INSTITUTO SUPERIOR DE ENGENHARIA DE LISBOA
LICENCIATURA EM ENGENHARIA INFORMÁTICA E DE COMPUTADORES
MESTRADO EM ENGENHARIA INFORMÁTICA E DE COMPUTADORES
IMAGE PROCESSING AND BIOMETRICS

2nd semester, 2017/2018

End-term exam | June, 6 ; 3:30 pm | Available time: 1:30

You can consult your class notes, with 2 A4 pages.
Explain, in detail, all your answers. Write down all the hand calculations that you carry out.

1. The $f[m,n]$ image has energy 172 J and its *Discrete Cosine Transform* (DCT) is $F[u,v] = \begin{bmatrix} 1 & -2 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ -3 & 0 & 1 & A \end{bmatrix}$.

   (a) $\{1.25\}$ State the value of A.

   (b) $\{1.25\}$ Compute the average intensity value of $f[m,n]$.

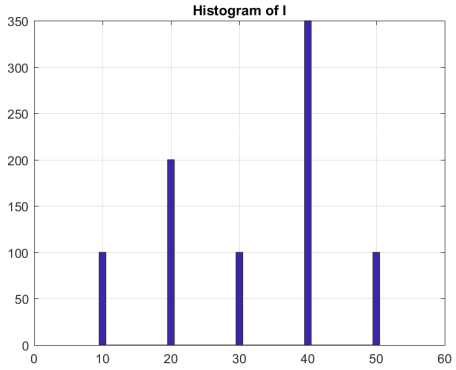
   (c) $\{1.25\}$ Let $g[m,n] = \begin{bmatrix} 4 & 4 & 4 & 4 \\ 4 & 4 & 4 & 4 \\ 4 & 4 & 4 & 4 \end{bmatrix} + 2f[m,n]$. Without performing the explicit computation of the DCT of $g[m,n]$, compute $G[u,v] = DCT[g[m,n]]$.

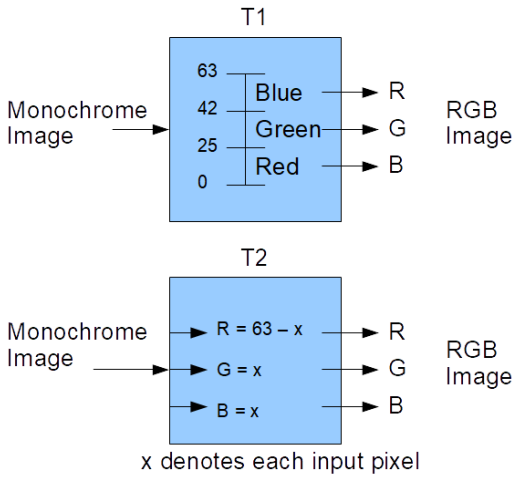
   The DCT of a $M \times N$ image is given by

$$F[u,v] = \text{DCT}[f[m,n]] = C[u]C[v] \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f[m,n] \cos\left(\frac{(2m+1)u\pi}{2M}\right) \cos\left(\frac{(2n+1)v\pi}{2N}\right),$$

$$\text{with} \quad C[u] = \begin{cases} \frac{1}{\sqrt{M}}, & u = 0 \\ \sqrt{\frac{2}{M}}, & u \in \{1, \ldots, M-1\} \end{cases} \quad \text{and} \quad C[v] = \begin{cases} \frac{1}{\sqrt{N}}, & v = 0 \\ \sqrt{\frac{2}{N}}, & v \in \{1, \ldots, N-1\} \end{cases}.$$

2. The following figure depicts the histogram of the monochrome image I with depth of $n = 6$ bit/pixel as well as a graphical representation of two pseudo-coloring techniques, named $T1$ and $T2$.





   (a) $\{1.25\}$ Identify the technique represented by $T1$. State the total number of pixel holding the Red, the Green, and the Blue color, after $T1$ is applied over I. State some color codes that represent the Red, Green, and Blue colors.

   (b) $\{1.25\}$ Identify the technique represented by $T2$. After applying $T2$ on I, state the number of distinct colors on the output image as well as the corresponding color codes.

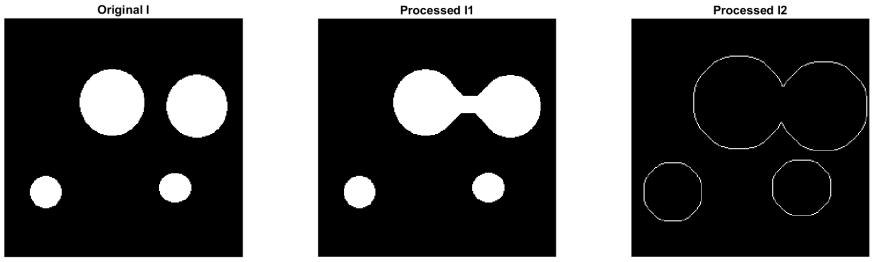
3. The following questions address full-color image processing techniques.

   (i) $\{1.5\}$ Show a sketch of an algorithm that performs *segmentation* of a RGB color image, locating all the pixels with the RGB color code $[0, 255, 0]$. Establish the set of input and output parameters of the algorithm stating their meaning and contents.

   (ii) $\{1.5\}$ Apply a modification on the algorithm of the previous question, in such a way that it now performs the *color slicing* operation over pixels with the RGB color code $[255, 50, 50]$. Establish the set of input and output parameters of the algorithm stating their meaning and contents.

   (iii) $\{1.25\}$ A given RGB image has Gaussian noise on the R band and impulsive noise (*salt & pepper*) on the G band. State how you would proceed to: remove the noise from the image; apply histogram equalization.

4. $\{2.0\}$ The following figure shows the output of two different morphologic procedures over the binary image I. Identify the morphologic operations that produced: I_1 from I; I_2 from I.



5. $\{1.25\}$ Let $I = \begin{bmatrix} 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 \end{bmatrix}$ and the structuring elements $SE1 = \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$ and $SE2 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$. Suppose that we apply the *hit and miss* operation on I, with the SE1 and SE2 structuring elements. What is the resulting image?

6. A given biometric system has a database of individual records as shown in the table.

   (a) $\{1.25\}$ State the number of features considered in the system. What seems to be the most discriminative feature? And the less discriminative one?

   (b) $\{1.25\}$ Suppose that the pattern $\mathbf{x} = [11, 9, 1, 2, 6]$ is applied to the system, for identification purposes. What is the identified individual? State all the assumptions that you make on this assessment.

   (c) $\{1.25\}$ Suppose that the pattern $\mathbf{x} = [13, 8, 7, 2, 1]$ is applied to the system for authentication of individual 2. The system will return a positive or a negative authentication? State all the assumptions that you make on this assessment.

Record	Individual
[18, 10, 1, 2, 5]	1
[13, 8, 1, 2, 7]	2
[15, 11, 2, 2, 8]	3
[10, 9, 2, 2, 6]	4

7. Some classifier was trained on a dataset with $c = 4$ classes. After training, the classifier was tested with a dataset holding 20 patterns per class. The following was observed:

   - for class 1, there were 17 patterns correctly classified and one patern misclassified in each one of the other classes;
   - for classes 2 and 4, there were no misclassified patterns;
   - for class 3, there were two patterns misclassified (one as class 1 and another as class 2).

   (a) $\{1.25\}$ State the confusion matrix that corresponds to the classifier test, as described above. State the error percentage per class and the global error percentage.

   (b) $\{1.25\}$ Regarding this classifier test, report the ideal confusion matrix.