Sequence 3 exercises

Exercises marked as homework are supposed to be done at home before the corresponding follow-up session and exercises marked as classroom work are going to be done during the follow up session

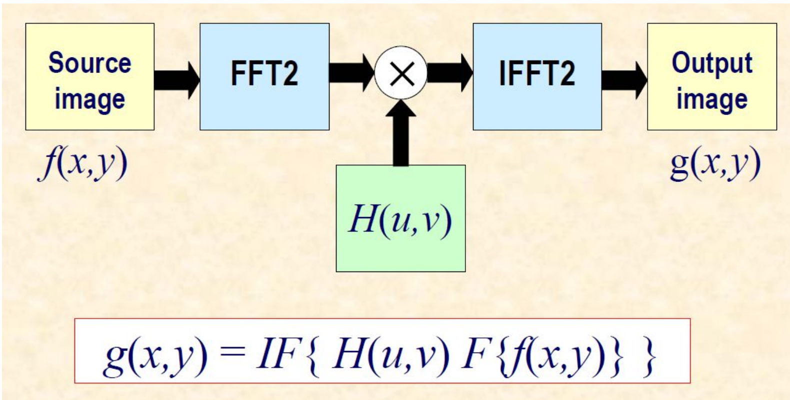
3.1 <u>Examples of image Fourier transform (homework)</u>

Download the file *Sequence3_Part1_code.py*.

Compute and comment the Fourier Spectrum of the following images: *sinus1_fen.bmp*, *sinus3_fen.bmp*, *alumgrns.tif*, *cameraman.bmp* and *coffee*. More specifically for natural images, what frequencies are the most present?

3.2 <u>Filtering in the frequency domain (homework)</u>

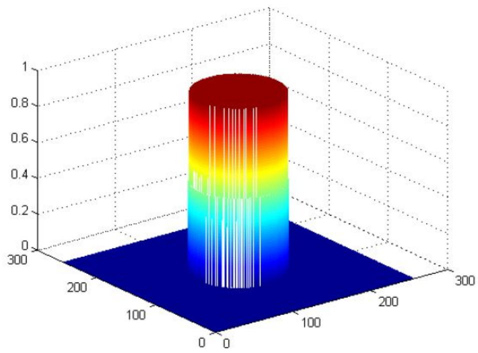
When filtering an image in the frequency domain, here is the global process:



In the file *Sequence3_part1_code.py*, two transfer functions H for frequential filtering have been defined. The first function called *filtrePB_Porte()* is for an ideal low pass filter of cut off frequency D_0 :

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

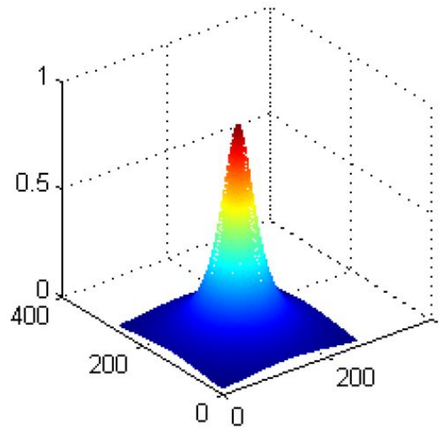
$$D(u,v) = \sqrt{u^2 + v^2}$$



and the second function called *filtrebutterworth* is for an Butterworth filter with cut off frequency D_0 and order n :

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

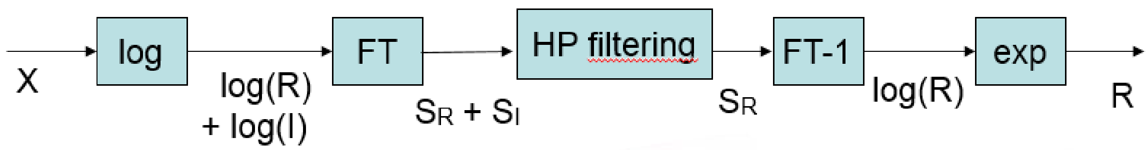
$$D(u,v) = \sqrt{u^2+v^2}, \quad n = 1,2,\ldots$$



- Let's consider the *coffee* grey level image. Display the image and its spectrum.
- Filter the grey level *coffee* image with the ideal low pass filter with $D_0 = fc = 0.05$. Display the filtered spectrum and the filtered image. Comment.
- Generate the transfer function of several Butterworth filters in order to study the influence of the order parameter and the cut off frequency.
- Filter the grey level *coffee* image with a Butterworth filter with $D_0 = fc = 0.05$ and n= 5. Comment the results

3.3 Homomorphic filtering (classroom work)

The idea of this exercise is to study the efficiency of the homomorphic process in order to reduce illumination variations on images. The whole process of homomorphic filtering is the following:



A High Pass filter is applied in the Fourier domain. In this exercise, the chosen filter is derived from the Gaussian filter in the following way:

$$H(w_x, w_y) = (r_H - r_L).(1 - \exp(-(\frac{w_x^2 + w_y^2}{2\delta_w^2}))) + r_L$$

Where δ_w controls the cut off frequency and r_H and r_L are the maximum and minimum coefficients of the filter. When $r_L < 1$ and $r_H > 1$, the filter is going to reduce low frequencies and to re enforce the middle and high frequencies (ie image contours and details).

Download *Sequence_3_part2_code.py* and implement the homomorphic filtering process.
Rmk: when computing the log of the whole image, add 0.001 to the image in order to avoid error in case of 0 grey level in the image.

Apply the homomorphic filtering on the following images: *tunnel.jpg*, *beach.jpg* and *page.png*. For each image, it will be necessary to tune the high pass filter parameters. Give for each image the best combination of parameters and conclude about the influence of each parameter.