INFO449 E
Image, Video & Audio

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Exercise I: Multiple choice [15 pts]

Circle the correct answer.

1. A Lempel-Ziv dictionary starts with two entries – "a" and "b". The dictionary size after parsing the symbol stream aababbaa is:
   a. 4
   b. 5
   c. 6
   d. 7

2. A source of 4 symbols a_1, a_2, a_3, a_4 having probabilities $P(a_1)=0.25$, $P(a_2) = 0.5$, $P(a_3) = P(a_4) = 0.125$ 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. $a_3\ a_2\ a_2$.

3. Which of the following statements is not true for arithmetic coding:
   a. Integral number of bits is assigned to each symbol.
   b. A real number in the interval [0, 1) indicates the entire coding sequence.
   c. Coding requires a priori knowledge of the probabilities of source symbols.
   d. Longer sequence of source symbols leads to longer code words.

4. A given image has 250 pixels horizontally and 200 pixels vertically and its color depth is 16. What is the approximate size of the image?
   a. 1 kBytes
   b. 100 kBytes
   c. 10 kBytes
   d. 1000 kBytes

5. Consider four information sources S1, S2, S3, S4 of vocabulary 4 with symbol probabilities P1={0.5, 0.25, 0.25, 0}, P2={0.125, 0.125, 0.25, 0.5}, P3={0.25, 0.25, 0.25, 0.25} and P4={0, 0, 1, 0} respectively, their corresponding entropies His are sorted as the following (answer without any calculation):
   a. H1>H2>H3>H4
   b. H2>H1>H4>H3
   c. H1>H2>H4>H3
   d. H3>H2>H1>H4

6. High contrast image corresponds 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

7. What is the number of colors that may be stored in a pixel that has a color depth of 8?

a. 8	b. 32
c. 128	d. 256

8. A source of 4 symbols a1, a2, a3, a4 having probabilities P(a1) = 0.4, P(a2) = 0.35, P(a3) = P(a4) = 0.125 are encoded by four different encoding schemes and the corresponding codes are shown below. Which of the following gives us the best coding efficiency?

a. $a_1 = 00, a_2 = 01, a_3 = 10, a_4 = 11$	b. $a_1 = 0, a_2 = 10, a_3 = 110, a_4 = 111$
c. $a_1 = 00, a_2 = 100, a_3 = 1100, a_4 = 1101$	d. $a_1 = 111, a_2 = 110, a_3 = 10, a_4 = 0$

9. JPG compression analyzes images in blocks of _____pixels in size and selectively reduces the detail within each block

a. 4 x 4	b. 8 x 8
c. 16 x 16	d. 32 x 32

10. A 4-symbol alphabet has the following probabilities P(a1)=0.1, P(a2)=0. 5, P(a3) = 0.25, P(a4) = 0.15 and following codes are assigned to the symbols a1 = 111, a2 = 0, a3 = 10, a4 = 111. The average code word length for this source is:

a. 1.25	b. 1.5
c. 1.75	d. 2

11. Match each value in the left column with a value in the right column.

a. Hue	1. Amount of color
b. Saturation	2. Intensity
c. Brightness	3. Name of the color

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

a. Gaussian Filter	b. Averaging Filter
c. Laplacian Filter	d. Median filter

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

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

15. Fourier transform is a _____ transform.

a. Linear	b. Non-linear
c. Bilinear	d. Bicubic

Exercise II: True / False [10 pts]

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

1. Coding large image/file size using LZW leads to poorer compression.	
2. In frame prediction, the parameter k of the search area should be increased when objects with fast motion are scanned.	
3. Huffman and Arithmetic encoding both require symbol frequencies.	
4. Smoothing filters are used to enhance the quality of the image.	
5. Zigzag ordering in the JPEG compression technique produces longer run of zeros.	
6. Sharpening is used to enhance homogeneous zones in the image.	
7. GIF is a lossless image type.	
8. TV signals are sent in RGB.	
9. In order to reduce the number of bits per pixel, the channels Y, U and V are sub-sampled.	
10. MPEG bases on motion estimation of the macroblocks from one frame to the next one in order to compress the video.	

Exercise III: [14 pts]

Given a camera sensor with a resolution of 2160 lines and 3840 pixels per line.

a) If the camera uses progressive scanning using the YCrCb color scheme, what is the average bit per pixel if a 4:2:0 sub-sampling scheme is used and each sample is represented with 8 bits?

b) What would be the bit-rate produced by this camera (bits per second) if 25 frames per second are captured?

c) Given that a USB 3.0 device can transfer 5 Gbps, what is the maximum progressive number of frames per second that can be transferred from this camera using the USB 3.0 standard?

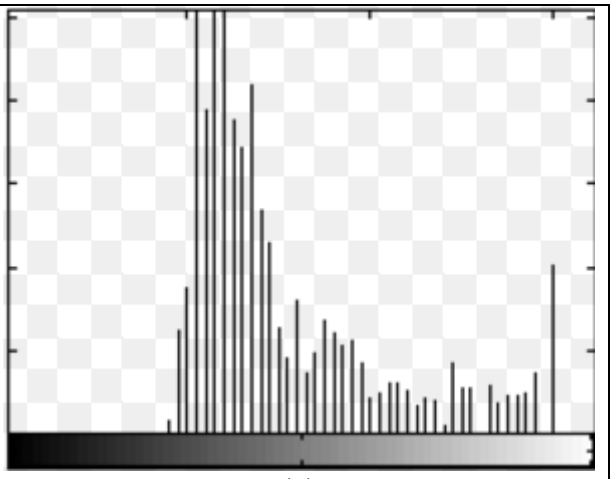
d) What would be the field rate if interlaced scanning was used instead of progressive scanning in (c)?

e) What is the image aspect ratio of the frames captured using this camera?

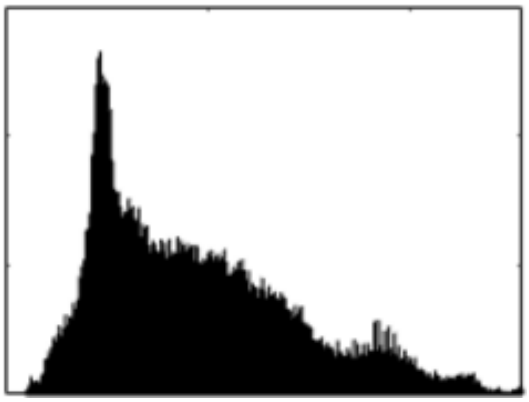
f) Given that the signal captured by this camera is to be losslessly (using 4:4:4 sub-sampling) stored, what is the required bus bandwidth to transfer 30 progressive frames per second? Is a USB 3.0 bus (that can transfer 5 Gbps) sufficient?

Exercise IV: Image histograms [8 pts]

Associate each of the following images with its associated histogram:

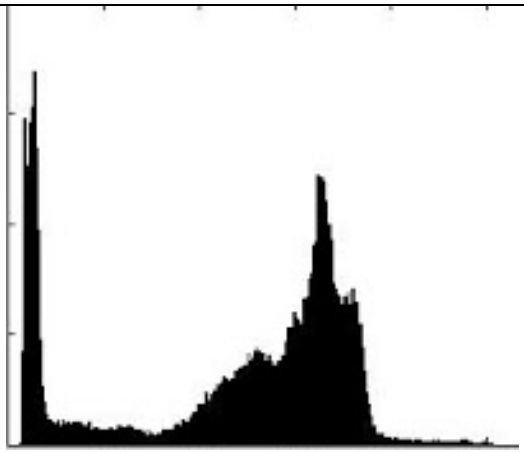
	
(a)	(1)

(b)



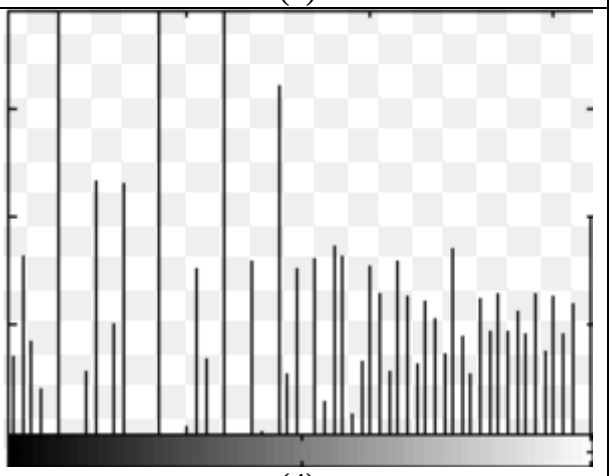
(2)

(c)



(3)

(d)



(4)

Exercise V: Histogram equalization [7 pts]

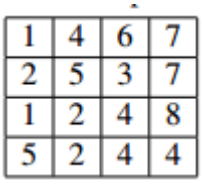
Equalize the histogram of the 8 × 8 image below and show the resultant image. The image has grey levels 0, 1, . . . , 7.

4	4	4	4	4	4	4	0
4	5	5	5	5	5	4	0
4	5	6	6	6	5	4	0
4	5	6	7	6	5	4	0
4	5	6	6	6	5	4	0
4	5	5	5	5	5	4	0
4	4	4	4	4	4	4	0
4	4	4	4	4	4	4	0

Exercise VI: Compression [16 pts]

Assume the 2 × 2 macroblock shown in the left figure is used for motion compensation. Given the corresponding intensities in the reference frame in the right figure, answer the following:

#	#	#	#
#	5	7	#
#	4	5	#
#	#	#	#



1	4	6	7
2	5	3	7
1	2	4	8
5	2	4	4

1. Calculate the motion vector, with complete search within a ±1 pixel search window (k=1). List the steps to obtain the result. Having computed the motion vector, determine the macroblock to be coded after motion compensation.

Consider the following block of frequency domain values from a video frame arising during MPEG compression:

196	207	1	129
1	7	129	199
11	73	73	194
75	78	139	135

2. Apply successively to this block: (1) MPEG quantization using a constant quantization value of 64. (2) Zig-zag scanning. (3) Run length encoding