



Exercise I [15 pts]

Fill the following table with the correct answer.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

1. A Lempel-Ziv dictionary starts with two entries – “a” and “b”. The dictionary size after parsing the symbol stream aababbaa is:

a. 4

c. 6

b. 5

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. $a_4 a_2 a_3$.

c. $a_3 a_1 a_3$.

b. $a_2 a_4 a_3$.

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.

c. Coding requires a priori knowledge of the probabilities of source symbols.

b. A real number in the interval $[0, 1)$ indicates the entire coding sequence.

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

c. 10 kBytes

b. 100 kBytes

d. 1000 kBytes

5. Consider four information sources S_1, S_2, S_3, S_4 of vocabulary 4 with symbol probabilities $P_1=\{0.5, 0.25, 0.25, 0\}$, $P_2=\{0.125, 0.125, 0.25, 0.5\}$, $P_3=\{0.25, 0.25, 0.25, 0.25\}$ and $P_4=\{0, 0, 1, 0\}$ respectively, their corresponding entropies H_i are sorted as the following (answer without any calculation):

a. $H_1 > H_2 > H_3 > H_4$

c. $H_1 > H_2 > H_4 > H_3$

b. $H_2 > H_1 > H_4 > H_3$

d. $H_3 > H_2 > H_1 > H_4$

6. High contrast image corresponds to:

a. Pixels tend to be dark

c. Range of pixel values is low

b. Pixels tend to be bright

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 a_1, a_2, a_3, a_4 having probabilities $P(a_1) = 0.4, P(a_2) = 0.35, P(a_3) = P(a_4) = 0.125$ 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 $P(a_1)=0.1, P(a_2)=0.5, P(a_3) = 0.25, P(a_4) = 0.15$ and following codes are assigned to the symbols $a_1 = 111, a_2 = 0, a_3 = 10, a_4 = 111$. 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:
- | | |
|---------------------------|---------------------------|
| 1. Low-Pass Filter (LPF) | 2. High-Pass Filter (HPF) |
| 3. Band-Pass Filter (BPF) | 4. All of the above |
15. Fourier transform is a _____ transform.
- | | |
|-------------|---------------|
| a. Linear | b. Non-linear |
| c. Bilinear | d. Bicubic |

Exercise II [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 better 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. The redundancy from frame to frame in video compression is better exploited on groups of pixels rather than individual pixels.	
6. Sharpening is used to enhance homogeneous zones in the image.	
7. GIF is a lossy image type.	
8. TV signals are sent in HSV.	
9. In order to reduce the number of bits per pixel, the channels Y, U and V are sub-sampled.	
10. B frames induce a forward and backward dependency	

Exercise III [8 pts]

Associate each of the following images with an histogram. Fill in the following table:

Image	a	b	c	d
Histogram				



(a)



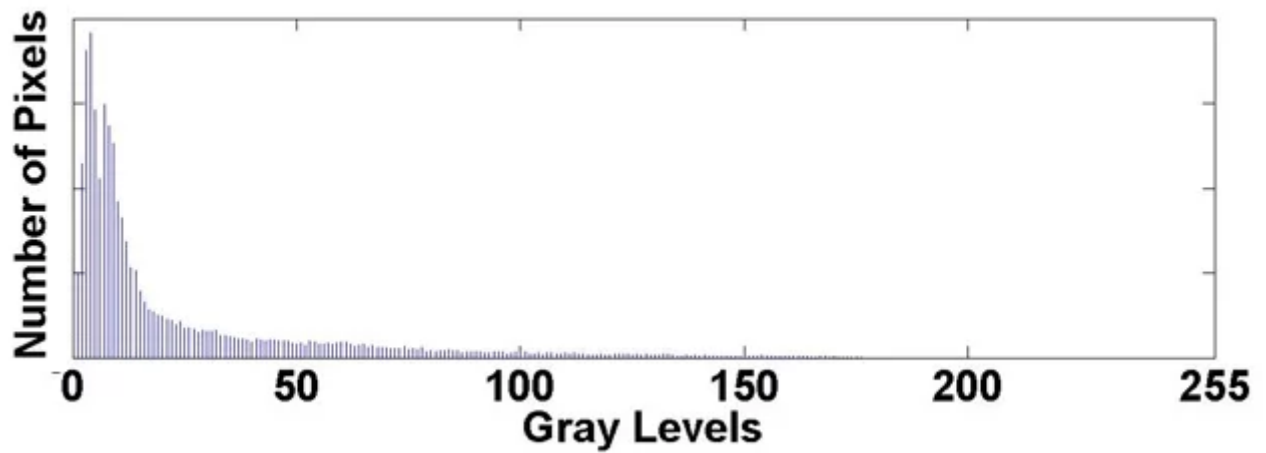
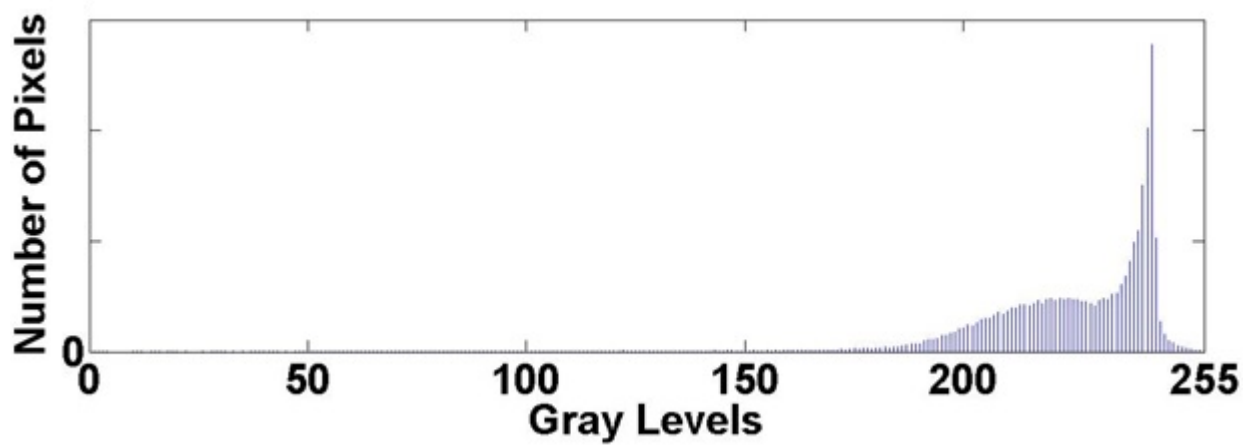
(b)

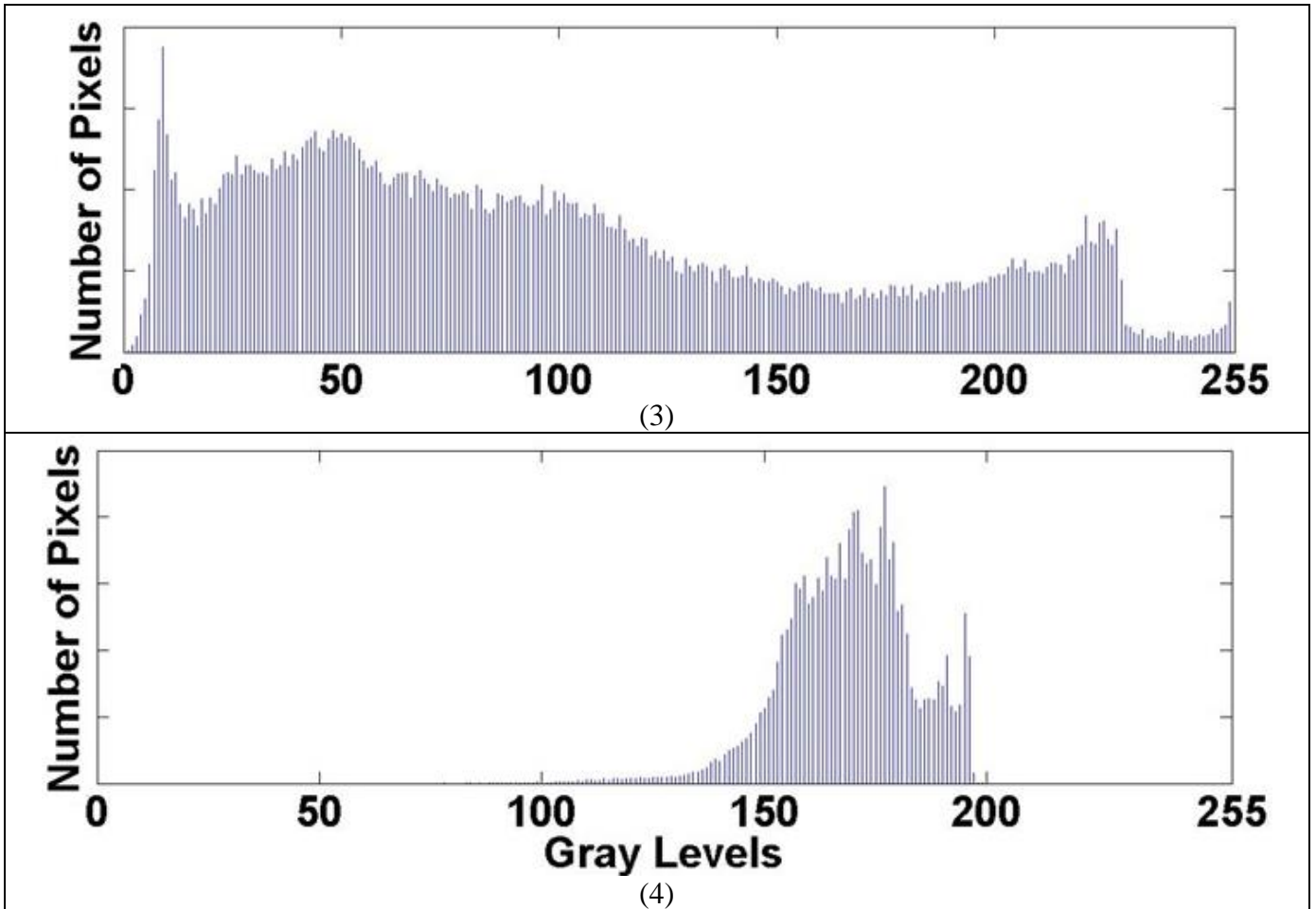


(c)



(d)





Exercise IV [14 pts]

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

- 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 V [14 pts]

Suppose we have a system named XXX broadcasting textual messages. The system has decided to broadcast messages made up of the letters "R", "E", "D", "S", "O", "X". The characters are chosen at random according to the probabilities given in the following table:

Letter	<i>R</i>	<i>E</i>	<i>D</i>	<i>S</i>	<i>O</i>	<i>X</i>
Probability	<i>0.21</i>	<i>0.31</i>	<i>0.11</i>	<i>0.16</i>	<i>0.19</i>	<i>0.02</i>

1. What is the entropy of the source?
2. Construct the Huffman codes for the above system.

3. Compute the average bits per pixel.
4. What is the efficiency of your codes?
5. Encode the message RDEDEDESDESXXXX using the Huffman codes.

6. Encode the above message using LZW algorithm. Consider here that the code of R is 0, E is 1, D is 2, S is 3, O is 4, and X is 5.

Exercise VI [9 pts]

Consider a 30-fps camera with frame resolution of 1920x1080, and a 24 bits per pixel colour density, 4x4 macroblock size, and search parameter $k=16$. The camera uses GOPs of size 15-frames each composed of one I-frame and 14 P-frames. Given that MAD is used to compute the block similarity and that it takes 0.5 microsecond to perform 1 MAD, how much time (in seconds) does the motion compensation step takes for each 1-second of video if:

1. A brute force method is used?

2. A logarithmic search is employed?

3. A 3-levels hierarchical search is employed?

