Lebanese University
Faculty of Sciences 5

INFO449 E
Image, Video & Audio

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Duration: 2 hours

Exercise I: Multiple choice [8 pts]

1. Which color model is used in your color printer?
   a. RGB
   b. HSI
   c. CMY/CMYK
   d. None of the above

2. Which of the following is not a type of noise?
   a. Salt and pepper
   b. Impulse
   c. Gaussian
   d. Median

3. If we add the original image I to the difference between the original image I and its smoothed version results in:
   a. Sharpening the image
   b. Smoothing the image
   c. Sharpening and smoothing the image
   d. None of the above

4. A source of 2 symbols a_1, a_2 having probabilities $P(a_1)=2/3$, $P(a_2) = 1/3$ is used for arithmetic coding. The decimal value 1/2 corresponds to the following message:
   a. $a_1a_2a_1$
   b. $a_1a_1a_1$
   c. $a_2a_2a_1$
   d. $a_2a_1a_2$

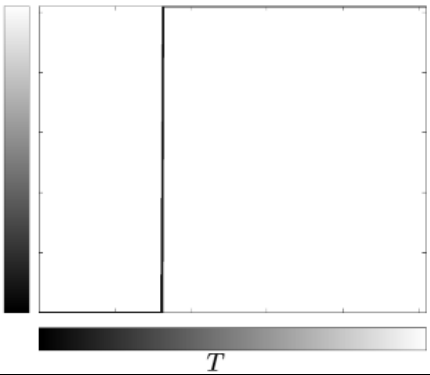
5. Which type of operation(s) has been applied on the original image (left one) to obtain the filtered image (right one)?
   a. Low-pass filtering
   b. Sharpening
   c. High-pass filtering
   d. Smoothing

Original image

Filtered image

6. Given the below image I and the transformation T, indicate which of the four images corresponds to applying T on the image I.

I



T

a.

b.

c.

d.

7. To remove the salt and pepper noise, we use the following filter(s):
   a. Min followed by max
   b. Gaussian
   c. Max followed by min
   d. Median

8. The compression steps in order followed for JPEG compression are:
   a. YUV conversion, subsampling, DCT, quantization, coding.
   b. Subsampling, YUV conversion, quantization, DCT, coding
   c. YUV conversion, subsampling, quantization, DCT, coding.
   d. YUV conversion, subsampling, DCT, coding, quantization.

Exercise II: True / False [12 pts]

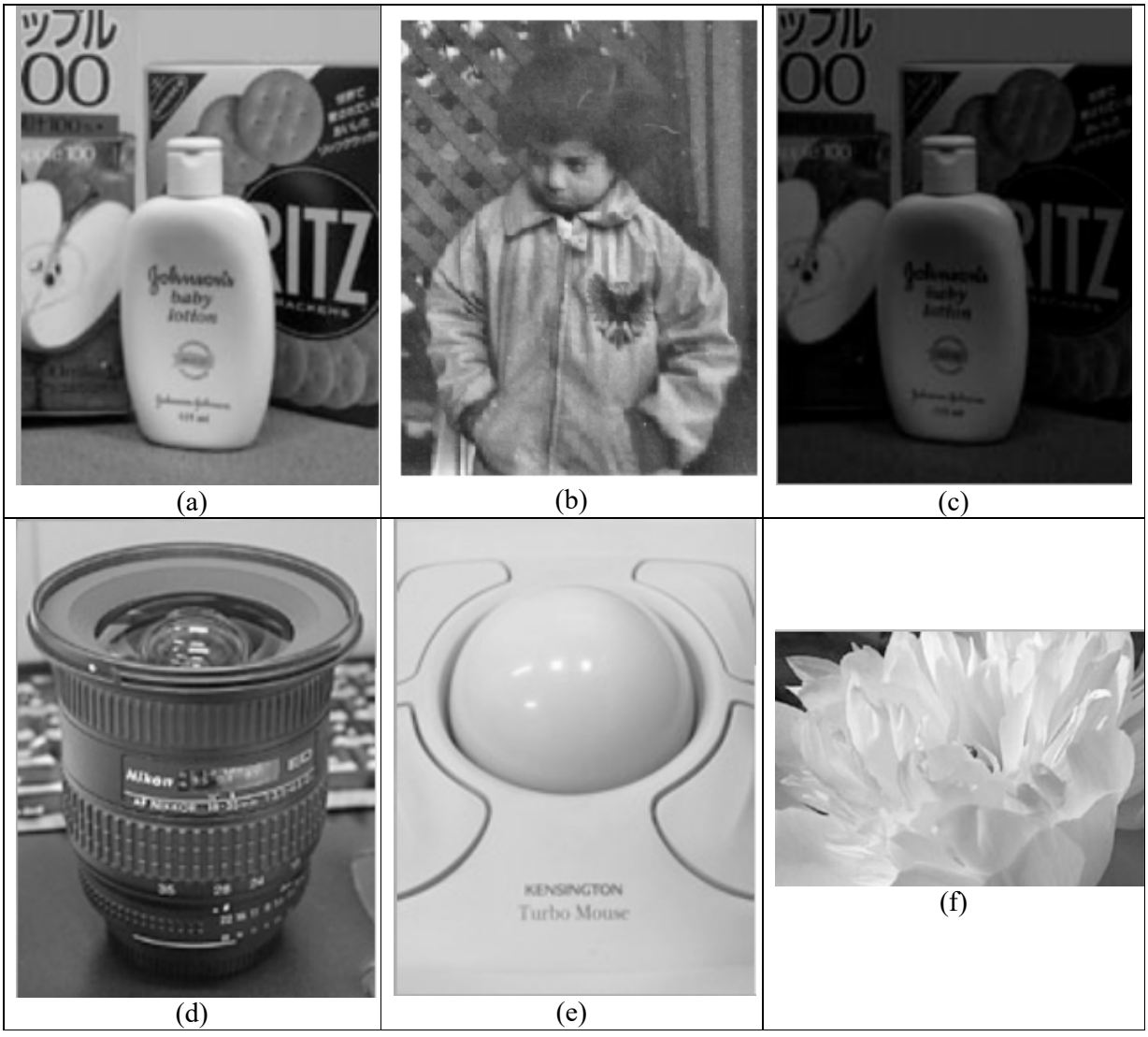
For each of the following questions, answer with true or false.

1. Histogram of equalized image has better contrast than the original one.
2. Salt and pepper noise is a random occurrences of white pixels.
3. When size of average filter increases, the image becomes more blurred.

4. Apply a filter on an image twice has the same effect as if the filter is applied one time.
5. Two different image content have necessarily two different histograms.
6. DPCM is the abbreviation of digital pulse channel modulation.
7. The HSV color space separates color information from intensity information which simplify image processing and analysis operations.
8. The discrete Fourier transform (DFT) performs as well as DCT for image compression.
9. Median filtering is a sharpening filter.
10. The first step in edge detection is differentiation.
11. Laplacian filter replaces the pixel value by the median value in the neighborhood.
12. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed.

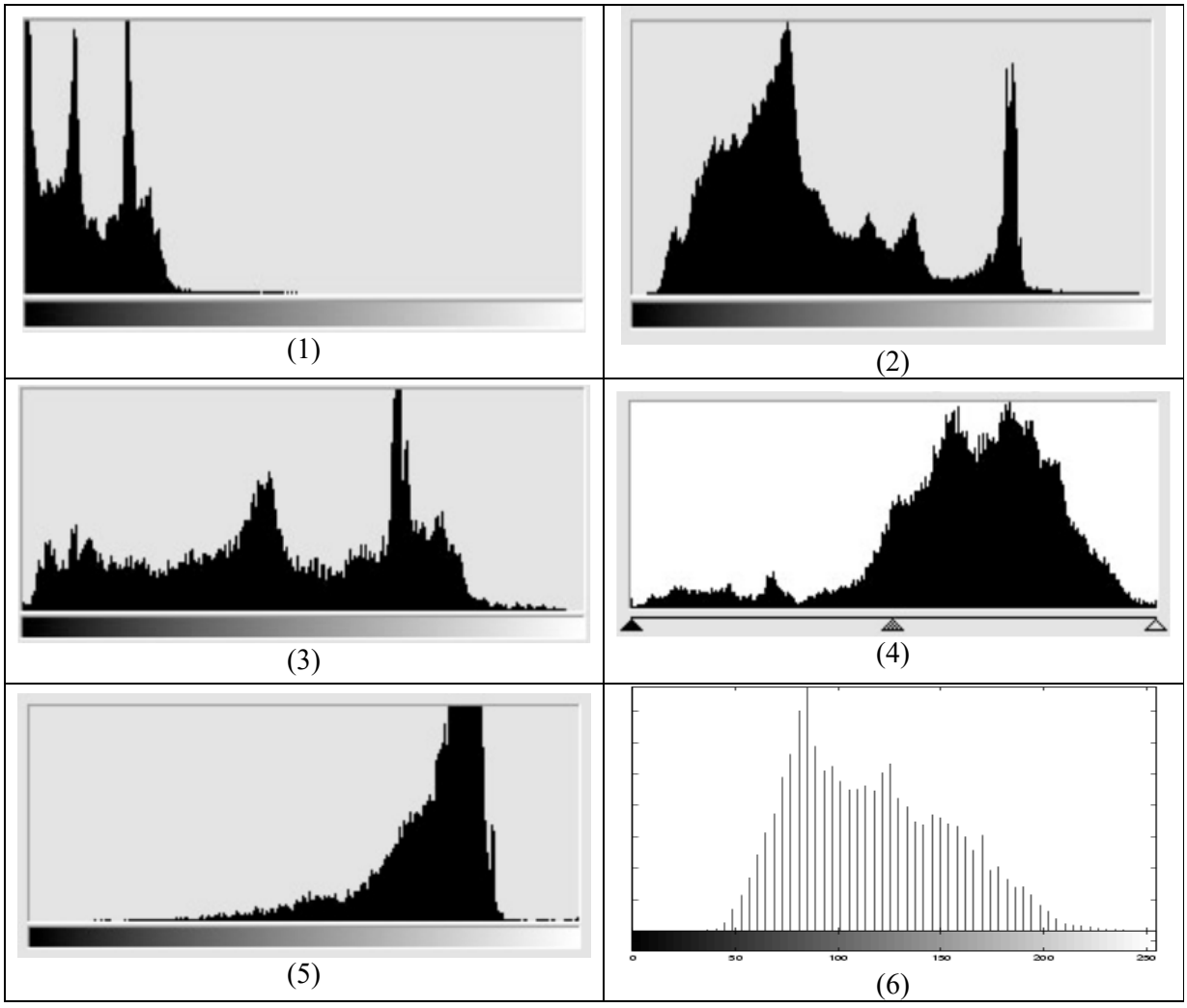
Exercise III: Histograms [6 pts]

Match each image with the corresponding correct histogram.



(a) (b) (c)

(d) (e) (f)



Exercise IV: Histogram Equalization [10 pts]

a. Given the following histogram for a 128x128 image with 8 gray levels. Apply the histogram equalization and compute the new histogram of the equalized image.

Gray Level	0	1	2	3	4	5	6	7
Number of pixels	34	50	500	1500	2700	4500	4000	3100

b. Suppose that a digital N x N image with k gray levels is subjected to histogram equalization. Show that a second pass of histogram equalization (on the histogram-equalized image) will produce exactly the same result as the first pass.

Exercise V [8 pts]

The image below has 64 grey levels (0-63).

a. Apply a 3x3 Sobel filter in both horizontal and vertical direction to the pixel at location (3, 3). Then calculate the magnitude.
b. Apply the following 3x3 median to the pixel at location (3,3).

c. Write a function that takes as input a gray scale image and the size of a median filter and returns the filtered image.

13	0	13	6	8
0	0	4	7	9
14	0	**7**	3	12
0	9	9	6	1
8	5	15	11	4

-1	-2	-1
0	0	0
1	2	1

Horizontal

-1	0	1
-2	0	2
-1	0	1

Vertical

Exercise VI: Video size [10 pts]

A video sequence is given to be encoded using H.263 in PB-mode (for every P we have a B), having a frame size of 4CIF (704x576), frame rate of 30 fps, and video length of 90 minutes. The following is known about the compression parameters: on average, two I-frames are encoded per second. The video at the required quality has an I-frame average compression ratio of 10:1, an average P-frame compression ratio twice as good as I-frame, and an average B-frame compression ratio twice as good as P-frame. Assuming the compression parameters include all necessary headers, calculate the encoded video size.

Exercise VII: Motion Vectors [16 pts]

The video compression steps based on Motion Compensation (MC) are the following:

1. Motion estimation (search motion vector).
2. Forecast based on MC.
3. Derivation of the prediction error, i.e. the difference.

a. Explain with schemas the principle of P frame coding in MPEG. Detail with another annotated schema(s) the motion compensation including the motion estimation process. What happens if no matching block was found?

b. Explain with schemas the principle of B frame coding. Detail with another annotated schema the adapted motion compensation process in this case.

c. Explain the principle of 2D logarithmic search for motion vectors. Use an annotated schema in which you indicate all the parameters involved.

d. Write a function to apply the 2D logarithmic search which given a reference frame, a target frame, a block center (or number) in the target frame, and a window parameter p, calculates and returns the motion vector of this block relatively to the reference frame.