CSE 4128
Lab 4

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Homographic Filtering

- an image $f(x,y)$ can be expressed as the product of its illumination, $i(x,y)$, and reflectance, $r(x,y)$, components:

$$f(x, y) = i(x, y)r(x, y)$$

- This equation cannot be used directly to operate on the frequency components of illumination and reflectance because the Fourier transform of a product is not the product of the transforms:

$$\Im[f(x, y)] \neq \Im[i(x, y)]\Im[r(x, y)]$$

$$
\begin{aligned}
z(x, y) &= \ln f(x, y) \\
&= \ln i(x, y) + \ln r(x, y)
\end{aligned}
$$

$$f(x, y) \Rightarrow \boxed{\ln} \Rightarrow \boxed{\text{DFT}} \Rightarrow \boxed{H(u, v)} \Rightarrow \boxed{(\text{DFT})^{-1}} \Rightarrow \boxed{\exp} \Rightarrow g(x, y)$$

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

Separate frequency components

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

Fourier transform high and low frequency components

$$Z(u,v) = F_i(u,v) + F_r(u,v)$$

$$S(u,v) = H(u,v)Z(u,v) = H(u,v)F_i(u,v) + H(u,v)F_r(u,v)$$

Filter out low frequency component

$$s(x,y) = \mathcal{F}^{-1}\{S(u,v)\} = \mathcal{F}^{-1}\{H(u,v)F_i(u,v)\} + \mathcal{F}^{-1}\{H(u,v)F_r(u,v)\}$$

Inverse transform

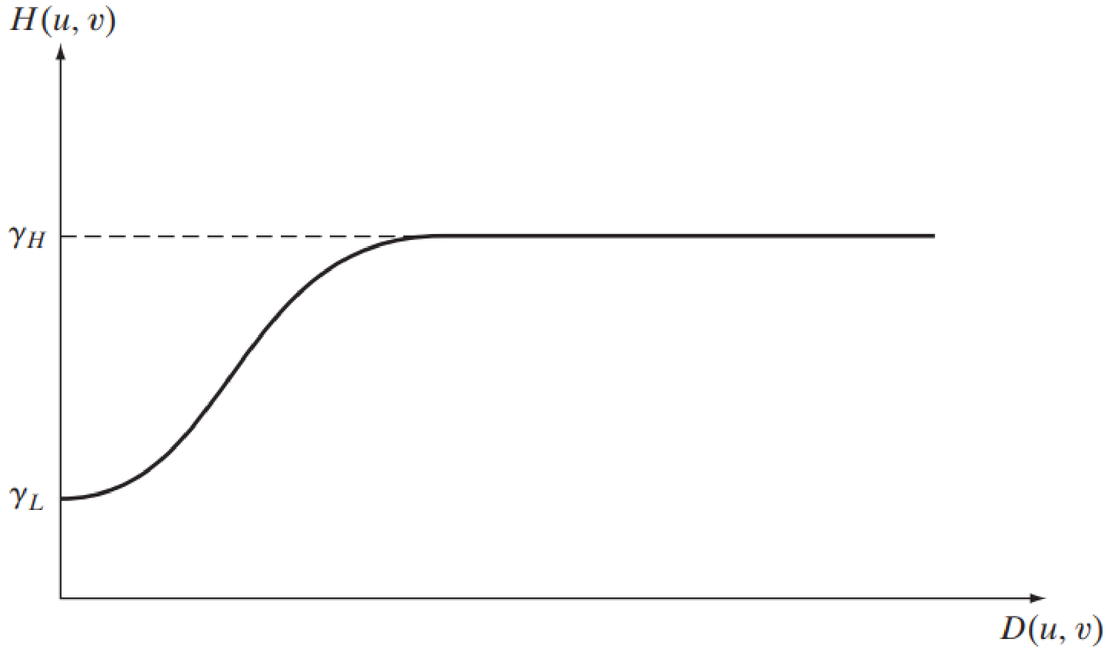
$$s(x,y) = i'(x,y) + r'(x,y)$$

$$g(x,y) = e^{s(x,y)} = e^{i'(x,y)}e^{r'(x,y)} = i_o(x,y)r_o(x,y)$$

Exponentiate to re-combine

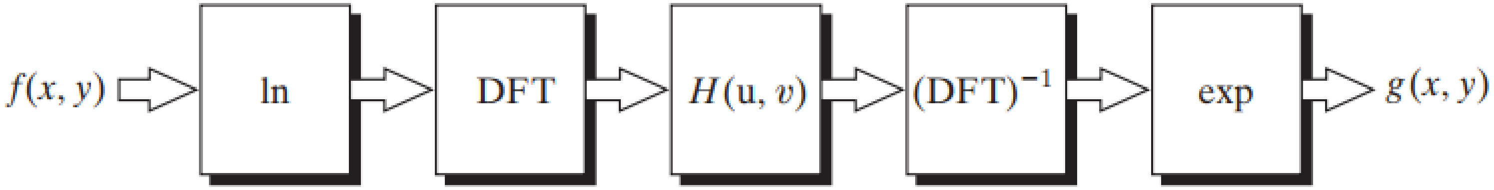
Modified form of the Gaussian highpass filter

$$H(u,v) = (\gamma_H - \gamma_L)\left[1 - e^{-c[D^2(u,v)/D_0^2]}\right] + \gamma_L$$



$\gamma_H > 1$
$\gamma_L < 1$
c controls smoothness

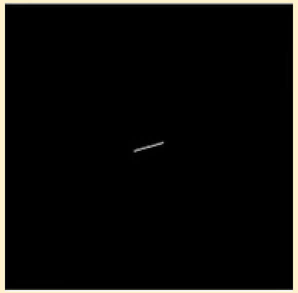
Fig: Radial cross section of a circularly symmetric homomorphic filter function. The vertical axis is at the center of the frequency rectangle and *D(u,v)* is the distance from the center.



$$H(u, v) = (\gamma_H - \gamma_L)\left[1 - e^{-c[D^2(u,v)/D_0^2]}\right] + \gamma_L$$

Assignment

- <u>Motion Deblur:</u>



$$f(x,y) * h(x,y) = g(x,y)$$

Camera Shake   Motion blurred image

$$h(x,y) \longrightarrow \boxed{\text{FT}} \longrightarrow H(u,v)$$

$$g(x,y) \longrightarrow \boxed{\text{FT}} \longrightarrow G(u,v)$$

$$F'(u,v) = \frac{G(u,v)}{H(u,v)} \longrightarrow \boxed{\text{IFT}} \longrightarrow f'(x,y)$$