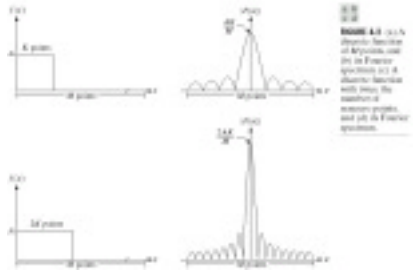
Frequency Domain Processing

Frequency domain processing
•Homomorphic filtering

Recap: Fig 4.1

An example: Fig 4.2



Basic Scheme

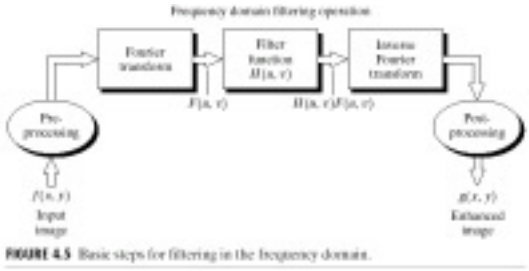
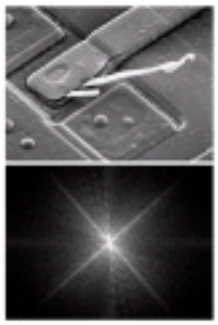
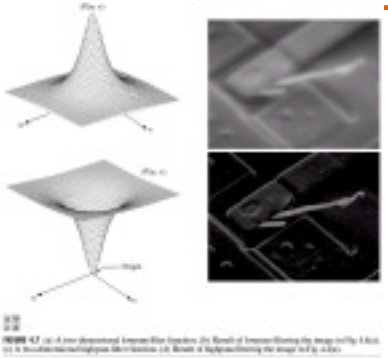


FIGURE 4.5 Basic steps for filtering in the frequency domain.

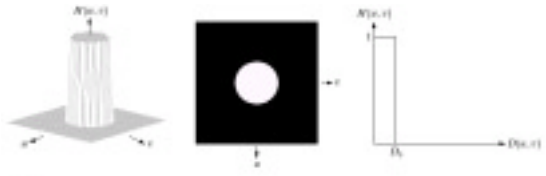
An image and its DFT: Fig 4.4



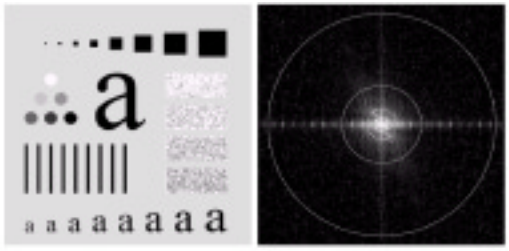
filtering



Ideal Low Pass Filter

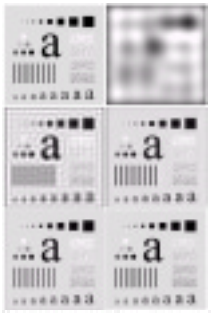


An image: Fig 4.11



LPF at different cut-off frequencies

Notice the "ringing" in b-f.



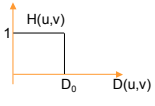
Butterworth LPF

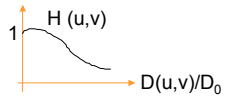
LPF :

$$G(u,v) = H(u,v)\,F(u,v)$$

$$H(u,v) = \begin{cases} 1 & \text{if } D(u,v) \le D_0 \\ 0 & \text{if } D(u,v) > D_0 \end{cases}$$

$$D(u,v) = \sqrt{u^2 + v^2} \quad \text{(Circularly symmetric)}$$

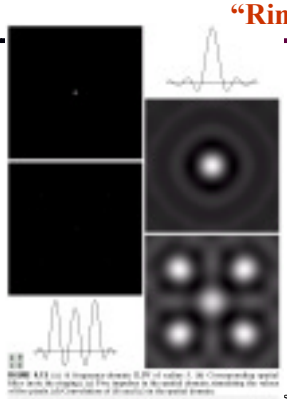




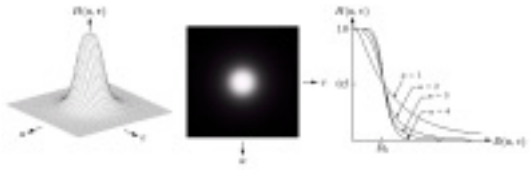
Butterworth filter:

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

"Ringing": Fig 4.13

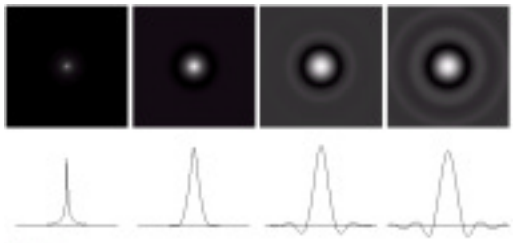


Butterworth filter: Fig 4.14

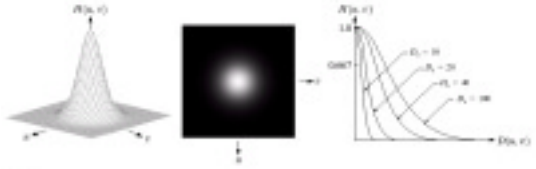


LPF example again

Spatial representation of BWF



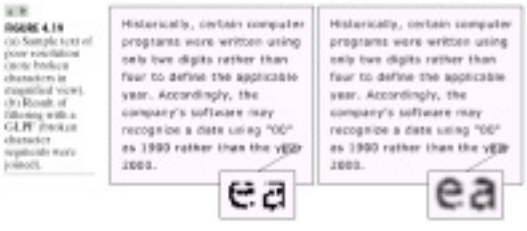
Gaussian LPF



$$H(u,v) = \exp(-D^2(u,v)/2\sigma^2)$$

Filtering using GLPF

Another example



Frequency domain processing HPF

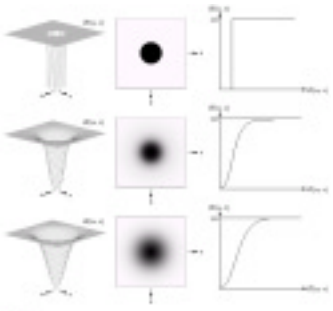
HPF :

$$H(u,v) = \begin{cases} 0 & \text{if} \quad D(u,v) \le D_0 \\ 1 & \text{if} \quad D(u,v) > D_0 \end{cases}$$

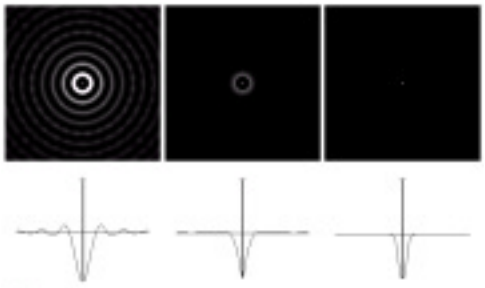
Butterworth filter:

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

HPF: Fig 4.22



Spatial representation of HPF



Ideal HPF

BWF

GHPF

Homomorphic filtering

Consider f (x,y) = i (x,y) . r (x,y)

Illumination ↗ Reflectance ↖

Now $\Im\{f(x,y)\} \neq \Im\{i.r\}$

So cannot operate on individual components directly

Let $z(x,y) = \ln f(x,y) = \ln i(x,y) + \ln r(x,y)$

$\Im\{z(x,y)\} = \Im\{\ln i\} + \Im\{\ln r\}$

$Z(u,v) = I + R$; Let $S(u,v) = HZ = HI + HR$

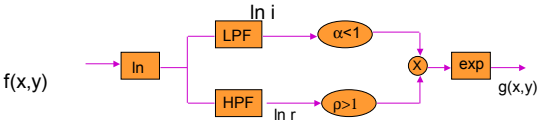
$s(x,y) = \Im^{-1}\{HI\} + \Im^{-1}\{HR\}$

Let $i'(x,y) = \Im^{-1}\{HI\}$; $r'(x,y) = \Im^{-1}\{HR\}$

Homomorphic filtering (contd.)

$$\therefore s(x,y) = i' + r'$$
$$g(x,y) = \exp\left(s(x,y)\right)$$
$$= \exp i' + \exp r'$$
$$= i_o(x,y)\, r_o(x,y)$$

In practice: i ⟶ slowly varying => LF
r ⟶ fast varying => HF



Homomorphic filtering (cont.)

An example