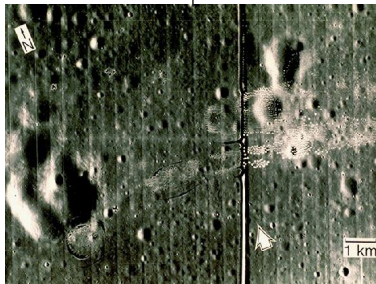


Filtragem



↑ FFT

↓ FFT⁻¹

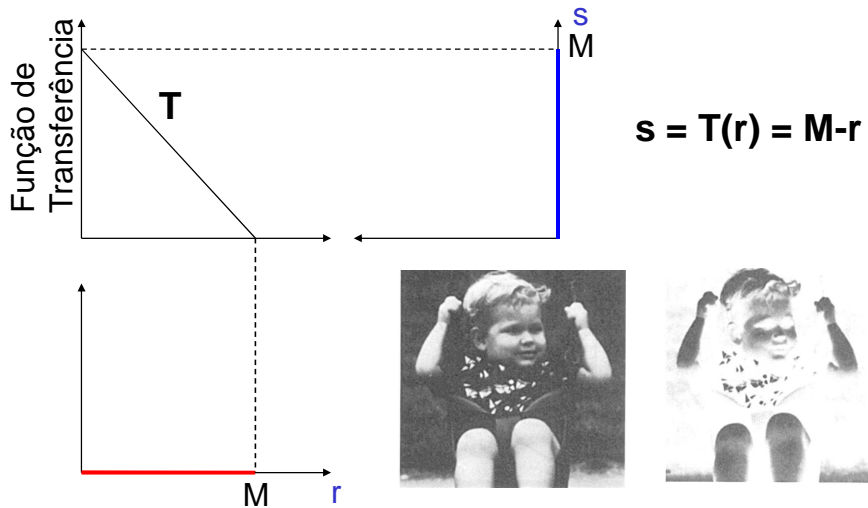


Remoção de ruídos



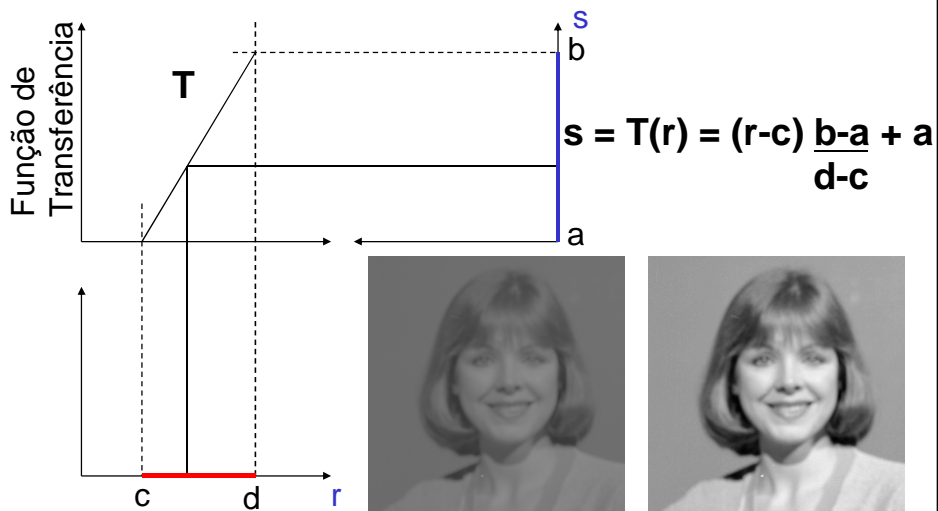
EA978 - 2s2008 - Ting

Funções de Transferência Negativos de Imagens



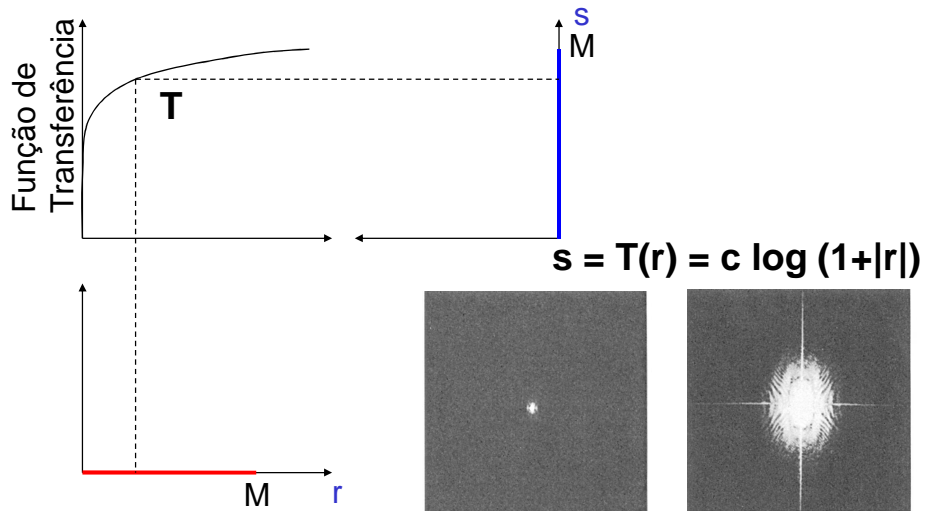
EA978 - 2s2008 - Ting

Funções de Transferência Alargamento da faixa (de contraste)



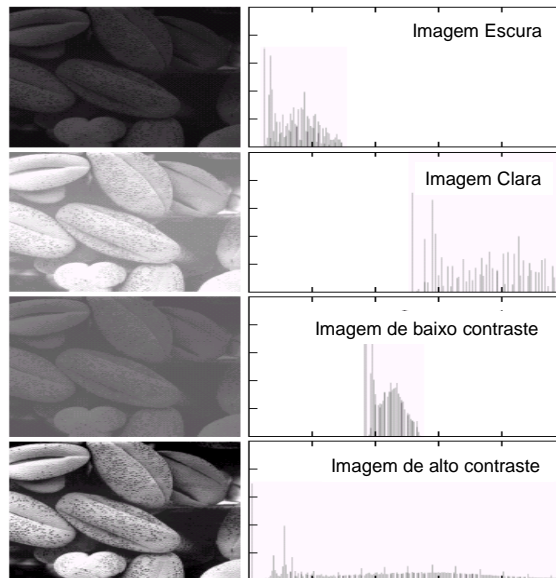
EA978 - 2s2008 - Ting

Funções de Transferência Compressão da Escala Dinâmica



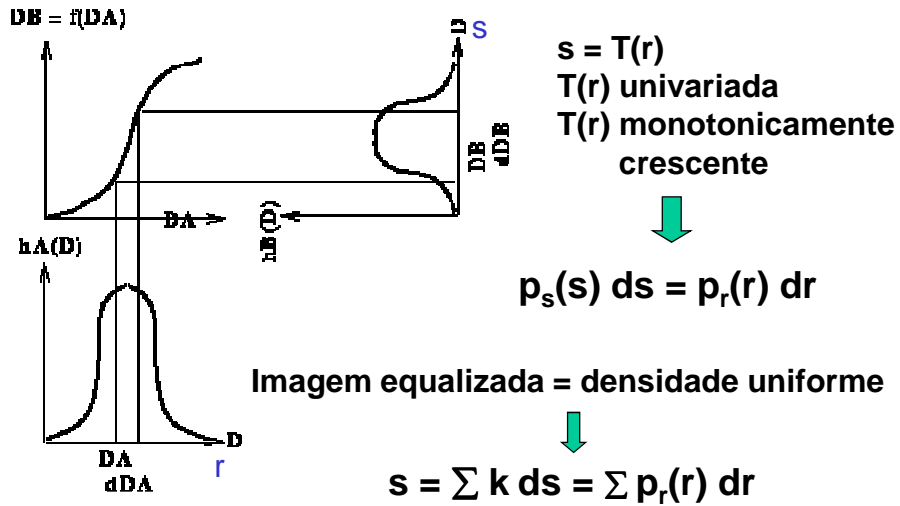
EA978 - 2s2008 - Ting

Processamento de Histograma



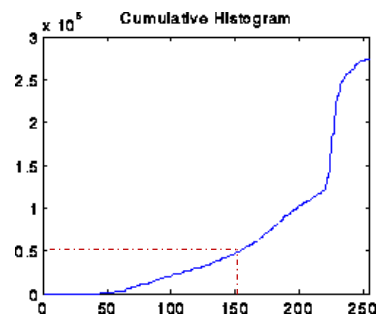
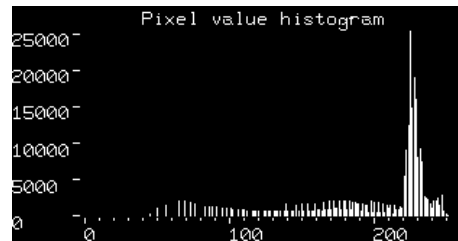
EA978 - 2s2008 - Ting

Equalização de Histograma



EA978 - 2s2008 - Ting

Função de Freqüência Cumulativa



EA978 - 2s2008 - Ting

Equalização de Histograma Algoritmo

1. Construir o histograma da imagem original ($n \times m$).
2. Determinar os níveis de cinza r_i , dentre L possíveis níveis, que ocorrem na imagem.
3. Para cada nível de cinza r_i , determinar o número de *pixels* n_i com intensidade menor que r_i .
4. Determinar os valores s_i correspondentes na nova imagem com L níveis de cinza $\{0, 1, 2, \dots, L-1\}$

$$s_i = T(r_i) = \max\left\{0, \left\lfloor \frac{n_i}{\frac{n \times m}{L}} \right\rfloor - 1\right\}$$

EA978 - 2s2008 - Ting

Equalização de Histograma

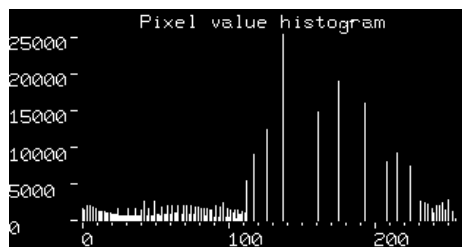
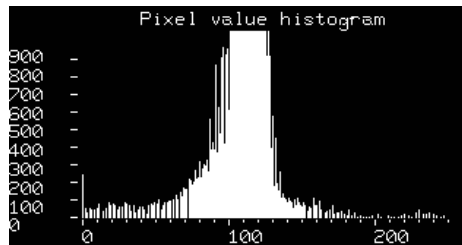
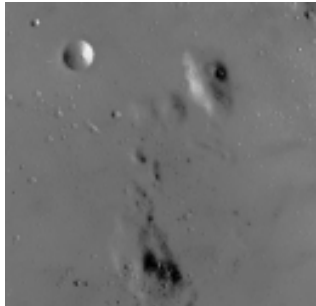


Imagem com
histograma
equalizado

EA978 - 2s2008 - Ting

Equalização de Histograma

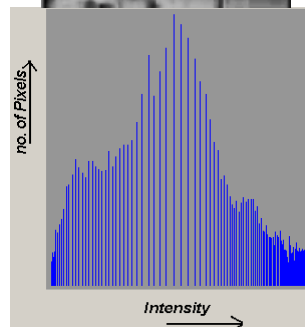
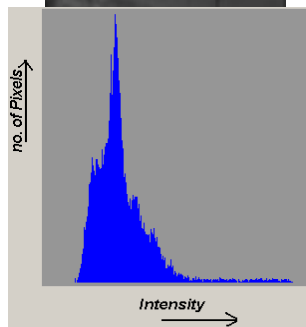
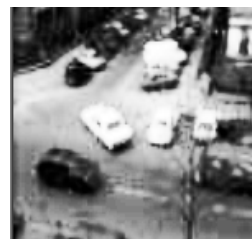
Exemplo



EA978 - 2s2008

Equalização de Histograma

Exemplo



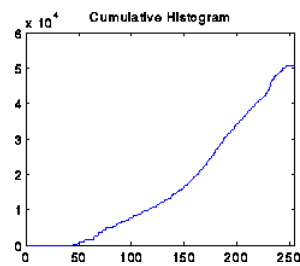
EA978 - 2s2008 - Ting



Altos contrastes na imagem e pequenos contrastes nos detalhes!

EA978 - 2s2008 - Ting

Equalização Local



EA978 - 2s2008 - Ting

Processamento Ponto a Ponto

Exemplos



(alargamento da faixa)



Equalização do histograma

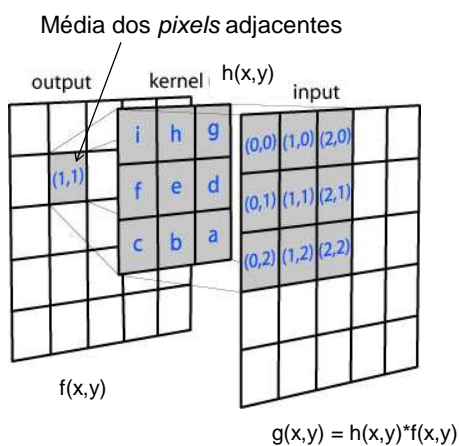


Equalização local



EA978 - 2s2008 - Ting

Filtragem Espacial



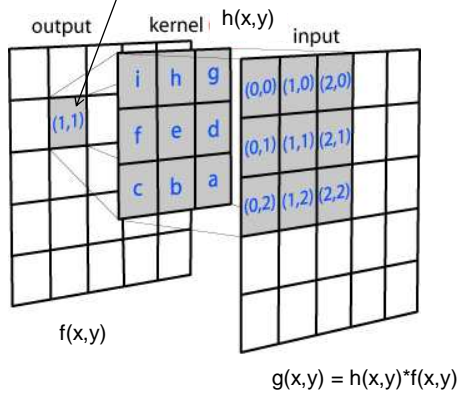
- **Filtros Lineares:** são máscaras de convolução $h(x,y)$, descritíveis no domínio espectral
- **Filtros por média** (máscara box)

$$h_{\text{rect}}[j,k] = \frac{1}{25} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

EA978 - 2s2008 - Ting

Filtragem Espacial

Soma ponderada pela função gaussiana



- **Filtros Lineares:** são máscaras de convolução $h(x,y)$, descritíveis no domínio espectral

- Filtros por média (máscara box)

$$h_{\text{rect}}[j,k] = \frac{1}{25} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

- **Filtros Gaussianos**

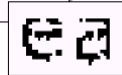
EA978 - 2s2008 - Ting

Filtro Linear Máscara de Convolução Gaussiana

a b

FIGURE 4.19
(a) Sample text of poor resolution (note broken characters in magnified view).
(b) Result of filtering with a GLPF (broken character segments were joined).

Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

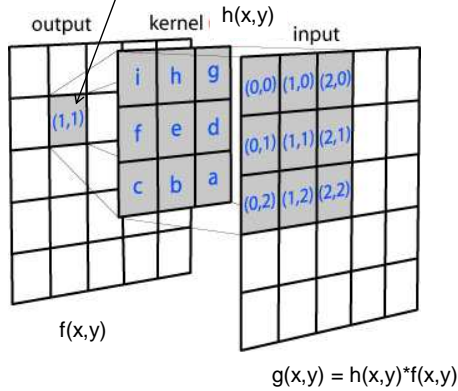


EA978 - 2s2008 - Ting

$$\frac{\partial f}{\partial x} = \frac{f[x+1, y] - f[x, y]}{\Delta x}$$

$$g(f[x, y]) = \left| \frac{\partial f}{\partial x} \right| + \left| \frac{\partial f}{\partial y} \right|$$

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



EA978 - 2s2008 - Ting

Filtragem Espacial

- **Filtros Lineares:** são máscaras de convolução $h(x,y)$, descritíveis no domínio espectral
 - Filtros por média (máscara box)

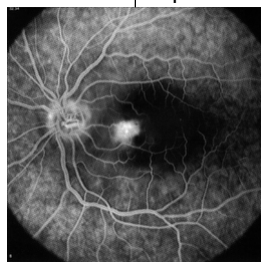
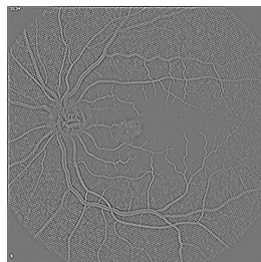
$$h_{\text{rect}}[j, k] = \frac{1}{25} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

- Filtros Gaussianos
- **Filtros por Derivadas**

Filtragem Espacial

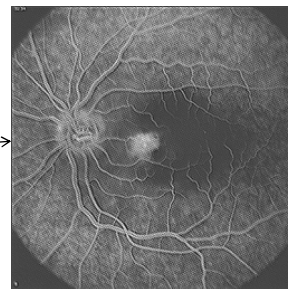
Filtros de Ajustamento

$$\frac{1}{9} \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$



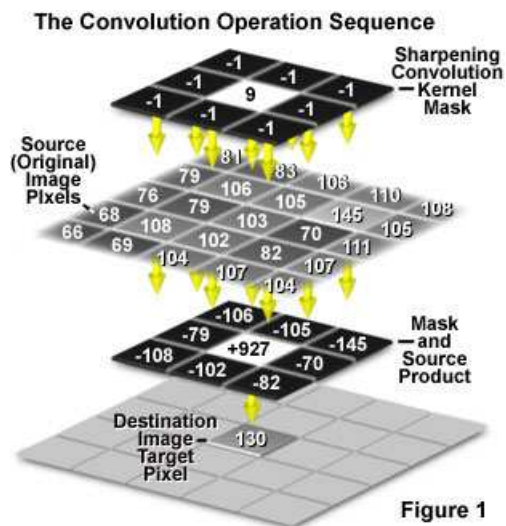
Filtro espacial
Laplaciano

+



EA978 - 2s2008 - Ting

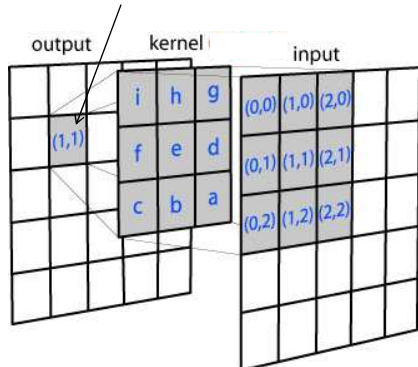
Filtragem



EA978 - 2s2008 - Ting

Filtragem Espacial

Mediana dos *pixels* cobertos pela máscara



- **Filtros Lineares:** são máscaras de convolução $h(x,y)$, descritíveis no domínio espectral
- Filtros por média (máscara box)

$$h_{rect}[j,k] = \frac{1}{25} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

- Filtros Gaussianos
- Filtros por Derivadas
- **Filtros não-lineares:** não são representáveis pela transformada de Fourier
 - Filtros por mediana

EA978 - 2s2008 - Ting

Filtragem Espacial

Filtro por Mediana



Imagem original

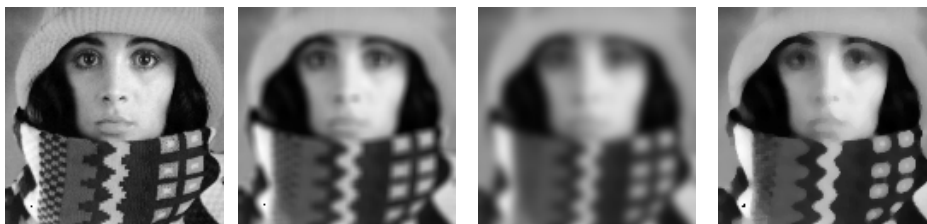
Imagem + ruído gaussiano

(Imagem + ruído gaussiano) filtrada

EA978 – 2s2008 - Ting

Filtragem Espacial

Exemplos de filtros de suavização



Original

Filtro por Média

Filtro Gaussiano

Filtro por Mediana

<http://www.ph.tn.tudelft.nl/Courses/FIP/frames/fip-Smoothin.html>

EA978 – 2s2008 - Ting

Filtragem no Domínio da Frequência

$$I_{realçada}(u,v) = H(u,v) I_{original}(u,v)$$

$H(u,v)$ { filtro passa-baixas → atenua bordas
 filtro passa-altas → acentua bordas

EA978 – 2s2008 - Ting

Filtragem no Domínio da Frequência

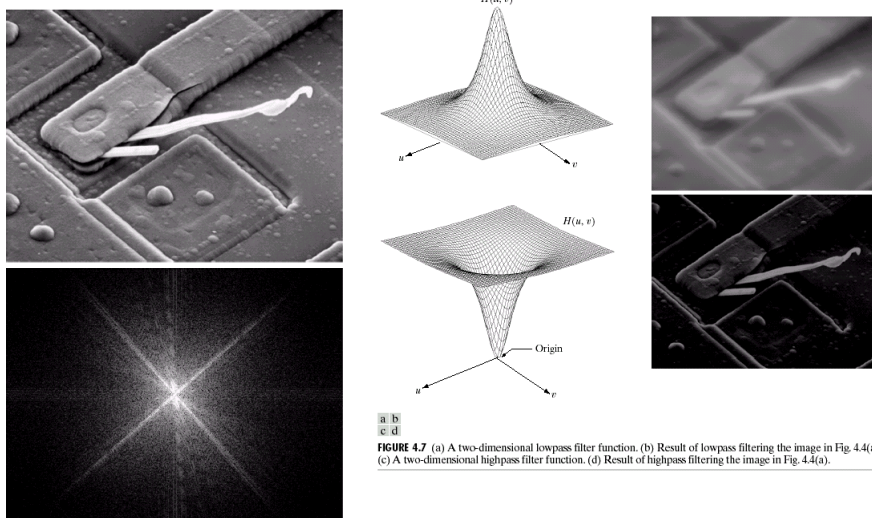


FIGURE 4.7 (a) A two-dimensional lowpass filter function. (b) Result of lowpass filtering the image in Fig. 4.4(a). (c) A two-dimensional highpass filter function. (d) Result of highpass filtering the image in Fig. 4.4(a).

EA978 – 2s2008 - Ting

Realce

Filtragem no domínio de frequências

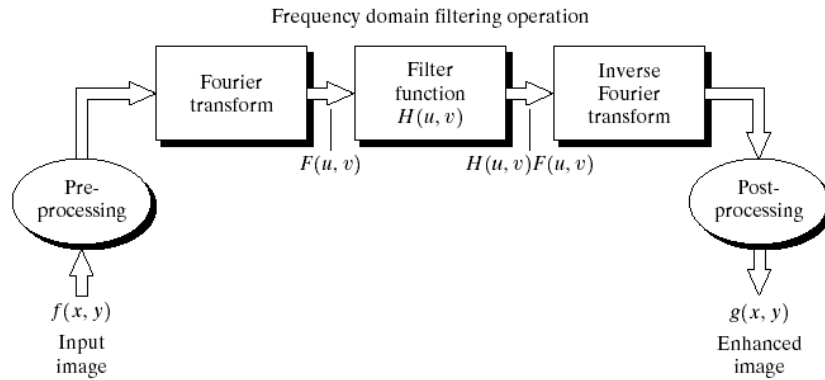


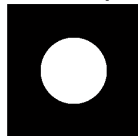
FIGURE 4.5 Basic steps for filtering in the frequency domain.

Implementação eficiente de $H(u, v)$:
máscaras de convolução

EA978 - 2s2008 - Ting

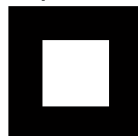
Filtros Passa-Baixas Ideais

Não-Separáveis



$$H(u, v) = \begin{cases} 1, & \text{for } \sqrt{u^2 + v^2} \leq D_0 \\ 0, & \text{otherwise} \end{cases}$$

Separáveis

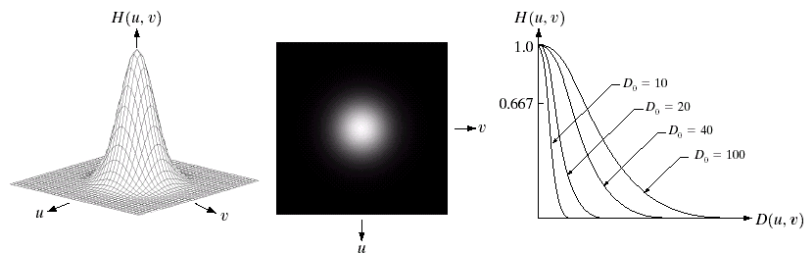


$$H(u, v) = \begin{cases} 1, & \text{for } u \leq D_u \text{ and } v \leq D_v \\ 0, & \text{otherwise} \end{cases}$$

EA978 - 2s2008 - Ting

Filtros Gaussianos Passa-Baixas

$$H(u, v) = e^{-\frac{\sqrt{u^2 + v^2}}{D_0}}$$

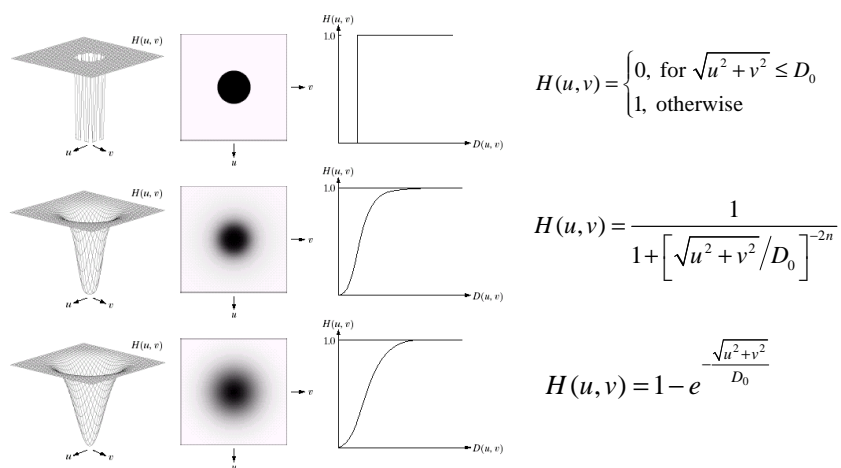


a b c

FIGURE 4.17 (a) Perspective plot of a GLPF transfer function. (b) Filter displayed as an image. (c) Filter radial cross sections for various values of D_0 .

EA978 - 2s2008 - Ting

Filtros Passa-Altas



$$H(u, v) = \begin{cases} 0, & \text{for } \sqrt{u^2 + v^2} \leq D_0 \\ 1, & \text{otherwise} \end{cases}$$

$$H(u, v) = \frac{1}{1 + \left[\frac{\sqrt{u^2 + v^2}}{D_0} \right]^{-2n}}$$

$$H(u, v) = 1 - e^{-\frac{\sqrt{u^2 + v^2}}{D_0}}$$

a b c
d e f
g h i

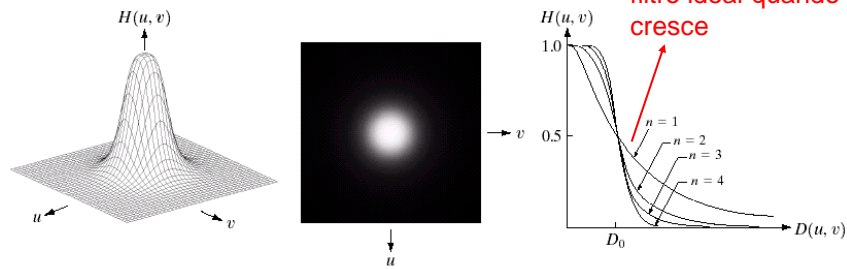
FIGURE 4.22 Top row: Perspective plot, image representation, and cross section of a typical ideal highpass filter. Middle and bottom rows: The same sequence for typical Butterworth and Gaussian highpass filters.

EA978 - 2s2008 - Ting

Filtros Butterworth

$$H(u, v) = \frac{1}{1 + \left[\sqrt{u^2 + v^2} / D_0 \right]^{2n}}$$

Comportamento se aproxima o de um filtro ideal quando n cresce

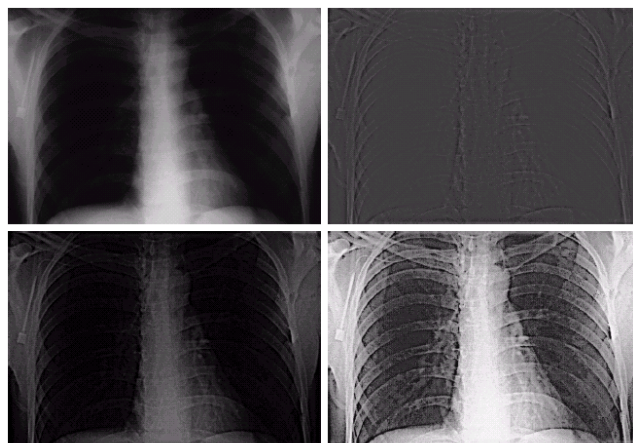


a b c

FIGURE 4.14 (a) Perspective plot of a Butterworth lowpass filter transfer function. (b) Filter displayed as an image. (c) Filter radial cross sections of orders 1 through 4.

EA978 - 2s2008 - Ting

Filtro Pass-Altas Exemplo



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.)

EA978 - 2s2008 - Ting