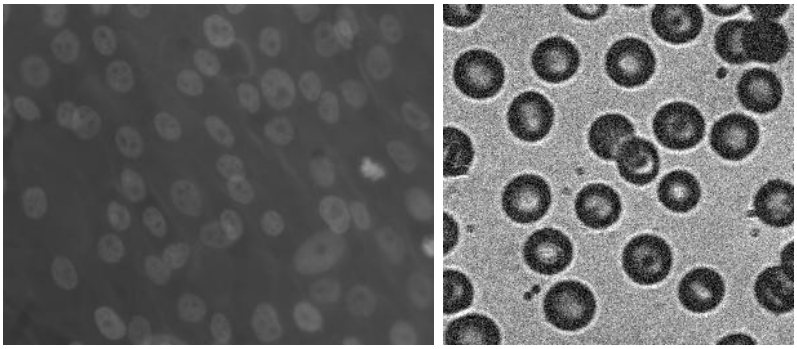
Tutorial: Image filtering

This practical work aims to investigate different image filters for smoothing, enhancing or highlighting intensity variations.

The different processes will be realized on the following images:



(a) osteoblast cells (b) blood cells

EXERCISE 1. *Low-pass filtering*

Low-pass filtering aims to smooth the fast intensity variations of the image to be processed.

- Test the low-pass filters 'mean', 'median', 'min', 'max' and 'gausian' on the noisy image 'blood cells' with the use of the matlab functions `imfilter` and `nlfilter`.
  Be careful to the function options for border problems.
  Also, the matlab function `fspecial` enables an operational window to be generated.
- Which filter is suitable for the restoration of this image?

EXERCISE 2. *High-pass filtering*

High-pass filtering aims to smooth the low intensity variations of the image to be processed.

- Test the high-pass filters HP on the two initial images in the following way: $HP(f) = f - LP(f)$ where LP is a low-pass filtering (see the previous exercise).
- Test the Laplacian (high-pass) filter on the two initial images with the following convolution mask:

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & +8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

EXERCISE 3. *Derivative filters*

Derivative filtering aims to detect the edges (contours) of the image to be processed.

- Test the Prewitt and Sobel derivative filters (corresponding to first order derivatives) on the image 'blood cells' with the use of the following convolution masks:

$$\begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

- Look at the results for the different gradient directions.
- Define an operator taking into account the horizontal and vertical directions.

Remark : the edges could be also detected with the zero-cressings of the Laplacian filtering (corresponding to second order derivatives)

EXERCISE 4. *Enhancement filtering*

Enhancement filtering aims to enhance the contrast or accentuate some specific image characteristics.

- Test the enhancement filter E on the image 'osteoblast cells' defined as: $E(f) = f + HP(f)$ where HP is a Laplacian filter (see exercise 2).
- Parameterize the previous filter as: $E(f) = \alpha f + HP(f)$, or $\alpha \in \mathbb{R}$.

EXERCISE 5. *Open question*

Find an image filter for enhancing the gray level range of the image 'osteoblast cells'.