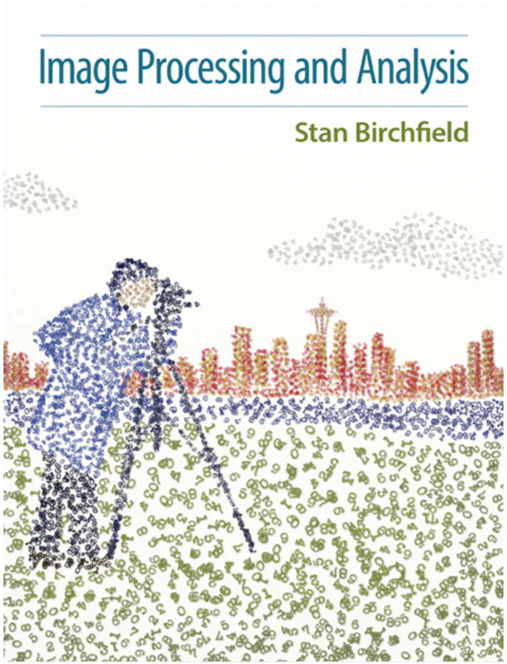
University of Stavanger

Prof. Kjersti Engan

ELE510 Image processing and computer vision

Frequency Domain processing, Frequency domain filtering (Chap6 Birchfield)
2020



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Reducing low frequency interference and high pass filtering

- Convenient high pass filters with good properties in the frequency domain are various derivatives of the Gaussian function, truncated and discretized (as the Gaussian filter)

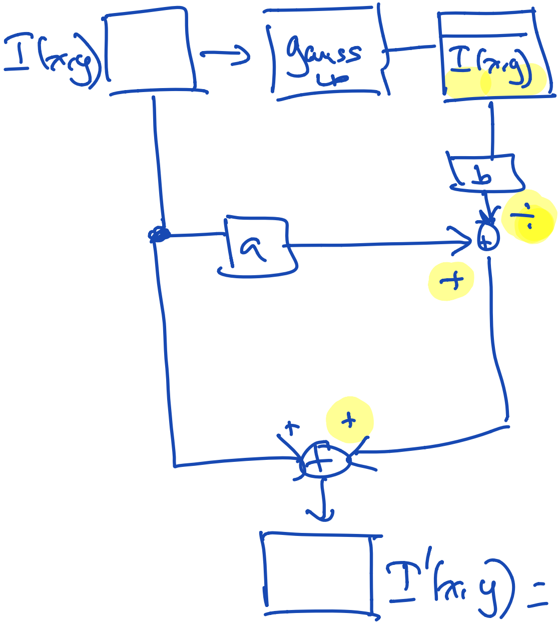
- Low frequency interference arises for example due to uneven illumination
- Uneven distance to the illumination source
  - A common problem indoor. Outdoor in natural light that is normally not a problem

- Shadows and ambient light
  - Problem both indoor and outdoor
  - Can also be mistaken for boundaries and edges

Uneven illumination

- Unsharp masking
- Homomorphic filtering
- Flatfielding: Correct an image so that it behaves as it was captured under uniform illumination. If possible a reference image can be captured on a uniform colored pice of paper and used as a model of the illumination.

Unsharp masking / high boost filtering



$$I(x,y) \circledast (-LoG(x,y)) = ? \left(I(x,y) - I(x,y) \circledast h_{LP} \right)$$

$$\boxed{I'(x,y) = (1+a-b)\cdot I(x,y) + \frac{b}{2}\, I(x,y) \circledast (-LoG(x,y))}$$

$$I'(x,y) = I(x,y) + \left(a \cdot I(x,y) - b \cdot I(x,y) \circledast h_{LP} \right)$$

$$h_{hp} = h_{allpass} - h_{LP} \quad \text{(implement as LoG filter)}$$

Unsharp masking

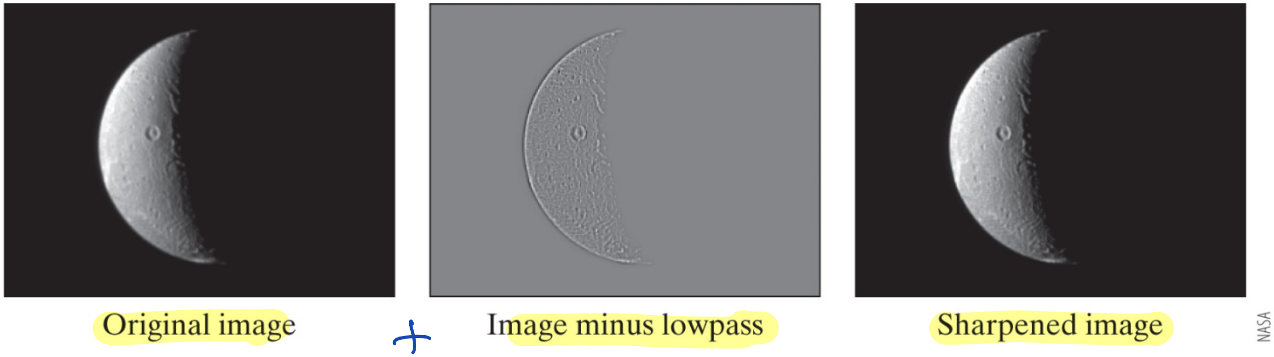
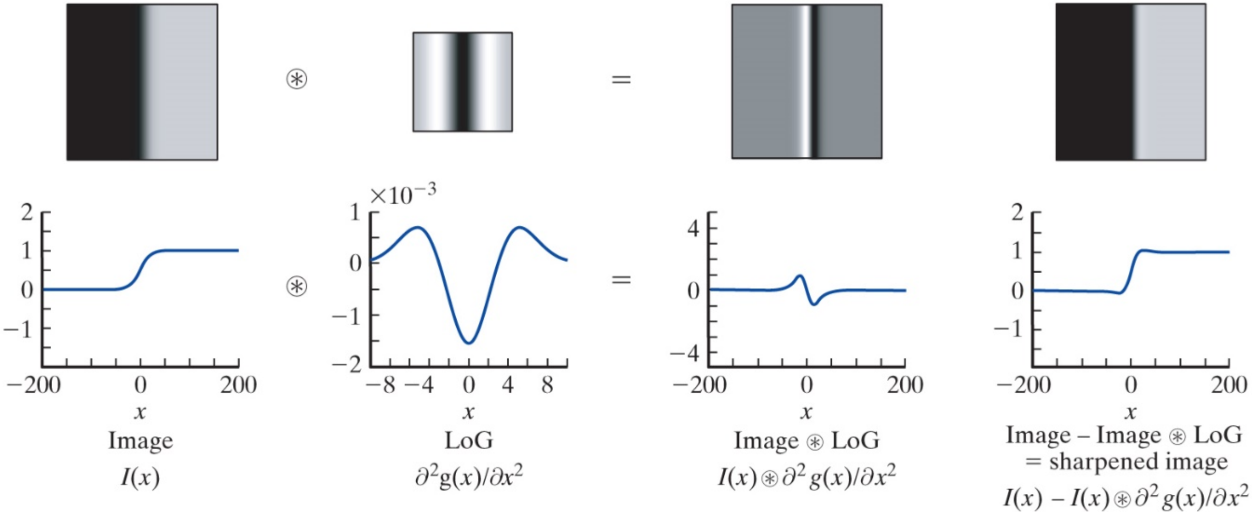


Figure 6.21 From left to right: An image of Saturn's moon Dione, the result of subtracting the low-pass filtered version of the image from itself, and the sharpened image resulting from adding this subtraction back to the original image.

Figure 6.22 The process of image sharpening: The image is convolved with the LoG, and the result is subtracted from the original image. The edge in the right column appears sharper than that in the left column.



Retinex algorithm

For enhancement and for removing uneven background illumination

$I(x,y)$

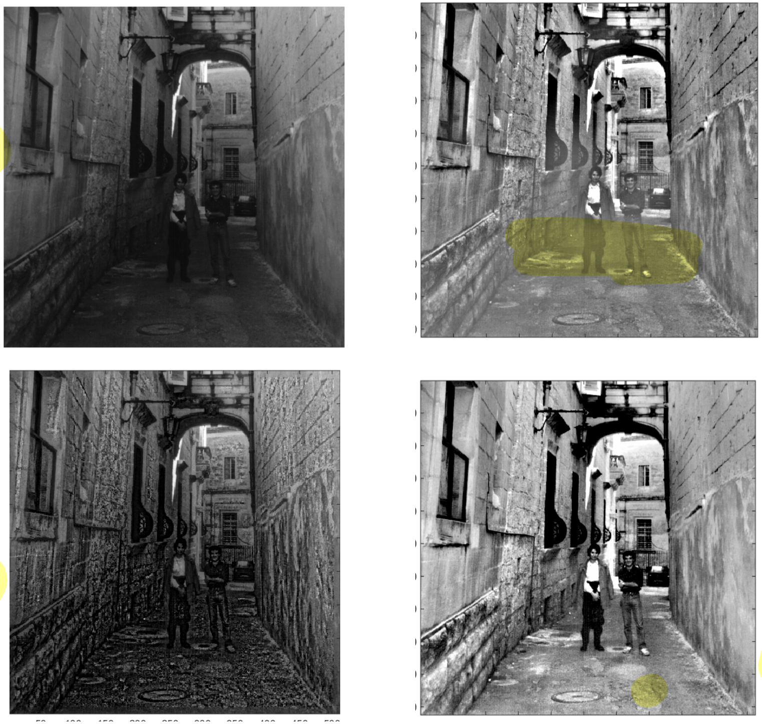
$$I'(x,y) = \ln\left(I(x,y)+1\right) - \ln\left[\underbrace{I(x,y) \circledast h_{LP}}_{\text{smoothed image}}\right]$$

large filter mask

$$I'(x,y) = \ln \frac{I(x,y)+1}{I(x,y) \circledast h_{LP}}$$

Must be scaled and thresholded after this to get back to [0, 255]

Unsharp masking and Retinex alg.



Original

Unsharp – global

Unsharp – local

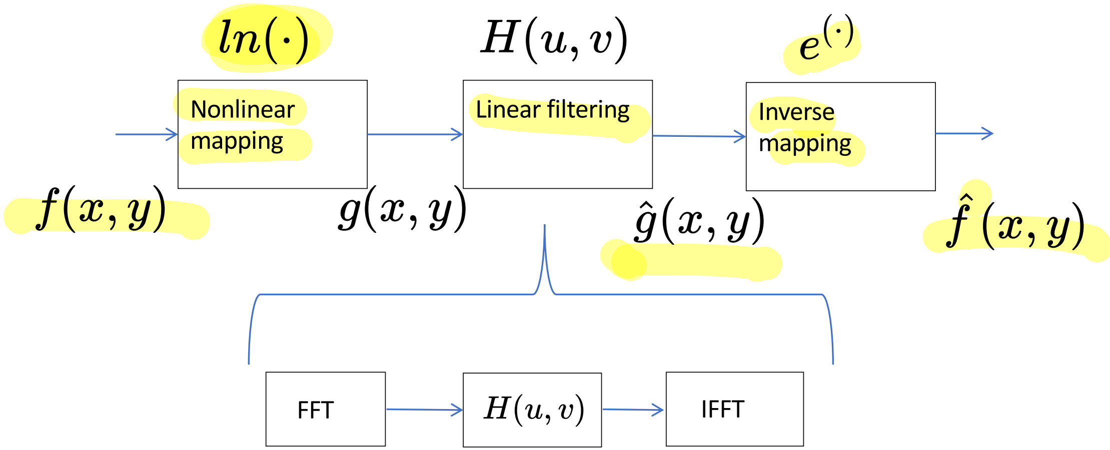
Retinex

Homomorphic filtering

- Homomorphic filtering is a technique used in signal and image processing:
  1. Use a non-linear maping to a different domain
  2. Thereafter use a linear filter
  3. Map back to the original domain

- Can be useful when signals are mixed by multiplication (multiplicative noise, or with uneven illumination).
- Logaritmic function makes multiplication become addition !

Homomorphic filtering



Homomorphic filtering – uneven illumination

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

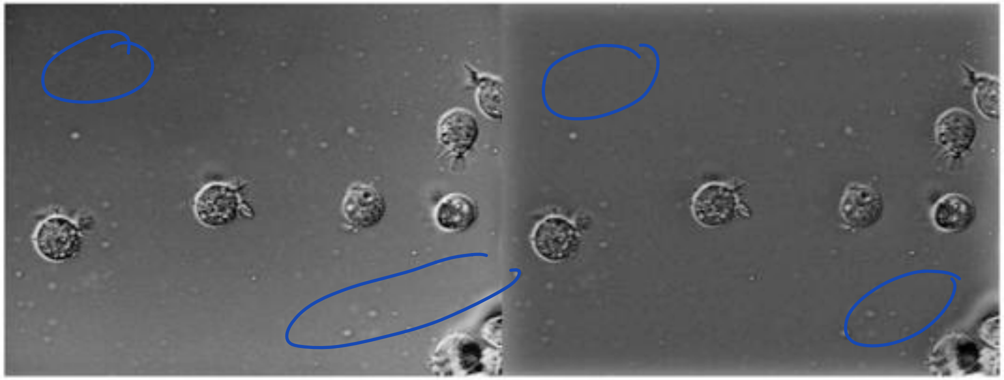
Illumination i(x,y) is generally of low frequency content.
Reflectance r(x,y) have more high frequency content due to edges between objects etc.

Make illumination and reflectance additive by logarithmic funciton, therafter high pass filter to remove uneven illumination, and transform back.

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

Original

After homomorphic filtering for removing uneven illumination



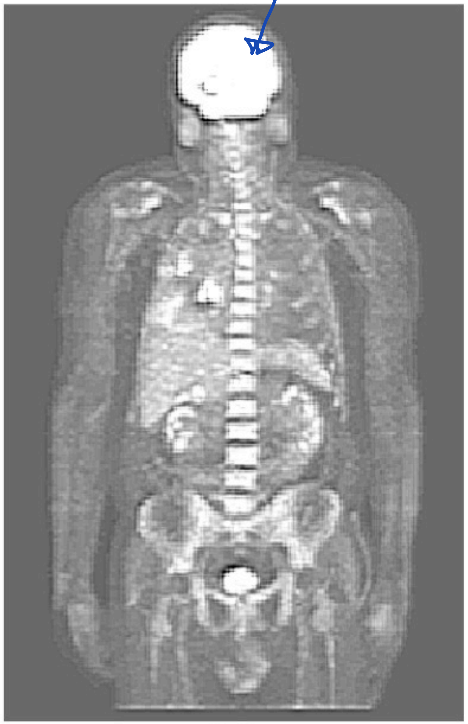


Figure 6.23 Left: An image with severe shadows, and the result of homomorphic filtering using a high-frequency filter to reduce the influence of lighting. Right: the result of multiplying the image by a constant and adding a constant to the image, for comparison. Note the ability of homomorphic filtering to reveal details in the shadow of the canon that are not visible in any of the other images.