Lebanese University
Faculty of Sciences 5

INFO449 E
Image, Video & Audio

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Duration: 2 hours

Exercise I: Multiple choice [15 pts]

1. A Lempel-Ziv dictionary starts with two entries – "0" and "1". The dictionary size after parsing the symbol stream 00101100 is:
   a. 4
   b. 5
   c. 6
   d. 7
   e. Less than 4
   f. Greater than 7

2. A source of 4 symbols a_1, a_2, a_3, a_4 having probabilities $P(a_1)=0.5$, $P(a_2) = 0.25$, $P(a_3) = P(a_4) = 0.125$ was used for arithmetic coding of a message. The real number associated to the message is 0.8. What would be the message
   a. $a_4\ a_2\ a_3$.
   b. $a_2\ a_4\ a_3$.
   c. $a_3\ a_1\ a_3$.
   d. $a_3\ a_1\ a_4$.
   e. None of the above

3. A quantizer at the encoder performs:
   a. One-to-one mapping.
   b. One-to-many mapping.
   c. Many-to-one mapping.
   d. Many-to-many mapping.
   e. All of the above
   f. None of the above

4. The run length encoding algorithm that encodes the occurrence of a symbol is not efficient when the encoded symbols are:
   a. Highly alternating
   b. Highly repetitive
   c. Highly and consecutively repetitive
   d. All of the above.
   e. None of the above

5. _____ Filter cannot be implemented using convolution mechanism.
   a. Average
   b. Median
   c. Gaussian
   d. All of the above
   e. None of the above

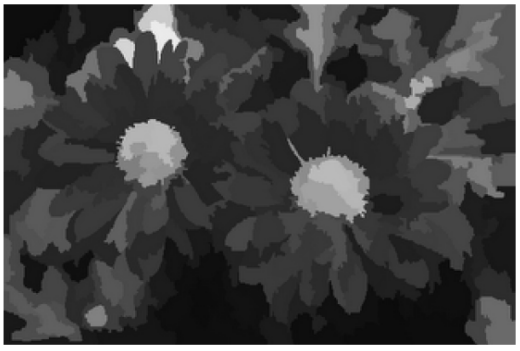
6. High contrast image correspond to:
   a. Pixels tend to be dark
   b. Pixels tend to be bright
   c. Range of pixel values is low
   d. Range of pixel values is high
   e. All of the above
   f. None of the above

7. _____ is the process of using known data to estimate values at unknown locations.

a. Decimation
b. Formulation
c. Interpolation
d. Interpolation and formulation
e. None of the above
f. All of the above

8. In order to obtain the image in figure on the right side from the original image on the left side, the following point processing operation should be applied:

a. Contrast compression
b. Negation (negative)
c. Histogram equalization
d. Histogram specification (matching)
e. None of the above
f. All of the above



Original image

Transformed image

9. An image element is usually called a :

a. Pixel
b. Voxel
c. Fixel
d. Drexel
e. All of the above
f. None of the above

10. The sum of all components of a normalized histogram calculated from an M x N image size is equal to_____.

a. M x N
b. M
c. N
d. 1
e. M + N
f. M - N

11. Sharpening the images is commonly accomplished by performing a spatial -------- of the image field.

a. Min filter
b. Smoothing filter
c. Integration
d. Differentiation
e. Max filter
f. Average filter

12. Which of the following filter(s) is (are) nonlinear:

a. Gaussian Filter
b. Averaging Filter
c. Laplacian Filter
d. Median filter
e. All of the above
f. None of the above

13. Which of the following filters is effective in the presence of salt-and-pepper noise?

a. Average filter
b. Median filter
c. Sobel filter
d. Robert filter
e. All of the above
f. None of the above

14. Ideal filters can be:

a. Low-Pass Filter (LPF)
b. High-Pass Filter (HPF)
c. Band-Pass Filter (BPF)
d. All of the above
e. None of the above

15. Fourier transform is a _____ transform.

a. Linear
b. Non-linear
c. Bilinear
d. Bicubic
e. All of the above
f. None of the above

Exercise II: True / False [10 pts]

For each of the following questions, answer with true or false.

1. In frame prediction, as the macroblock size decreases, the prediction error increases.
2. In frame prediction, the parameter k of the search area should be increased when objects with fast motion are scanned.
3. The Brute-Force search leads to better resolution as compared to the Logarithmic one.
4. A P frame can be obtained from I or P frames.
5. Zigzag ordering in the JPEG compression technique produces longer run of zeros.
6. Larger image/file size leads to poorer compression using LZW.
7. Sharpening is used to enhance homogeneous zones in the image.
8. RGB colors space is the suitable colors space for image processing and analysis.
9. In video compression, a B Frame can serve as reference for P frames only.
10. MPEG bases on motion estimation of the macroblocks from one frame to the next one in order to compress the video.

Exercise III: Filters [10 pts]

An original image (the intensity values of the pixels are normalized to be between 0 and 1) passes through several point-wise intensity transformations listed below:

(1) $s = r^2$

(2) $s = 1 - r$

(3) $s = 0.5r + 0.25$

(4) $s = \begin{cases} 0 & r \le 0.7 \\ 1 & else \end{cases}$

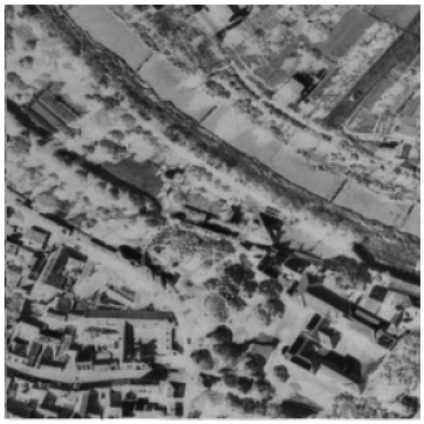
(5) $s = \begin{cases} 0 & r < 0.25 \\ 2r - 0.5 & 0.25 \le r \le 0.75 \\ 1 & 0.75 < r \end{cases}$

The original and transformed images are shown in the figures below. For each resulting image (A)-(E), determine the corresponding intensity transformation that creates it.

Original

(A)

(B)



(C)

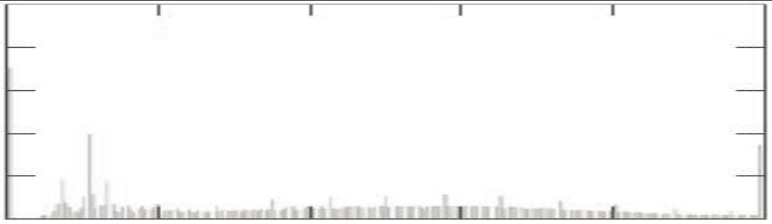
(D)

(E)

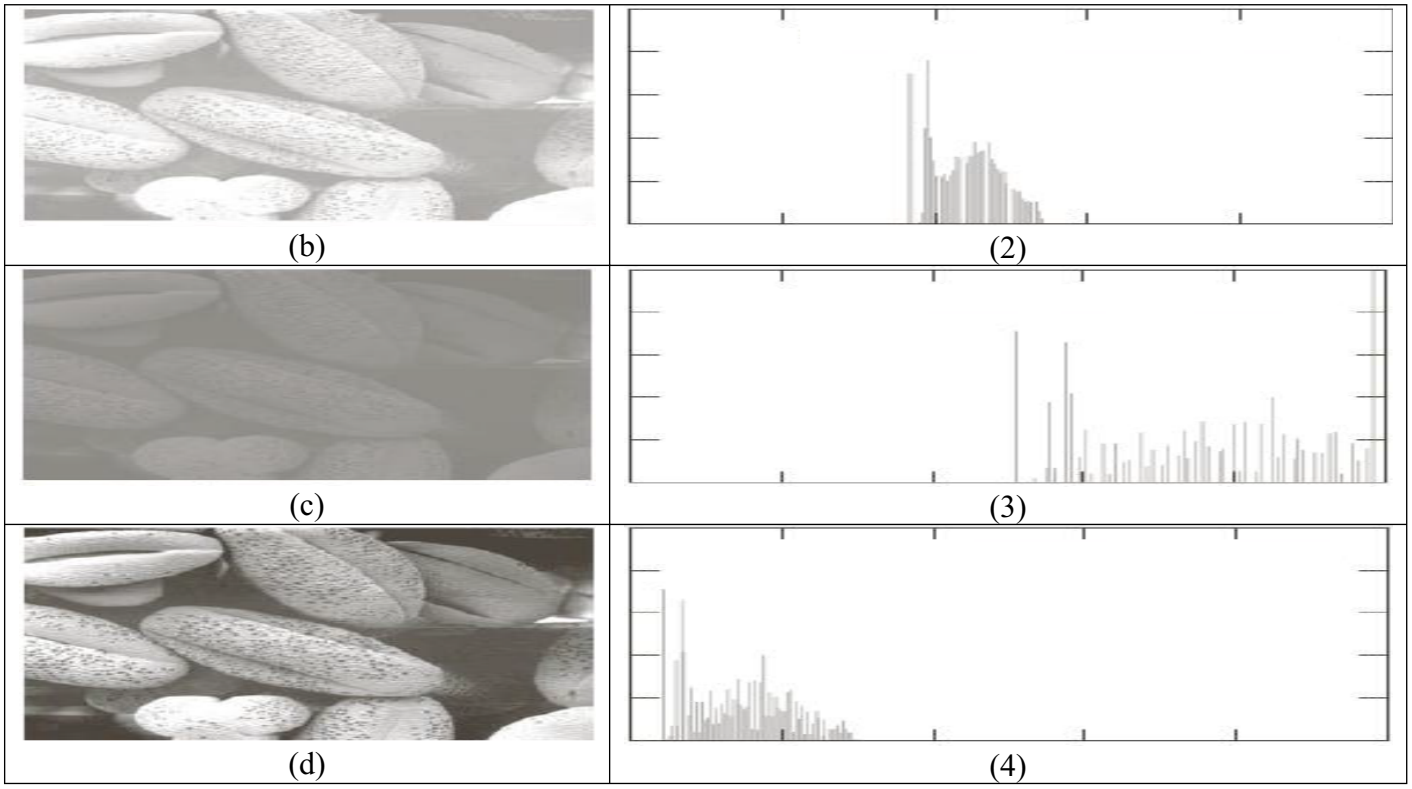
Exercise IV: Image histograms [8 pts]

Associate each of the following images with their associated histograms:

(a)



(1)

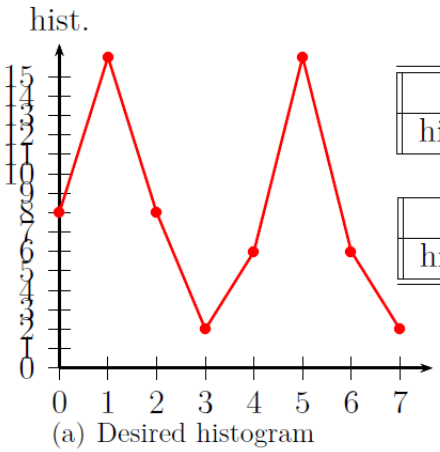


Exercise V: Histogram Equalization and matching (specification) [11 pts]

Given the following piece of image with grey levels between 0 and 7. You are asked to do the following:

1. Compute the histogram of the image.
2. Compute the cumulative distribution function of the grey levels of the image (CDF).
3. Apply on the image the histogram equalization operation and then compute the histogram of the equalized image. Has the new histogram changed?
4. Apply histogram matching (specification) to the image using the following histogram:

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7



(a) Desired histogram

i	0	1	2	3
hist.	0.125	0.250	0.125	0.0312

i	4	5	6	7
hist.	0.0938	0.250	0.0938	0.0312

(b) CDF of the desired histogram

Exercise VI: Logarithmic Search Analysis [16 pts]

Consider the encoding of a 640x480 video at 30 fps using I and P frames. To encode the P frames, we consider 8x8 macroblocks and **use logarithmic search** to find the best motion vector. Assume that the search area parameter k is equal to 8.

a. Calculate the number of candidate blocks to be matched against a target macroblock.
b. Calculate the number of MAD evaluations per frame (assume that all target macroblocks, including the boundary ones, have the same number of candidates).
c. Consider now 10 minutes of video knowing that one I frame is inserted after every 4 consecutive P frames as follows:
   I PPPP I PPPP I … . Assume that 1 MAD evaluation takes 0.1 ms.
   1. What is the Total number of frames? I frames? P frames?
   2. Deduce the time spent on motion vector computation for these 10 minutes of video.
   3. Can this be used for real-time encoding and distribution setup? Justify.