CS 3570 Introduction to Multimedia Technology
Midterm Examination (5/11/2018)
(Totally 8 questions and 117 points on 2 pages)

1. (15 pts) Given a 8-bit grayscale image I(x,y) of size 100X100, assume this image is too dark in overall appearance. (a) Describe how to compute the histogram of the image I. (b) Describe how to brighten this image with a **Gamma** transformation. (c) Briefly describe the procedure of applying error diffusion dithering to reduce the bit depth of image I to 2 bits. Note the mask for error diffusion is given below:

	p	7/16
3/16	5/16	1/16

2. (12 pts) For the color interpolation problem, the Bayer pattern is commonly used in color image acquisition. Assume we acquire the following RGB values in a small patch of an image. Calculate the RGB values of the three bold-face and underlined pixels by using the nearest-neighbor algorithm.

G=100	R=80	G=108	R=90	G=124
B=230	G=120	**B=224 (pixel 2)**	G=140	B=222
G=110	R=86	G=132	**R=88 (pixel 3)**	G=142
B=232	**G=125 (pixel 1)**	B=222	G=138	B=220
G=130	R=90	G=136	R=82	G=140

3. (15 pts) (a)What is the entropy of the 8-by-8 image below, where numbers (0, 20, 50, 99) denote the gray-level intensities with 8-bit representation?
   (b) Show how to construct the Huffman tree to encode the above four intensity values in this image and the resulting code for all these four intensity values.
   (c) What is the average number of bits needed for each pixel, using your Huffman code? How does it compare to the entropy computed in (a)?

99	99	99	99	99	99	99	99
20	20	20	20	20	20	20	20
0	0	0	0	0	0	0	0
0	0	50	50	50	50	0	0
0	0	50	50	50	50	0	0
0	0	50	50	50	50	0	0
0	0	50	50	50	50	0	0
0	0	0	0	0	0	0	0

4. (15 pts) The 2D DCT formula for an M-by-N image f(r,s) is given below:

$$F(u,v) = \sum_{r=0}^{M-1}\sum_{s=0}^{N-1} \frac{2C(u)C(v)}{\sqrt{MN}} f(r,s)\cos\left(\frac{(2r+1)u\pi}{2M}\right)\cos\left(\frac{(2s+1)u\pi}{2N}\right)$$

(a) Consider M=N=8, what is the physical meaning of the value F(u,v)? What is the basis function corresponding to the coefficient F(u,v)?

(b) How are the DCT coefficients processed in JPEG compression? How is the JPEG image compression ratio/quality adjusted?

(c) What are the two main sources of error in JPEG compression?

5. (15 pts) Given a discrete audio signal f(i), i=0, …, 1023, we would like to filter the audio signal with an N-th order FIR filter h(n), n=0, …, N-1. (a) Describe how to filter the audio signal with the FIR filter [h(0), h(1), …, h(N-1)] in temporal domain. Give the specific filtering operation. Discuss the computational cost required in the above filtering operation. (b) Plot the transfer function for an ideal low-pass filter. What is the main parameter in the low-pass filter? (c) Design a low-pass FIR filter based on the impulse response of an ideal low-pass filter to substitute the FIR filter h.

6. (15 pts) Consider video compression in the MPEG standard. Assume a video is compressed with the GOP sequence: IBBBPBBBPBBBI. Assume we apply full-search motion estimation for MPEG video compression. Consider each frame is of size 640-by-480 and the size of a macroblock is 8X8. (a) Give a pseudo code for finding the block motion vector for a target image block T(x,y) of size 8X8 (P frame) from the reference frame R(i,j) with the search range within [-15, 15] along x and y directions. Use the SAD for the block matching criterion here. (b) Compute how many 8X8 SAD calculations are needed for the motion estimation when compressing an entire B frame here? (c) Discuss the advantages/disadvantages of applying full search and approximate search (such as the 2D logarithm search algorithm).

7. (15 pts) A Bézier curve is a parametric curve described by polynomials based on a sequence of control points. Consider a cubic Bézier curve determined by four ordered control points (p_0, p_1, p_2, p_3).

(a) Give the equation for representing the associated cubic Bézier curve P(t) with these control points and the associated blending functions.

(b) What are the four conditions imposed by the four control points onto the associated cubic Bézier curve? The answer should be specific and clear.

(c) Try to justify that the Bézier curve P(t) satisfies the four conditions given in (b).

8. (15pts) In the image rendering of 3D models, it involves geometric projection and photometric rendering.

(a) Briefly describe what the geometric transformations between different coordinate systems are involved here.

(b) For the photometric rendering, give the formula of diffuse reflection and clearly explain the notation used in the formula.

(c) Discuss the main difference (property) between the diffuse and specular reflection models.