INFO449 E
Image, Video & Audio

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Exercise I: Multiple choice [15 pts]

1. A still image has the following form(s) of statistical redundancy
   a. Spatial redundancy.
   b. Spatial as well as temporal redundancy.
   c. Temporal redundancy.
   d. Neither spatial nor temporal redundancy.

2. A still image with uniform intensity exhibits
   a. Best spatial redundancy.
   b. Worst spatial redundancy.
   c. Best temporal redundancy.
   d. Worst temporal redundancy.

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.

4. The entropy of a source of symbols is dependent upon:
   a. The number of source outputs generated.
   b. The average codeword length.
   c. The probabilities of the source symbols.
   d. The order in which the source outputs are generated.

5. Which one of the following is not true for Huffman coding?
   a. No codeword of an elementary symbol is a prefix of another elementary symbol.
   b. Each symbol has a one-to-one mapping with its corresponding codeword.
   c. The symbols are encoded as a group, rather than encoding one symbol at a time.
   d. Shorter code words are assigned to more probable symbols.

6. A source of 4 symbols a_1, a_2, a_3, a_4 having probabilities $P(a_1)=0.5$, $P(a_2) = 0.25$, $P(a_3)=P(a_4)=0.125$ is used for arithmetic coding. The source symbol sequence a_2a_1 will correspond to the interval (mark the closest answer):
   a. [0.25, 0.375)
   b. [0.5, 0.625)
   c. [0.75, 0.875)
   d. [0,1)

7. M-JPEG is a video compression technique that uses:
   a. Spatial redundancy
   b. Spatial as well as temporal redundancy
   c. Temporal redundancy
   d. Neither spatial nor temporal redundancy

8. Given the below DCT coefficients of an image in the table on the right, reading them in zig-zag order produces the following sequence :

a. 118, 42, 54, 150, 42, 32, 30, 34, 100, 60, 43, 98, 44, 39, 40, 31
b. 118, 42, 100, 44, 42, 32, 60, 39, 54, 30, 43, 40, 150, 34, 98, 31
c. 118, 42, 42, 54, 32, 100, 44, 60, 30, 150, 34, 43, 39, 40, 98, 31
d. 118, 42, 42, 100, 32, 54, 150, 30, 60, 44, 39, 43, 34, 98, 40, 31

118	42	54	150
42	32	30	34
100	60	43	98
44	39	40	31

9. To map a narrow range of low gray-level input image into a wider range of output levels , we use:
   a. Log intensity transformation
   b. Power-law intensity transformation
   c. Inverse Log intensity transformation
   d. Identity intensity transformation

10. The sum of all elements in the (m x n) average mask of the smoothing spatial filtering must be equal to:
   a. m
   b. n
   c. m x n
   d. 1

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

12. One of the following filters is nonlinear:
   a. Gaussian Filter
   b. Averaging Filter
   c. Laplacian Filter
   d. Median filter

13. To remove salt and pepper noise without blurring, we use:
   a. Max filter
   b. Min filter
   c. Average filter
   d. Median filter

14. Which filter (s) cannot be implemented by the convolution operation.
   a. Average filter
   b. Gaussian filter
   c. Median filter
   d. Min filter

15. Both the -------- and -------- filters are used to enhance horizontal edges (or vertical if transposed).
   a. Prewitt and Sobel
   b. Sobel and Gaussian
   c. Prewitt and Laplacian
   d. Sobel and Laplacian

Exercise II: True / False [10 pts]

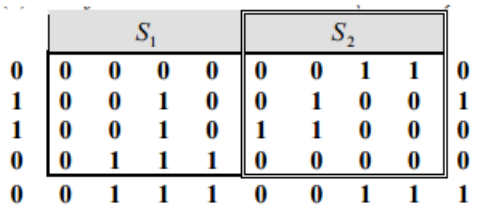
For each of the following questions, answer with true or false.

1. JPEG2000 compression bases on the DCT transformation.
2. Coding large image/file size using LZW leads to poorer compression.
3. The sequential search of motion vectors is faster than hierarchical search.
4. I frames are inserted as access point frames.
5. VOP stands for Video Object Plane.
6. Median filter is a ranking filter.
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. A P frame can be obtained from I, P or B frames
10. B Frame is used in all the video compression standards today.

Exercise III: Adjacency [3 pts]

Consider the two image subsets, S_1 and S_2, shown in the following figure. Two pixels are of the same class if they are equal to one. Determine and justify whether these two subsets are:

a. 4-adjacent
b. 8-adjacent
c. m-adjacent



Exercise IV: Filters [6 pts]

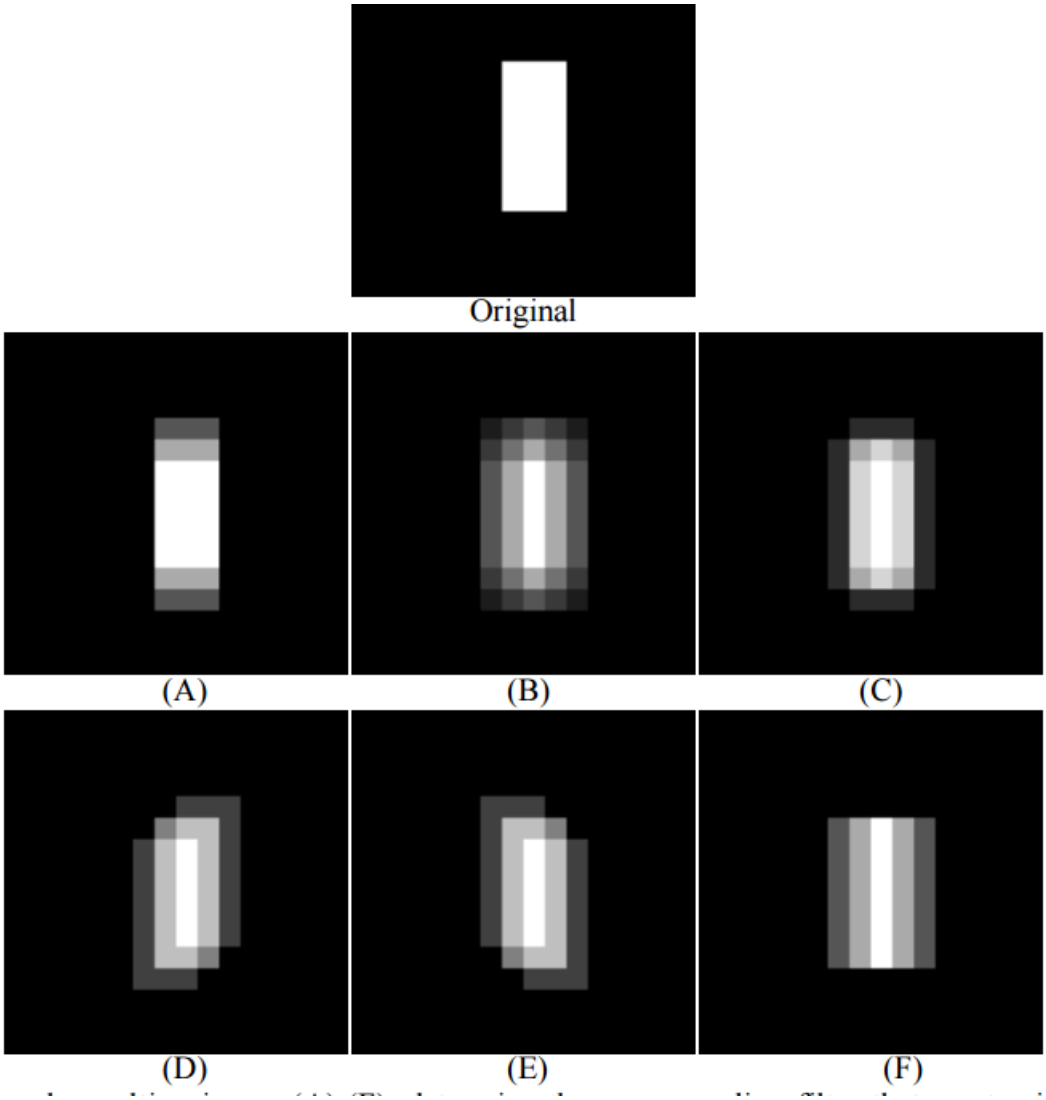
An original 16 x 16 image passes through several filters, match each filtered image with the corresponding filter applied on it. Find below the filters and the filtered images.

a. h_1
b. h_2
c. h_3
d. h_4
e. h_5
f. h_6

1. (A)
2. (B)
3. (C)
4. (D)
5. (E)
6. (F)

$$h_1(m,n)=\begin{bmatrix}1&0&0\\0&2&0\\0&0&1\end{bmatrix};\quad h_2(m,n)=\begin{bmatrix}0&1&0\\1&2&1\\0&1&0\end{bmatrix};\quad h_3(m,n)=\begin{bmatrix}0&0&0\\1&1&1\\0&0&0\end{bmatrix}$$

$$h_4(m,n)=\begin{bmatrix}1&1&1\\1&1&1\\1&1&1\end{bmatrix};\quad h_5(m,n)=\begin{bmatrix}0&1&0\\0&1&0\\0&1&0\end{bmatrix};\quad h_6(m,n)=\begin{bmatrix}0&0&1\\0&2&0\\1&0&0\end{bmatrix}$$



Exercise V: GOP Frames Order [4 pts]

Given the following coding schemes for a group of sequential frames in MPEG-2:

I	B	B	P	B	B	B	P	I	B	B	B	P	B	P	P
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

What is the coding order of the frames?

Exercise VI: Histogram Equalization [5 pts]

The following table gives the number of pixels at each of the grey levels 0-7 in an image with those grey values only. Compute the equalized histogram.

0	1	2	3	4	5	6	7
3244	3899	4559	2573	1428	530	101	50

Exercise VII: Filtering & Histogram [10 pts]

Given the following piece of image, the Laplacian, and the low-pass filters, compute the following:

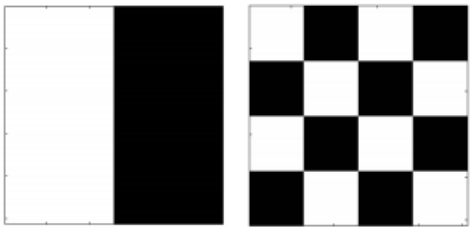
Y / X	Image				
	1	2	3	4	5
1	3	7	6	2	0
2	2	4	6	1	1
3	4	7	2	5	4
4	3	0	6	2	1
5	5	7	5	1	2

Laplacian mask		
0	1	0
1	-4	1
0	1	0

Low pass filter		
0.01	0.1	0.01
0.1	0.56	0.1
0.01	0.1	0.01

a. The output of a 3 × 3 mean (average) filter at the pixel (3, 3).
b. The output of the 3 × 3 Laplacian filter shown above at the pixel (3, 3).
c. The output of the 3 × 3 low-pass filter shown above at the pixel (3, 3).
d. The histogram of the whole image.
e. The cumulative histogram of the whole image.

Exercise VIII [5 pts]



The following two 4x4 images of the figure on the right are quite different but they have equal histograms. Suppose that each of them is filtered by a 3x3 averaging mask.

a. Would the histograms of the filtered images still the same? Justify.

Exercise IX: Motion Vectors [12 pts]

Consider the following piece of two consecutive frames. Suppose now that we want to search sequentially for the highlighted block of the frame n+1 in the whole frame n. Answer the following questions:

a. For each block in frame n+1, how many MAD calculations should be done?
b. Deduce the total number of MAD calculations to be done in order to calculate the motion vector for all the 2x2 blocks in frame n+1.
c. If each 2x2 MAD calculation takes 1 ns, what is the time needed to predict all the motion vectors of all the blocks in the frame n+1?
d. Answer the parts a, b, and c if we consider a logarithmic search instead of sequential search.

139	144	149	153	155	155	155	155
144	151	153	156	159	156	156	156
150	155	160	163	158	156	156	156
159	161	162	160	160	159	159	159
159	160	161	162	162	155	155	155
161	161	161	161	160	157	157	157
161	162	161	163	162	157	157	157
162	162	161	161	163	158	158	158

frame *n*

155	155	139	144	149	153	155	155
156	156	144	151	153	156	159	156
156	156	150	155	160	163	158	156
159	159	159	161	162	160	160	159
155	155	159	160	161	162	162	155
157	157	161	161	161	161	160	157
157	157	161	162	161	163	162	157
158	158	162	162	161	161	163	158

frame *n+1*