HOMOMORPHIC FILTERING

Motivation

- **Image** with a **large dynamic range**, e.g., a natural scene on a bright sunny day, recorded on a **medium** with a **small dynamic range**, results in image contrast significantly reduced especially in the dark and bright regions
- **Objective**: **Reduce** dynamic range & increase local contrast **prior** to recording it on medium with a small dynamic range

- Non-linear mapping is applied to the signal, linear filtering is applied to the new image and then inverse filtering is applied.
- This can be applied to speech, audio or images
- The objective is to decreasing the dynamic range while increasing the local contrast of an image.
- Based on the model of the image, It is a product of Slow varying illumination term, fast varying reflective term


dreamstime

Image Model

$$x(n_1, n_2) = i(n_1, n_2) \cdot r(n_1, n_2)$$

Image formed by recording light reflected from objects which are illuminated by some light source

Illumination: assumed to be slowly varying and main contributor to dynamic range

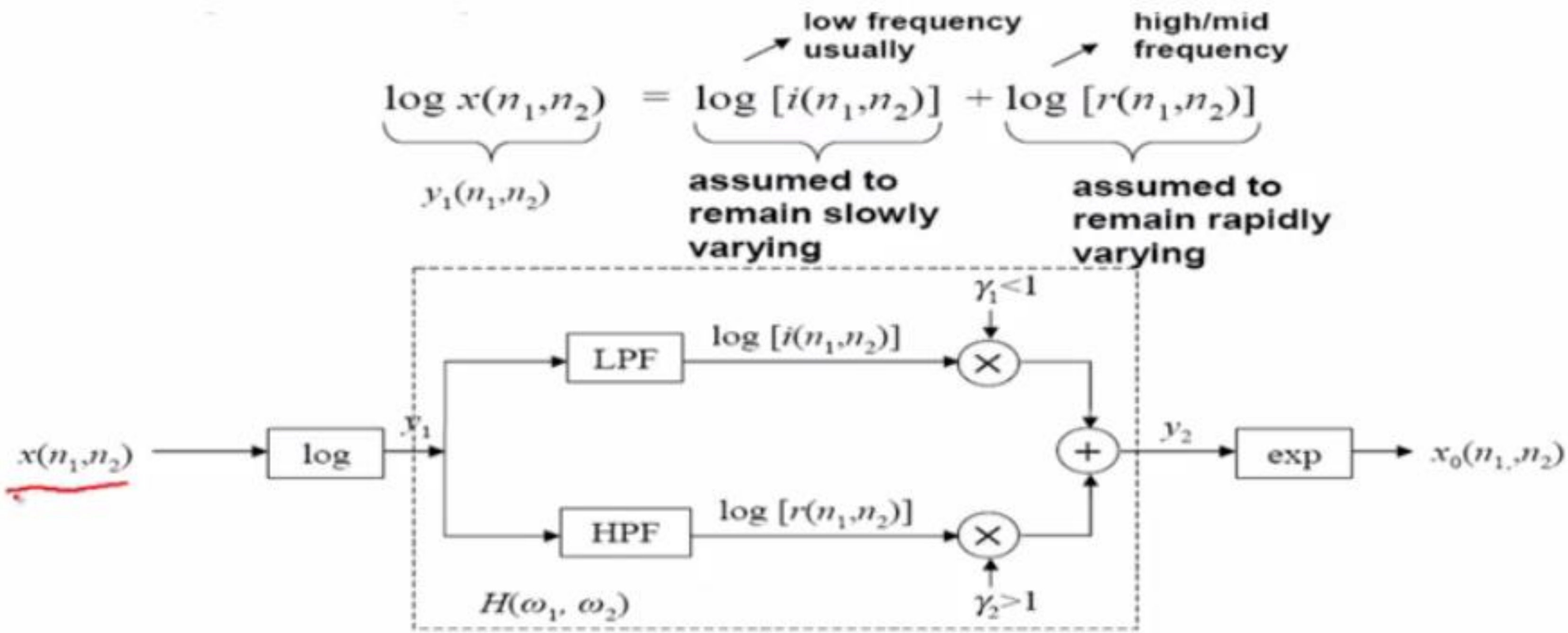
Reflectance: represents details of objects and assumed to vary rapidly and the primary contributor to local contrast

- To decrease dynamic range, decrease $i(n_1, n_2)$
- To increase local contrast, increase $r(n_1, n_2)$

Procedure :

- After taking logarithm of image then two terms are additive.
- This can be separated by LSI filtering
- In the frequency domain illumination term is reduced and reflectance term is boosted.
- Then exponentiation is performed (inverse of log) to bring the image back to the original domain

Homomorphic Processing



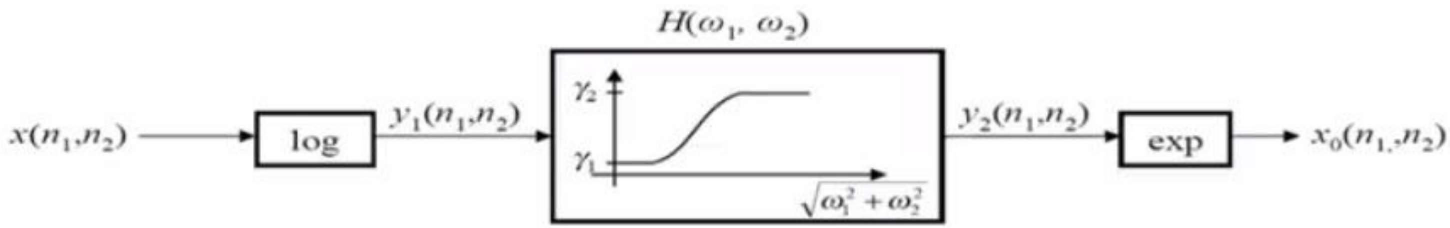
Step 1: Apply logarithmic for the image to decrease the dynamic range and increase the local contrast.

Step 2: Apply LPF, this will isolates the first component means log of illumination and I want to decrease it, so I multiplied with gamma value < 1

Step 3 : At the other end, HPF applied to y1, this gives 2nd component. We want to amplify this, So multiplied with gamma2 > 1 value,

Step 4: Exponent of both is taken to get back original image which is enhanced.

Homomorphic Processing



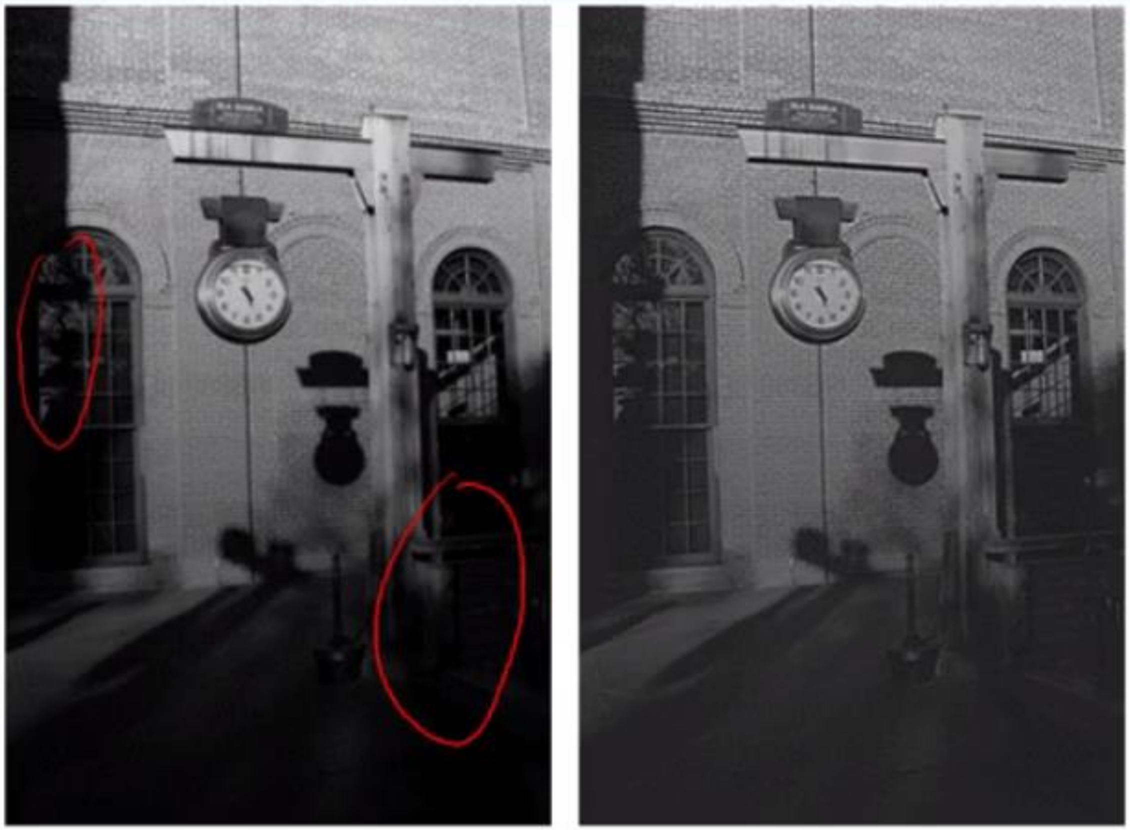
$$y_2(n_1,n_2) \approx \gamma_1 \log\,[i(n_1,n_2)] + \gamma_2 \log\,[r(n_1,n_2)] \Rightarrow x_0(n_1,n_2) = [i(n_1,n_2)]^{\gamma_1}\,[r(n_1,n_2)]^{\gamma_2}$$

Illumination typically varies slowly across the image as compared to reflectance which can change quite abruptly at object edges. This difference is the key to separating out the illumination component from the reflectance component. In homomorphic filtering we first transform the multiplicative components to additive components by moving to the log domain.

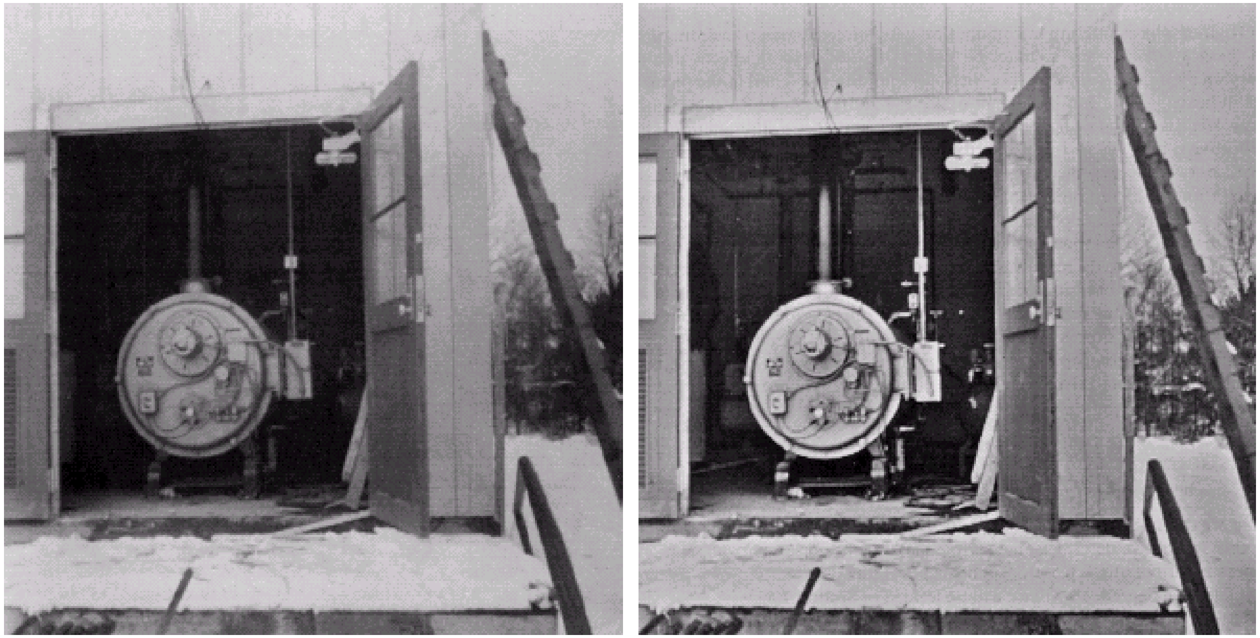
$$\ln(I(x,y)) = \ln(L(x,y)\,R(x,y))$$
$$\ln(I(x,y)) = \ln(L(x,y)) + \ln(R(x,y))$$

Since illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain.

Homomorphic Processing Example



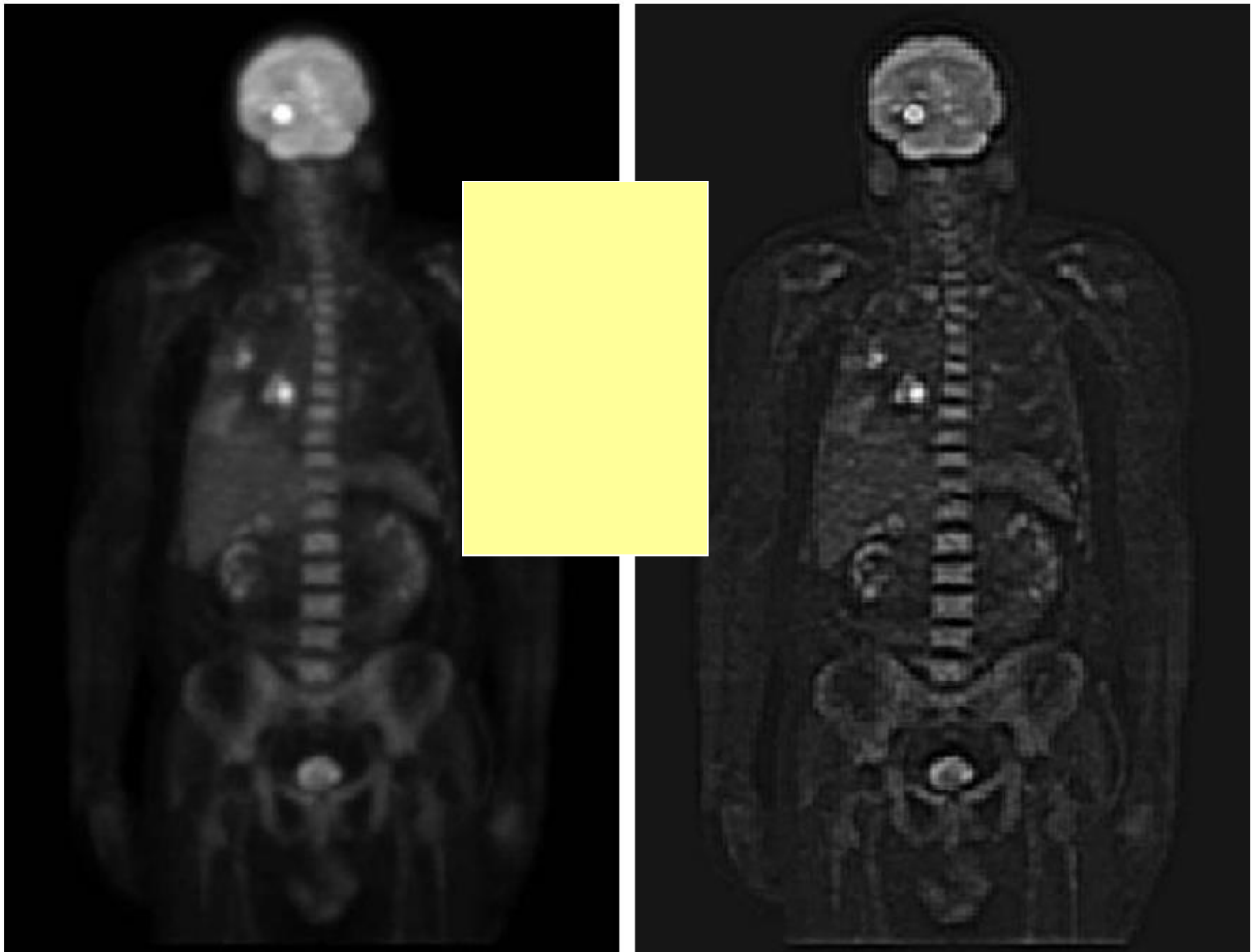
Homomorphic Filtering: Example



a b

FIGURE 4.33
(a) Original image. (b) Image processed by homomorphic filtering (note details inside shelter). (Stockham.)

Homomorphic Filtering: Example



a b

FIGURE 4.62 (a) Full body PET scan. (b) Image enhanced using homomorphic filtering. (Original image courtesy of Dr. Michael E. Casey, CTI PET Systems.)