Master in Computer Vision Barcelona

UAB UOC UPC upf.

Module: **M1. Introduction to human and computer vision** **Final exam**
Date: November 30th, 2020 **Time: 2h30**
Teachers: Ramon Morros, Javier Ruiz, Philippe Salembier, Javier Vázquez, Verónica Vilaplana

- Books, lecture notes, calculators, phones, etc. are not allowed.
- All sheets of paper should have your name.
- All results should be demonstrated or justified.

At the beginning of your exam, please write the following statement and sign below:

I hereby certify that I am doing this exam without using any books, lecture notes, personal notes, video related to the course content and that I have no communication with anyone beside the teachers.

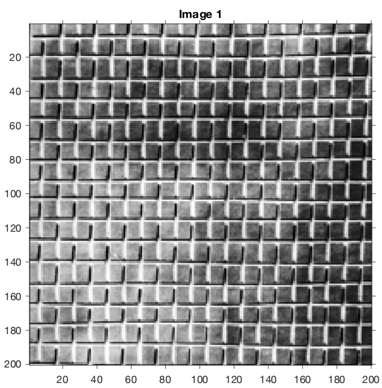
PB 1 (0.5 point): Explain the idea of color opponency.

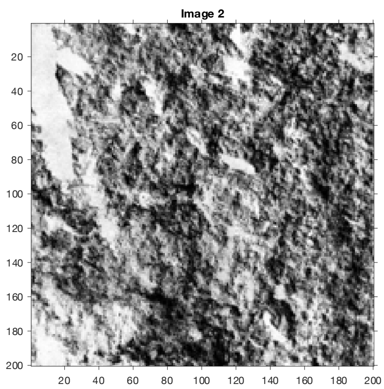
PB 2 (0.5 point): Explain the CIE Lab color space. Which is its main advantage over the CIE XYZ space?

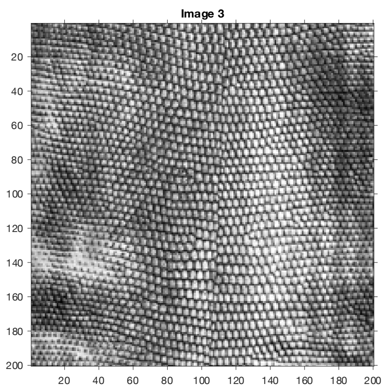
PB 3 (0.5 point): Explain the Grey-World and the MaxRGB methods for white balance

PB 4 (0.5 point): Explain the basic auto-exposure method that cameras use.

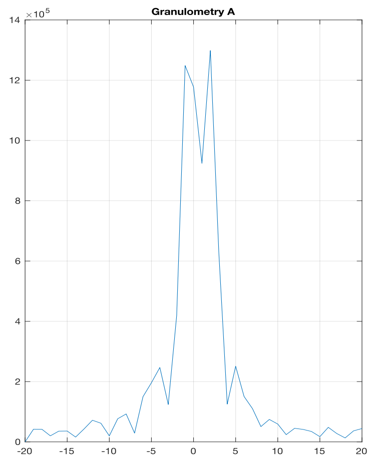
PB 5 (0.5 point): Considering the following three images: image 1, 2 and 3.

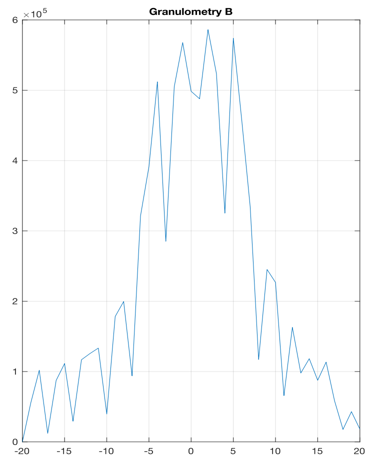


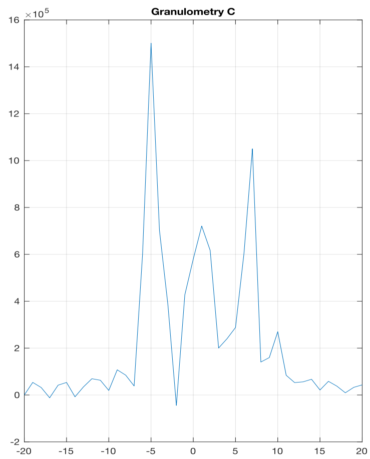




We have computed their granulometry with circular structuring element. The three pattern spectrums: granulometry A, B and C are shown below.





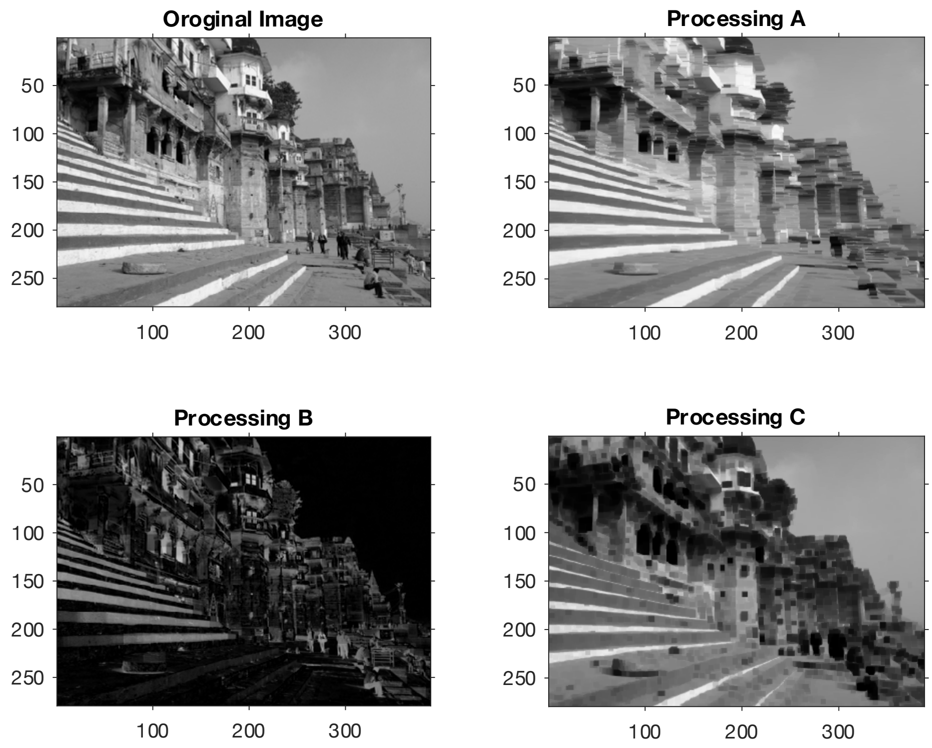


Define the correspondence between the granulometric curves (A,B,C) and the images (1,2,3). **Justify precisely your reasoning.**

PB 6 (0.5 point): The original image of size 388x279 shown in the upper left part of the following figure has been processed by three different operators:

- An erosion with a horizontal structuring element on length 5 followed by an erosion with a vertical structuring element on length 5.
- A closing with a horizontal structuring element on length 7 followed by a closing with a horizontal structuring element on length 7.
- A dual tophat involving a closing with a structuring element of size 13x13.

The results of are shown in Processing A, B and C. Assign an operator to each of these results. Justify your answer taking into account the various operator properties and the observed visual effects.



PB 7 (0.5 point): Consider the image I below (left side) and its negative (right soide). All images are quantized with 4 bits.

0	4	4	12	4
0	4	4	12	0
0	0	4	15	12
4	0	4	12	15
4	15	4	15	15

Image I

15	11	11	3	11
15	11	11	3	15
15	15	11	0	3
11	15	11	3	0
11	0	11	0	0

Negative of I

Compute in both cases the image after histogram equalization. Are the resulting images negative of each other?

PB 8 (0.5 point): We would like to construct two sets of structuring elements of increasing sizes in order to use them to compute granulometries. The first set is based on SE_1^A and the second one on SE_1^B (show below). In each case, the locations included in the structuring element is shown with "×".

$SE_1^A[m,n] = \begin{bmatrix} . & \times & . \\ \times & . & \times \\ . & \times & . \end{bmatrix}$ and $SE_1^B[m,n] = \begin{bmatrix} \times & \times & . \\ \times & \times & \times \\ \times & \times & \times \end{bmatrix}$

We consider these structuring elements are of size one (represented by the sub-index 1) and in order to create structuring elements of larger size we simply dilate them by themselves. As examples, we have:

$SE_2^A[m,n] = SE_1^A[m,n] \oplus SE_1^A[m,n]$, $SE_3^A[m,n] = SE_1^A[m,n] \oplus SE_2^A[m,n]$, etc.

$SE_2^B[m,n] = SE_1^B[m,n] \oplus SE_1^B[m,n]$, $SE_3^B[m,n] = SE_1^B[m,n] \oplus SE_2^B[m,n]$, etc.

Compute the structuring elements $SE_2^A[m,n]$ and $SE_2^B[m,n]$.

Can we use the set of SE_k^A or of SE_k^B structuring elements to compute granulometries?

PB 9 (1.0 point): Consider the image x[m,n] with values between [0,1], X[k,l] its Discrete Fourier Transform (DFT) of NxN samples (X[k,l] =DFT_{NxN}\{x[m,n]\}) and X(F_x,F_y) the Fourier Transform of x[m,n]

a. Justify the maximum size of the input image so the Discrete Fourier Transform of MxN samples of an image, X[k,l], represents the sampled version of its Fourier Transform X(F_x,F_y): $X[k,l] = X(F_x,F_y)\big|_{F_x=\frac{k}{N}, F_y=\frac{l}{N}}$

Consider the size of the input image NxN and the image y[m,n] = 1 + x[m,n].

b. Compute Y[k,l]=DFT_{NxN}\{y[m,n]\}, in terms of X[k,l]

c. Compute the inverse DFT of Y[k,l] - X[k,l]

PB 10 (1.0 point): Consider the following filter h[m,n] with impulse response (kernel) of size 3x3 and the image x[m,n] of size 4x4:

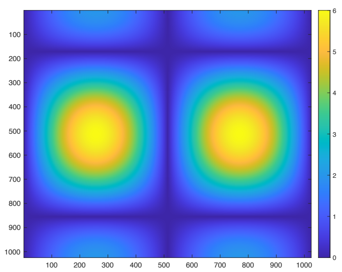
$$h[m,n] = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \qquad x[m,n] = \begin{bmatrix} 1 & 1 & 2 & 2 \\ 1 & 1 & 2 & 2 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

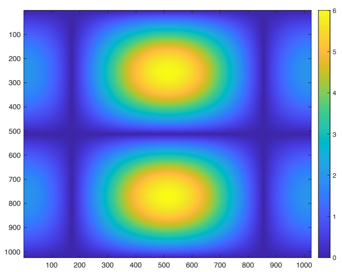
a. Compute the filtered image $y[m,n] = x[m,n] * h[m,n]$ (If necessary zero-padding may be assumed).

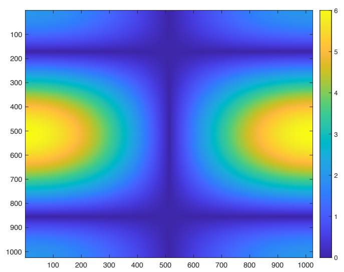
b. Does the filter correspond to a low-pass or high-pass filter? In which (horizontal or vertical) component?

c. Justify if the filter detects any vertical or horizontal contours.

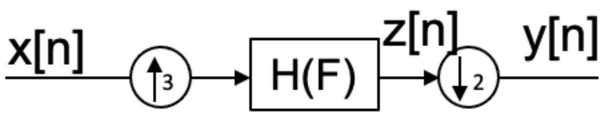
d. Justify which on the following 3 images represents the modulus of the DFT of the filter h[m,n]


A)


B)


C)

PB 11 (1.0 point): Consider the following decomposition using down-sampling and up-sampling processes (without filtering).

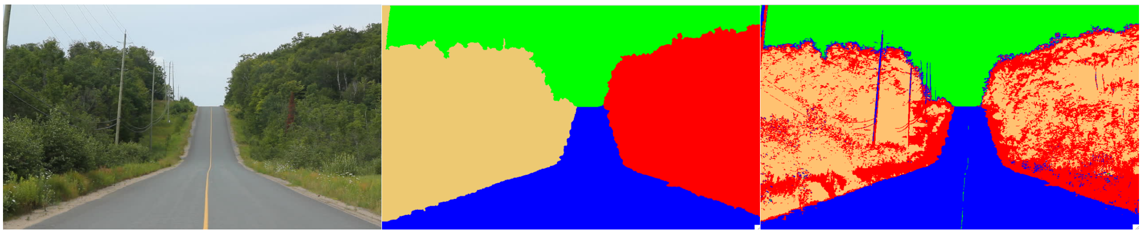


1. Assume we are using an ideal filter H(F). Would you use a low-pass or a high pass filter?
2. Using again an ideal filter H(F), what would the cut off frequency be? (use normalized discrete frequency values)
3. Are there any aliasing in the signal z[n]?
4. Express the Fourier Transform Z(F)=FT\{z[n]\} as a function of X(F)=FT\{x[n]\} and H(F).
5. Express the Fourier Transform Y(F)=FT\{y[n]\} as a function of Z(F)=FT\{z[n]\}.

PB 12 (0.5 point): Describe the Laplacian of Gaussian blob detector. In particular, explain the motivation and the idea of the scale selection.

PB 13 (0.5 point): Describe the SIFT descriptor. That is, describe how the pixel neighborhood around a detected keypoint is converted to a 128-dimensional feature vector. Mention at least two computer vision tasks or applications where keypoint detectors/descriptors like SIFT are commonly used. Explain what is the benefit of using SIFT in the applications (e.g. compared to methods which are not scale invariant).

PB 14 (0.5 point): We have applied two segmentation algorithms, k-means and watershed, to image (1). For k-means, clustering has been performed in the RGB space using k=4. For watershed, 4 markers have been defined manually by drawing 4 strokes over the image and using the strokes as markers. The results are shown in images (2) and (3). Explain which image corresponds to k-means and which to watershed (justify your answer). In each case, explain if an extra step is needed to obtain a partition.



(1) (2) (3)

PB 15 (0.5 point): Hough Transform:

1. Write the pseudocode to detect circumferences in a contour image using the Hough transform.
2. Assuming that we know the gradient at each contour position, explain how this information can be used to improve the previous algorithm, Provide the pseudo-code of the modified algorithm.

   Equation of a circumference: $\begin{matrix} a = x - r\cos(t) \\ b = y - r\sin(t) \end{matrix}$

PB 16 (0.5 point): RANSAC: Explain the LMedS algorithm and its advantages over RANSAC

PB 17 (0.5 point): Segmentation using region merging: Give two examples of similarity measures between two regions.