Color and multispectral Imaging
Lab. n° 3

Objective:

The goal of this lab is to study the efficiency of some of the demosaicing algorithms we have studied in class. You will also manipulate multispectral images for their color visualization using the methods of "true-color".

Start by copying the images in your Matlab Working Directory.

Part 1: demosaicing

1- Write a Matlab function that transforms an input color image into an image simulating the ouput of a CFA before demosaicing.

Synopsis : Image_CFA= bayer (Input_RGB),
where Input_RGB is the input color image of dimensions (Nb_Lines, Nb_Columns, 3) and Image_CFA is an image of the same dimensions supposed issued from a CFA. This means that the missed pixels have a value equal to 0.

1- Write a Matlab function for each of the following algorithms:

Synopsis: **Output_RGB = fonction(Image_CFA)**
where Output_RGB is the reconstructed color image after demosaicing.

a. Bilinear interpolation using a loop
   (Replicate the line/column N-1 if the dimension is N, on the borders of the image in order to avoid boundaries artefacts)
b. Bilinear interpolation using convolution masks
c. Interpolation algorithm under the constraint of hue constance
d. Interpolation algorithm under the constraint of edge preservation

2- Test your programs on the images in the folder Demosaicage.

3- Implement each of the following metrics in a Matlab function: MSE and ΔE.

Usage of these functions is: metric_value = metric (Input_RGB, Output_RGB)

4- Provide a table that summarizes the comparison between the different algorithms using the previous metrics results. In addition, your table should contain a subjective visual criterion and running time.
5- Discuss and comment your results.

Part 2: multispectral images visualization

Most of today's visualization devices are based on the paradigm that a combination of three primary colors (red, green and blue) is sufficient for the human eye to characterize any color. However, in many applications such as remote sensing, medical or art imaging, measuring the electromagnetic properties of a scene has to be made with high spectral precision. This can be achieved by multispectral imaging.
Multispectral imaging consists of acquiring more than three spectral components from a scene, usually dozens, each one of them being acquired at a reduced range of wavelengths. Usually, multispectral images are acquired in the visible range of wavelengths which is about [400...700]nm, however, it is also common to cover the infrared range (beyond 700nm). Images with a number of channels ranging from a hundred to a thousand are referred to as hyperspectral and higher dimensionality datasets are called ultraspectral. Even though the multispectral imaging is currently widespread, the visualization devices are still based upon the principle of the tri-stimulus representation. Therefore it is necessary to convert a multispectral image to a color one in order to be able to visualize it.
One of the most common approaches is probably the one referred to as "true color". It can basically be achieved in two different ways: one consists of selecting the bands at 700nm, 546.1nm and 435.8nm (or the closest) and mapping them to the three primaries: R,G and B, respectively. The other one uses the CMF-based (XYZ) band transformation (each primary R,G and B is the result of a linear combination of spectral channels in the visible range of wavelengths).

To do:

In this part, you will transform a multispectral image to a color one in order to be able to visualize it. In order to do this, you will reconstruct an image where each pixel has a dimension of 31; from 400 to 700 by step of 10nm. We call this image the image of reflectance. Image_reflectance (Nb_ligne, Nb_column, 31) is reconstructed from a multispectral image composed of seven channels: Image_multispectrale (Nb_ligne, Nb_column, 7). You can use a method of interpolation, e.g *interp1* with option 'Spline'.
The image of reflectance will be used for the conversion from the reflectance to a color image using the two "true-color" methods.

Data:

You have two multispectral images (Macbeth_7 and Flowers_7): these two images were acquired by a multispectral camera having 7 interference filters in the visible spectrum sampled by step of 40nm starting with 440nm.

-CIE-CMF: the color matching functions (XYZ) in the range [400, 700]nm

-Standard Illuminants A and D65: the values in the range [400, 700]nm.

-Use *makecform* Matlab function to convert xyz tri-stimuli to sRGB values, to be able to visualize them.