CS 3570 Introduction to Multimedia Technology
Midterm Examination (5/6/2011)
(Totally 9 questions and 112 points on 2 pages)

1. (10 pts) Briefly describe the characteristics of bitmap, vector graphics, and procedure modeling for image creation. How are these different types of images created?

2. (12 pt) The indexed color has been used to reduce the color bit depth in color image processing. (a) Compare the performance of using uniform partitioning and median-cut algorithms to determine the indexed colors. (b) To reduce the 24-bit color to 8-bit color, how many indexed colors are needed? Once you have the indexed colors, how do you convert the 24-bit color to 8-bit color representation? (c) What quantitative measure (discussed in class) is commonly used to compare the above color quantization results? Give its definition.

3. (10pt) Consider the following set of color-related terms: (a) wavelength, (b) C_b-C_r in YC_bC_r space, (c) brightness, (d) purity. Please match each of the above term to each of the following characteristics: Luminance, (2) Hue, (3) Saturation, (4) Chrominance.

4. (10 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 for the 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**	G=140	B=222
G=110	R=86	G=132	**R=88**	G=142
B=232	**G=125**	B=222	G=138	B=220
G=130	R=90	G=136	R=82	G=140

5. (20 pts) JPEG compresses an image by using several compression techniques, including DCT, predictive coding, chroma subsampling, quantization, entropy coding, run-length coding. (a) Give a flow diagram of using JPEG compression for a 256-by-256 RGB color image. (b) For the 4:2:0 chrominance subsampling used in JPEG, determine how many function calls to the 8-by-8 DCT are required in this problem. Show how you calculate this answer. (c) Discuss the source of image distortion in the lossy JPEG compression. (d) The following normalization matrix (quantization matrix) Z is used for luminance quantization. Describe how it is used in JPEG and why it is designed this way. (e) How do you adjust the compression ratio and image quality in JPEG?

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

6. (20 pt) (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 each intensity value.

   (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)?

   (d) Compute the compression ratio of using the Huffman coding in this example.

   (e) Use the run-length coding to represent the above image. Show the result.

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

7. (10pt) To produce a digital zoom of an N-by-N digital grayscale image f(i, j), $0 \le i, j < N$, we usually apply the backward mapping with an interpolation technique to compute the zoomed image. (a) Give the pseudo code of using nearest-neighbor interpolation to produce a 3-times zoomed image. (b) Give the pseudo code of using bilinear interpolation to produce a 3-times zoomed image.

8. (10pt) In audio encoding, the nonlinear quantization (companding) technique is usually applied. It involves using the mu-law function, denoted by m(x), and inverse mu-law function, denoted by d(x), in the nonlinear quantization process. Assume we want to requantize a 16-bit audio to 8-bit audio by using the companding technique. (a) Please describe the procedure of companding and plot the mu-law function. (b) What is the advantage of using the companding quantization over the uniform quantization? What quantitative measure can be used to show this advantage?

9. (10 pts) Consider an audio signal f(t) given as follows: $f(t) = 10\sin(2000\pi t) + 20\cos(3000\pi t)$. The time t is represented in seconds. (a) What is the minimal sampling frequency that can avoid aliasing for this signal? Give the reason for your answer. (b) Assume the sampling rate is large enough such that there is no aliasing. What is the DFT of the sampled audio signal of 1 second duration? Plot the corresponding Fourier spectrum.