Lebanese University
Faculty of Sciences 5

INFO449 E
Image, Video & Audio

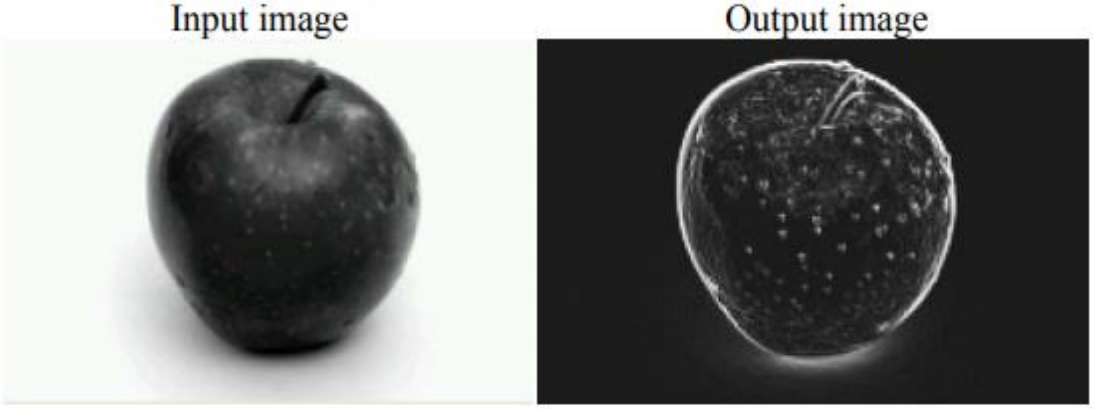
Final 2018- 2019
Date: 2 August 2019
Duration: 2 hours

Exercise I: Multiple choices [20 pts]

Fill the following table with the correct answer.

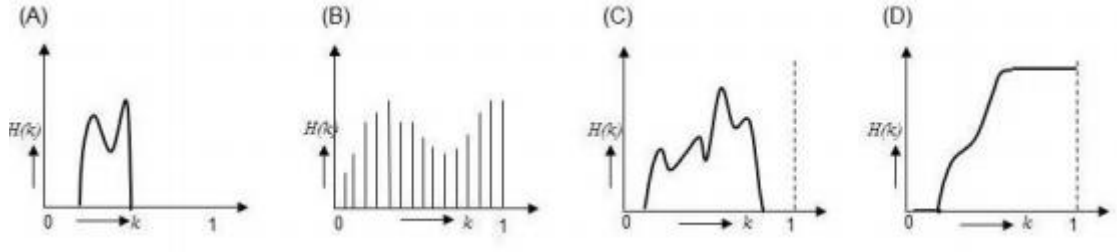
1	2	3	4	5	6	7	8	9	10
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**

1. What is the most likely filter that has been applied on the left image to obtain the right one?



a. Average
b. Gaussian
c. Median
d. Laplacian

2. Let us consider two images with histograms show in (A) and (C) below.



a. A has lower contrast than C
b. C has lower contrast than A
c. A and C have the same contrast.
d. Cannot tell if the contrasts of A and C are different

3. If we apply a global histogram stretching to the figure A shown in the previous question, the most likely histogram that would result is?

a. A
b. C
c. B
d. None of the above

4. To map a narrow range of low gray-level input image into a wider range of output levels, we use
   a. Log Intensity Transformation Function
   b. Power-law Intensity Transformation Function
   c. Inverse Log Intensity Transformation Function
   d. Identity Intensity Transformation Function

5. What is the most effective mask that can be used to filter the below image?

   a. Sobel
   b. Median
   c. Average
   d. Gaussian

6. Process that increases the dynamic range of gray levels in an image is called
   a. Linear stretching
   b. Contrast stretching
   c. Color stretching
   d. Elastic stretching

7. Given the following piece S of an image S=5 5 3 2 0 0 6 0 8 10, the second order derivative is :

a.

0	-2	-1	-2	0	6	-6	8	2

b.

0	2	1	2	1	-6	6	-8	-2

c.

2	-1	1	-2	-6	12	-14	6

d.

-2	1	-1	2	6	-12	14	-6

8. Which of the following operators is used to detect edges?
   e. Butterworth
   f. Ideal
   g. Gaussian
   h. Laplacian

9. What is the relationship between High-Pass filter and Low-Pass filter in the 2-D frequency domain?

a. $H_{hpf}(u,v) = 1 - H_{lpf}(u,v)$
b. $H_{hpf}(u,v) = 1 + H_{lpf}(u,v)$
c. $H_{hpf}(u,v) = 1 - H_{lpf}{}^{c}(u,v)$
d. None of the above

10. Which of the following matrices represents a Laplacian mask?

a. $\begin{pmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{pmatrix}$
b. $\begin{pmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{pmatrix}$
c. $\begin{pmatrix} 1 & 1 & 1 \\ 1 & 8 & 1 \\ 1 & 1 & 1 \end{pmatrix}$
d. Both a and b

11. Variable length coding (VLC) achieves compression by

a. Using psychovisually motivated quantization tables.
b. Assigning shorter code words to more probable symbols.
c. Assigning longer code words to more probable symbols.
d. Using transformations such as DFT, DCT, DWT etc.

12. An audio clip (2 minutes, 22 kHz, 16 bits, compression ratio: 3) is recorded in stereo. What is the file size of the audio clip in MB?

a. 1.678
b. 2.750
c. 3.521
d. 13.427

13. Which of the following is the lowest possible color resolution we need to use if the image contains 6480 colors?

a. 10 bits
b. 11 bits
c. 12 bits
d. 13 bits

14. Given that the original file size of an image is 52 MB. What is the file size of the image after compressing with the compression ratio of 4?

a. 0.4 GB
b. 13 MB
c. 52 MB
d. 60KB

15. Given that a 22-inch monitor with an aspect ratio of 16:9 has a monitor resolution of 1920x1080, what is the width of the monitor?

a. 8.53 inches
b. b. 10.79 inches
c. c. 19.17 inches
d. c. 22 inches

16. For a lossless encoder-channel-decoder combination, the PSNR of the reconstructed image measured in dB will be

a. Zero
b. 20 dB
c. 40 dB
c. Infinity

17. Which of the following is a second order derivative operator?

a. Histogram
b. Laplacian
c. Prewit
c. Sobel

18. Histogram equalization is a --------- technique.

a. Frequency domain
b. spatial domain
c. Both
c. None of the above

19. ---------- filter is used to emphasize high frequency components representing image details without eliminating low frequency components representing homogeneous areas in the image.

a. High-Boost filter
b. Low-Pass filter
c. High-Pass filter
c. Median filter

20. If the playback rate of an animation is 12 fps, and the number of frames created is 120, what is the duration of the animation?

a. 5 seconds
b. 10 seconds
c. 15 seconds
c. 20 seconds

Exercise II: True or False [10 pts]

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

1	2	3	4	5	6	7	8	9	10

1. Laplacian filter is a non-linear filter.
2. The sum of all entries in normalized histogram is equal to 256.
3. The second pass of histogram equalization produces a different result than the first histogram equalization pass.
4. Assuming an NxN image, the complexity of 2D FFT is $O(N^4)$.
5. Image negative produces image equivalent to a photographic negative.
6. DFT is more efficient for image filtering than other transformations.
7. Prewit and Sobel operators are used for edge detection.
8. The filter shown below is a sharpening filter.

$$\begin{matrix} 1 & 2 & 1 \\ 2 & 1 & 2 \\ 1 & 2 & 1 \end{matrix}$$

9. Poor illumination of the scene to be photographed results in low contrast image.
10. In chromaticity diagram, points on the boundary are fully saturated.

Exercise III: Image Filtering [10 pts]

For the following 5 x 5 image f(x,y) with 3 bits per pixel, i.e. pixel values in {0,1,..,7}:

a. Compute the histogram of f(x, y). (1 pt)

$$f(x,y) = \begin{matrix} 0 & 0 & 1 & 1 & 2 \\ 0 & 1 & 1 & 2 & 4 \\ 1 & 1 & 2 & 4 & 5 \\ 1 & 3 & 4 & 5 & 6 \\ 3 & 3 & 5 & 6 & 7 \end{matrix}$$

b. Find the equalized image, g(x,y). (3 pts)

c. Compute the Euclidean distance between the histograms of the original image and the equalized one. (2 pts)

A 4 x 4 gray-scale original image f(x,y) is given below. Compute the filtered output images after passing through:

$$f(x,y) = \begin{matrix} 12 & 10 & 8 & 6 \\ 10 & 8 & 6 & 4 \\ 8 & 6 & 4 & 2 \\ 6 & 4 & 2 & 0 \end{matrix}$$

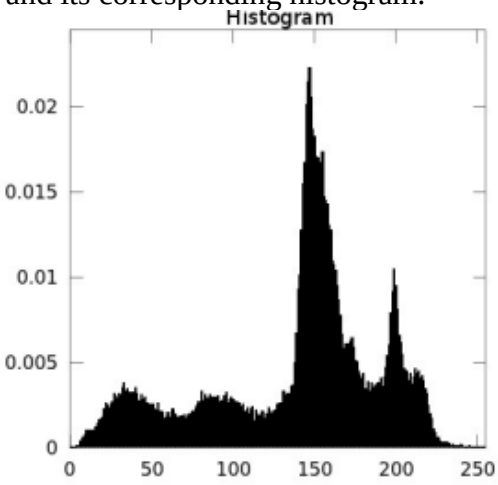
d. the spatial linear filter as specified by the mask w1 (by using zero-padding of the original image). (2 pts)

$$w_1 = \frac{1}{2}\begin{pmatrix} 0 & 1 & 0 \\ -1 & 2 & -1 \\ 0 & 1 & 0 \end{pmatrix}$$

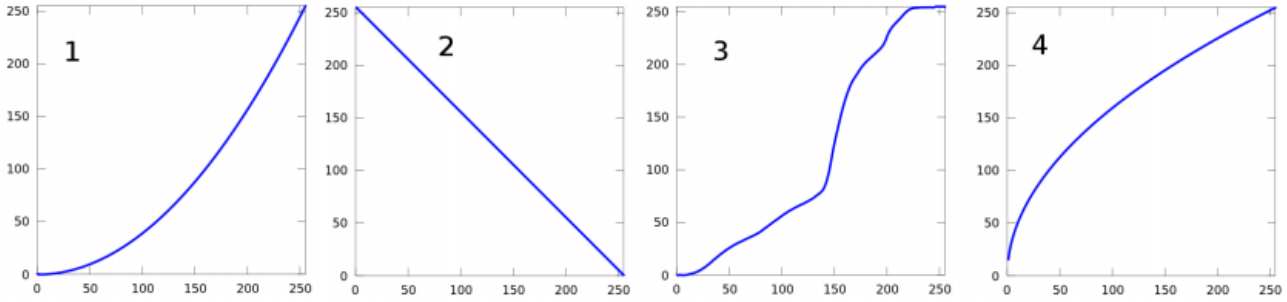
e. a 3x3 median filter (by using zero-padding of the original image). (2 pts)

Exercise IV: Histograms [8 pts]

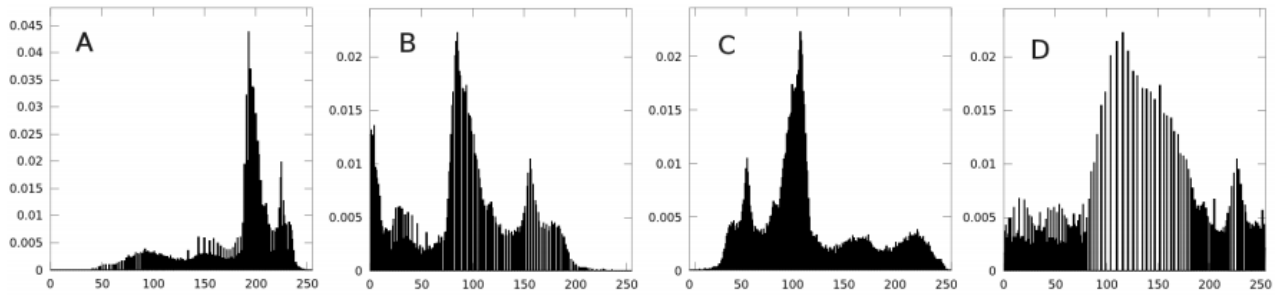
The following figure shows a gray-value image and its corresponding histogram.



The following four (1 to 4) different intensity transformations have been applied to the image.



Assign the histograms (A to D) that are shown below to the transformations, Fill your answer in the table below.



Histogram	A	B	C	D
Transformation				

Exercise V: GOP [8 pts]

a. High Definition TV consists of a 1920 x 1080 pixel image, refreshed at a rate of 30 images per second. 24-bit color is used. What is the data rate required to transmit an uncompressed HDTV movie in real-time? (2 pts)

b. Consider a video stream with 30 frames per second playback rate and an audio stream. If each frame consists of 160 x 120 pixels of 24-bit colors depth and the audio is sampled at 8000 Hz with 16-bit sampling. Calculate the total storage required to store the above video file for ten minutes. (3 pts)

c. Suppose now that for the video is coded with a GOP of size 15 in which we find one I frame, and each P frame is separated by 2 B frames. The compression ratio of each I frame is 3, for P frames is 6 and for B frames is 8. Moreover, The DPCM technique is used to compress the audio. The difference between consecutive samples is coded on 3 bits and one reference value is inserted every 80 samples (1^{st}, 80^{th}, 160^{th}, 240^{th} …). What is the new size of the ten minutes of video? (3 pts)

Exercise VI: Motion Vectors [14 pts]

Given a HD video of resolution 3840×2160, 24 bits/pixel at 30 fps using I, P and B frames. For B frames, the best motion vector between the two previous and the two next frames is chosen. To encode the P and B frames, we consider 32x32 macroblocks and a search area of k = 32.

a. How many MADs is done to find the best motion vector for each macro-bloc in a P and B frames if the search method is sequential? Logarithmic? Hierarchical with 4 levels? (6 pts)

b. What is the total number of macroblocks in each frame? Deduce the total number of MADs that you should perform for each type of frames (P, B). (4 pts)

c. Suppose that the size of the GOP is 15 frames in which we have 4 P frames and 10 B frames. What is the total number of MADs to be calculated per second? (4 pts)