Tutorial: 2D Fourier Transform

> The main objective of this tutorial is to study image filters applied in the frequencial or spatial domain with the Fourier transform.

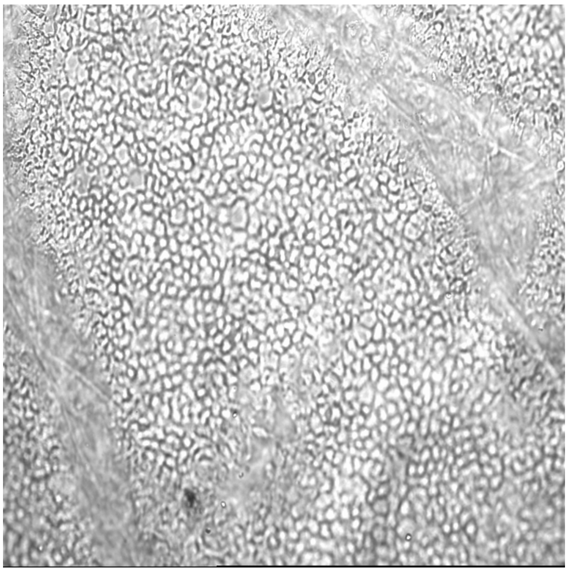
Use fft2 , ifft2 , fftshift functions to compute the Fourier Transform, angle and abs for phase and amplitude.

Use module np.fft for Fourier Transform functions (function fft2), phase and abs for phase and amplitude.

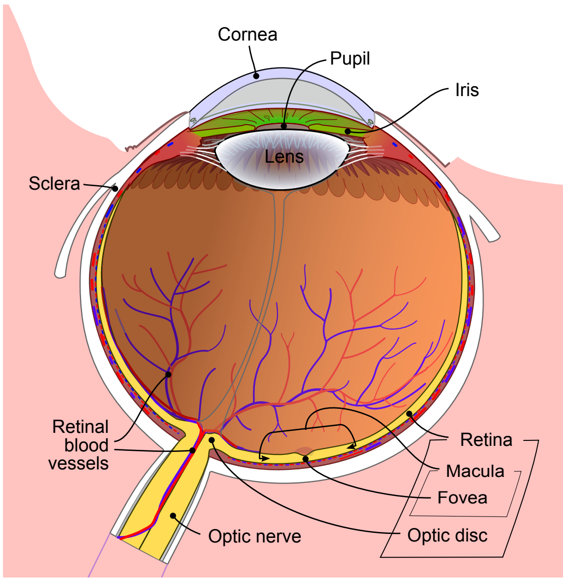
The image to be used comes from a human cornea endothelium observed ex vivo by optical microscopy.

Figure 1: Image of human cornea endothelium observed by optical microscopy. The ophthalmologists would like to know the cell density, without manually counting all the cells.

(a) Human corneal endothelium, extracted from a donor and observed here before grafting.



(b) Human eye (from Wikipedia, authors: Rhcastilhos and Jmarchn, CC-By-SA).



1 Fourier transform

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1. Load an image and visualise it.
2. Compute the Fourier Transform by the fft algorithm.
3. Visualise the images of the phase and amplitude of the Fourier Transform.

2 Inverse Fourier transform

In this exercise, it can be interesting to consider different images, like a Lena picture for example.

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1. Apply the inverse Fourier transform on the Fourier transform to find the original image.
2. Now, apply the inverse Fourier transform on the phase information only (without using the frequency informations).
3. In a same spirit, apply the inverse Fourier transform on the frequency informations only (without the phase).

3 Low-pass and high-pass filtering

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1. Modify the Fourier transform of the image to
   - keep only low frequencies,
   - keep only high frequencies.
2. Apply the inverse Fourier transform on both and comment.

4 Application: evaluation of cellular density

The ophthalmologists would like to evaluate the cell density of the cornea endothelium observed in Fig. 1.

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1. Compute the Fourier transform of the image. If one considers that the cells constitute a repeated pattern on the whole image, locate the repetition frequency on the amplitude image.
2. Can this frequency be linked to the cell density ?

The answer to this last question is obviously yes. Here follows a simple method to evaluate the cell density (or the mean cell radius), if these cells a considered as circular [**?**].

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1. The amplitude information is very noisy. First of all, a gaussian filter should be applied (see functions `fspecial` and `imfilter`).
2. Find a simple way to evaluate the mean radius of the cells.