Homomorphic filtering in Digital Image Processing

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Introduction

Many times, we want to remove shading effects from an image.

(i.e. due to uneven illuminations)

Purpose:

1. Enhance high frequency components.
2. Attenuates low frequency components but preserve fine details.
3. To normalize the intensity across the entire image and to increase contrast.

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

Illumination (low freq.)

Reflectance (high freq.)

Shading effects: Original image

Outcome of homomorphic filtration

General Information about Homomorphic filtering

- The illumination components $i(x,y)$ varies slowly and affects low frequencies mostly.
- The reflection components $r(x,y)$ varies faster and affects high frequencies mostly.
- Separate the low frequencies due to $i(x,y)$ from high frequencies due to $r(x,y)$.
- The key idea: the logarithm function can be used to separate the illumination and the reflectance components.

The method is based on the following assumptions:

- Illumination *i(x,y)* changes in the image very slowly (low frequencies).
- Reflectance *r(x,y)* changes in a more fast fashion, because the scene is usually rather diverse.
- The image can be decomposed (factorized) in each pixel into a product of two components – illumination *i(x,y)* and reflectance *r(x,y)*.

Illumination (low freq.) Reflectance (high freq.)

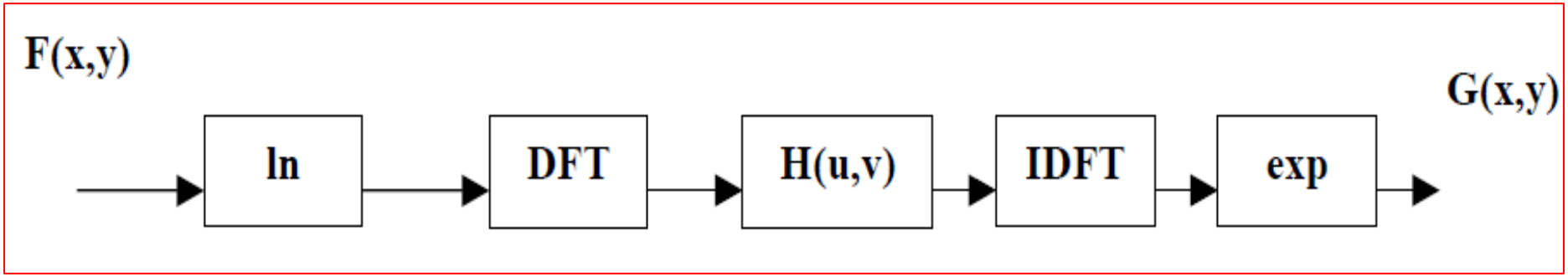
$$f(x, y) = i(x, y) \cdot r(x, y)$$

Homomorphic Filtering Process:

The homomorphic filtering process consists of five steps:

- A natural log transform (ln—base '*e*')
- The Fourier transform (2D-DFT)
- Filtering [H(u,v)]
- The inverse Fourier transform (2D-IDFT)
- The inverse log function (exponential)

Homomorphic Filter: Block diagram



- Homomorphic filtering is a frequency domain filtering process that compresses the brightness (from the illumination-light condition) while enhancing the contrast (from the reflectance properties of the object).

More about Homomorphic filter…

- In many applications, it is useful to enhance the reflectance component, while reducing the contribution from the illumination component.
- The log transform will decouple the $i(x,y)$ and $r(x,y)$ from a multiply into a sum.

Cont'd…

- The Fourier transform will convert the image into its frequency-domain representation so that filtering can be done.
- The typical filter used is a filter similar to a non-ideal high-frequency emphasis filter.

Mathematical Treatment:

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

Fourier spectrum

$$Z(u, v) = I(u, v) + R(u, v)$$

Filtering in the frequency domain:

freq. domain enhancement

$$S(u, v) = H(u, v)Z(u, v)$$
$$= H(u, v)I(u, v) + H(u, v)R(u, v)$$

Inverse transformation back into spatial coordinates:

$$S(x, y) = F^{-1}\{S(u, v)\}$$

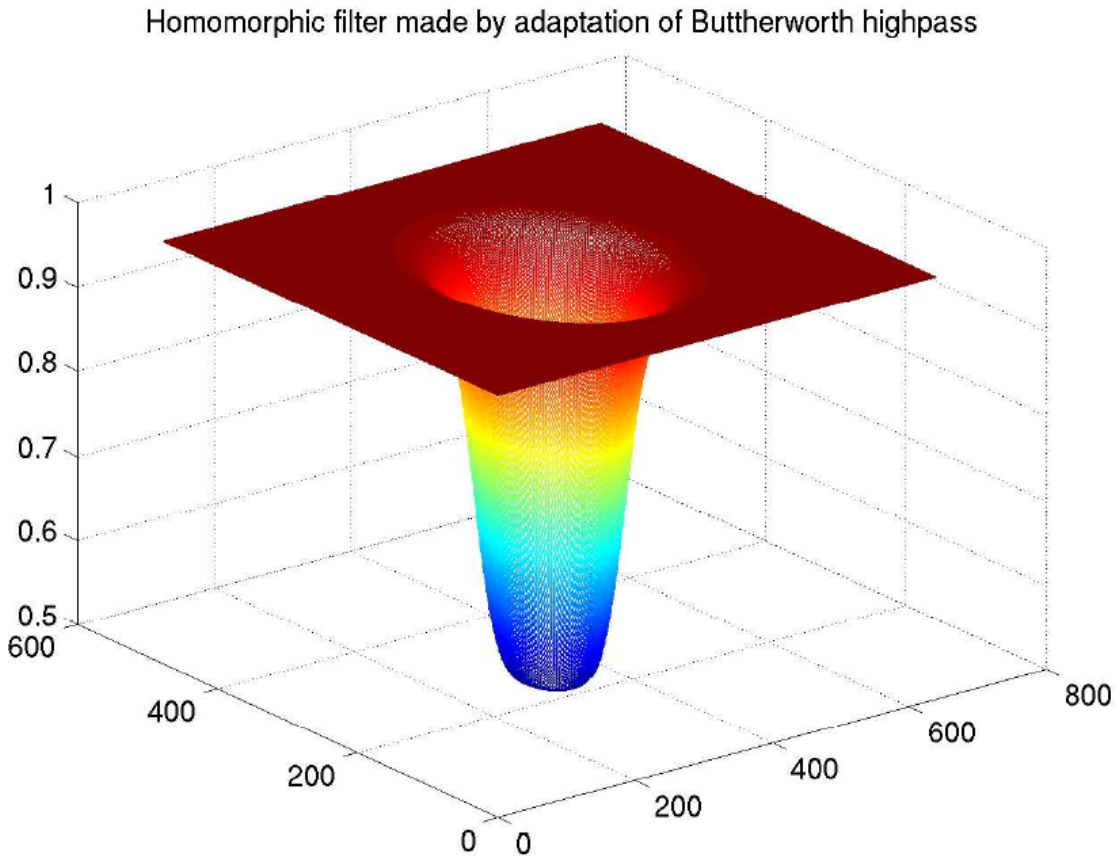
and return to original gray scale from the logarithmic one by taking exponential after inverse-DFT.

Cont'd…

$$g(x, y) = exp\,(s(x, y))$$

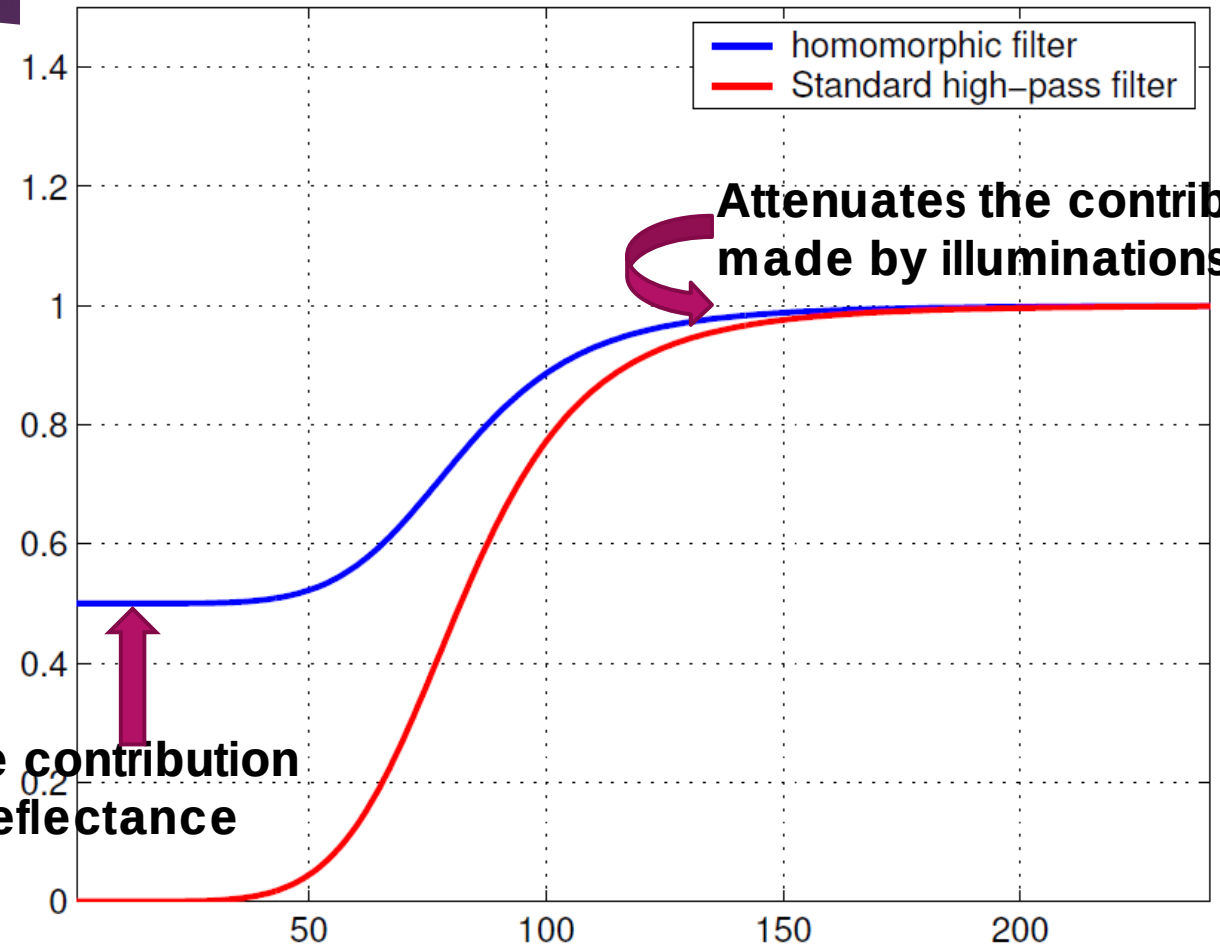
The outcome image (spatial domain) is the suppression in the illumination changes in the scene and the improvement of the reflectance component.

Homomorphic filter made by Butterworth High-pass filter



Homomorphic Filter compared with standard high pass filter

$\mathcal{H}(u,v)$

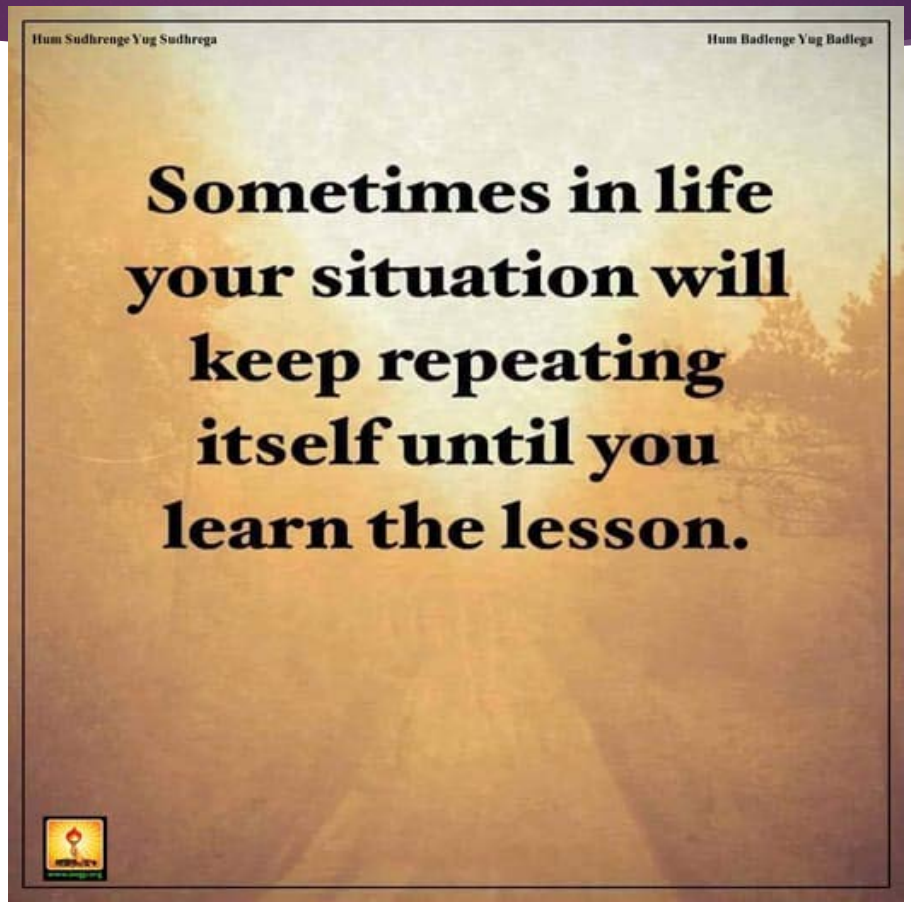


Attenuates the contribution made by illuminations

Amplify the contribution made by reflectance

Summery: Homomorphic Filter

Here the illumination and reflectance model is used to develop a frequency domain procedure for improving the appearance of an image by simultaneous intensity (brightness) range compression and contrast enhancement.


Hum Sudhrenge Yug Sudhrega
Hum Badlenge Yug Badlega
Sometimes in life your situation will keep repeating itself until you learn the lesson.

Thanks !

Any Question please ?