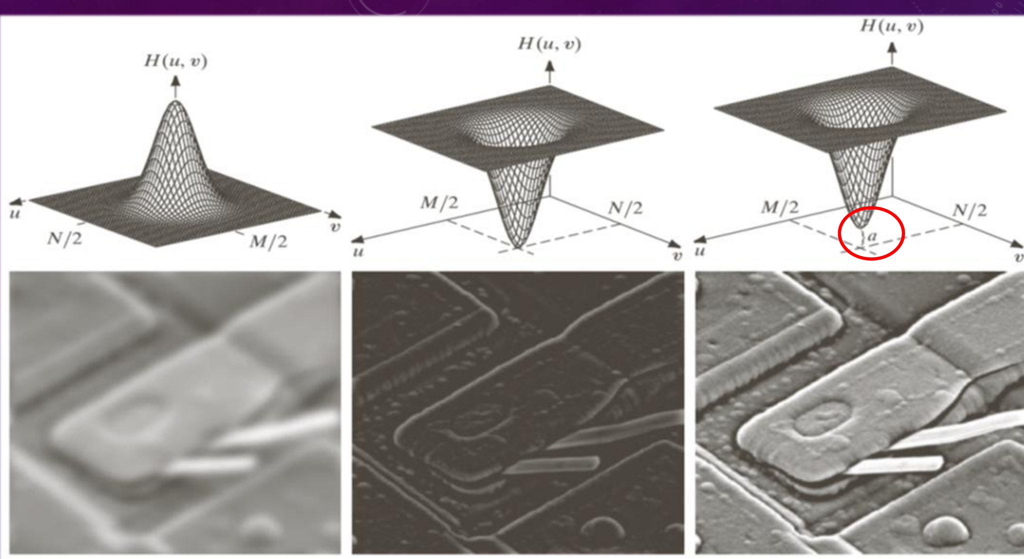
FREQUENCY DOMAIN FILTERING

- Low frequencies in the transform domain are related to slowly varying intensity components
- High frequencies are caused by sharp transitions in intensity, such as edges and noise
- Lowpass filter would blur an image
- Highpass filter would enhance sharp detail, but cause a reduction in contrast in the image



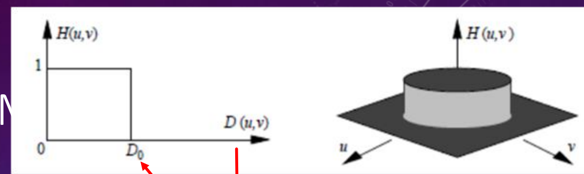
a b c
d e f

FIGURE 4.31 Top row: frequency domain filters. Bottom row: corresponding filtered images obtained using Eq. (4.7-1). We used $a = 0.85$ in (c) to obtain (f) (the height of the filter itself is 1). Compare (f) with Fig. 4.29(a).

ng

tonality

FREQUENCY DOM

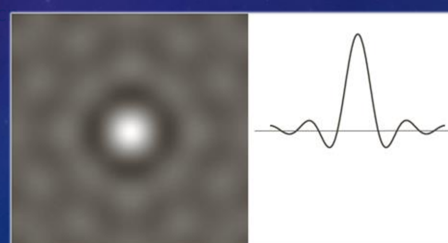


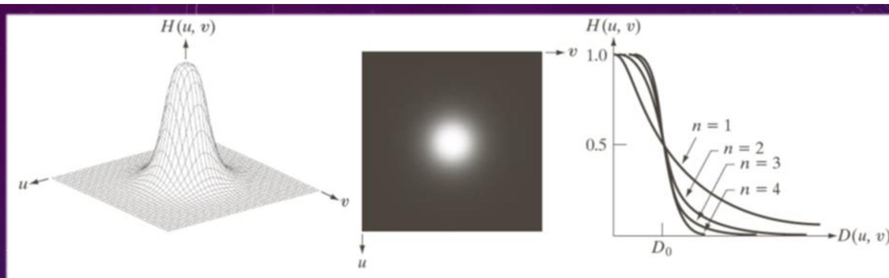
- Ideal LPF:

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

$$D(u,v)=\sqrt{(u-P/2)^2+(v-Q/2)^2}$$

F:





a b c

FIGURE 4.44 (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.

- Butterworth LPF:

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

- Gaussian LPF

FREQUENCY DOMAIN FILTERING

- Ide
- Bu

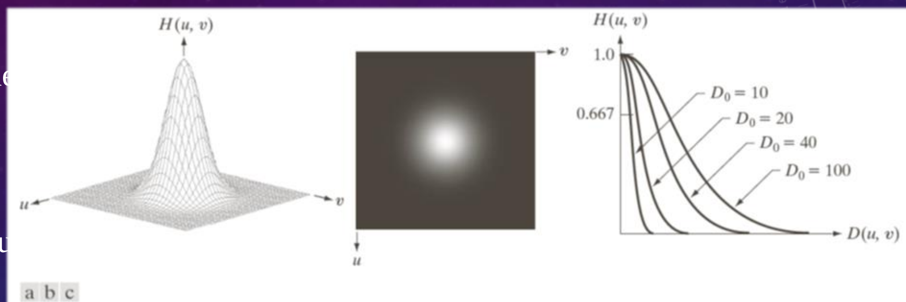


FIGURE 4.47 (a) Perspective plot of a GLPF transfer function. (b) Filter displayed as an image. (c) Filter radial cross sections for various values of D_0.

- Gaussian LPF

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

$$H(u,v) = \exp\left\{-\left[\frac{D(u,v)}{D_0}\right]^n\right\}$$

FREQUENCY DOMAIN FILTERING

- Ideal LPF:

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

- Butterworth LPF:

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

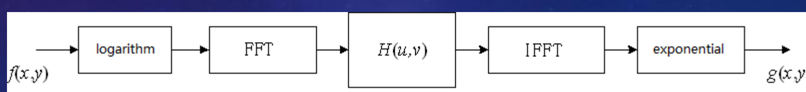
- Gaussian LPF

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

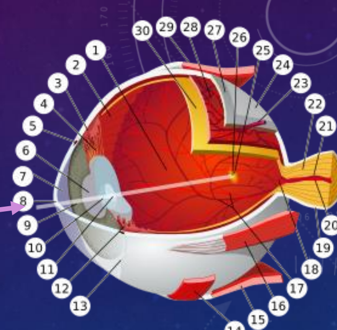
$$H_{HP}(u,v) = 1 - H_{LP}(u,v)$$

HOMOMORPHIC FILTERING

- Homomorphic filtering is a generalized technique for signal and image processing, involving a nonlinear mapping to a different domain in which linear filter techniques are applied, followed by mapping back to the original domain.
- It simultaneously normalizes the brightness across an image and increases contrast



BASIC CONCEPTS



$$I = f(x, y, \lambda, t)$$

$$0 < f(x, y) < \infty$$

- ***I*(.)** represents **the spatial energy distribution** of an image source of **radiant**.

HOMOMORPHIC FILTERING

- Illumination and reflectance combine multiplicatively：

$$f(x,y) = f_i(x,y) \cdot f_r(x,y)$$

$$0 < f_i(x,y) < \infty$$

$$0 < f_r(x,y) < 1$$

- Illumination $f_i(x,y)$ and reflectance $f_r(x,y)$ are not separable, but their approximate locations in the frequency domain may be located.

HOMOMORPHIC FILTERING

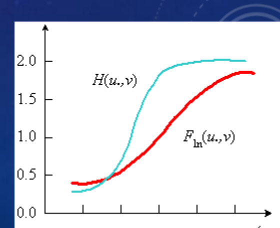
$$\ln f(x,y) = \ln[f_i(x,y) \cdot f_r(x,y)] = \ln f_i(x,y) + \ln f_r(x,y)$$

$$\begin{aligned} F_{\ln}(u,v) &= F[\ln f(x,y)] = F[\ln f_i(x,y) + \ln f_r(x,y)] \\ &= F_{i,\ln}(u,v) + F_{r,\ln}(u,v) \end{aligned}$$

$$\begin{aligned} G_{\ln}(u,v) &= F_{i,\ln}(u,v) \cdot H(u,v) + F_{r,\ln}(u,v) \cdot H(u,v) \\ &= G_{i,\ln}(u,v) + G_{r,\ln}(u,v) \end{aligned}$$

$$\begin{aligned} F^{-1}[G_{\ln}(u,v)] &= \ln g_i(x,y) + \ln g_r(x,y) \\ &= \ln[g_i(x,y) \cdot g_r(x,y)] \end{aligned}$$

$$g(x,y) = \exp\{\ln[g_i(x,y) \cdot g_r(x,y)]\} = g_i(x,y) \cdot g_r(x,y)$$



HOMOMORPHIC FILTERING

Original Picture

Homomorphic Filter

SUMMARY

- Spatial domain processing $g(x, y) = T[f(x, y)]$
  - Spatial filtering
    - image sharpening(gradient/laplacian/unsharp masking & highboost filtering), smoothing(averaging/median filter)
  - Intensity transformation
    - Contrast manipulation, thresholding, histogram equalization, histogram specification
- Frequency domain processing $g(x, y) = F^{-1}\{T[F[f(x, y)]]\}$
  - Homomorphic filtering