Final Examination: ESE 558 Digital Image Processing
Date: 5/16/2006, Duration: 2 hours, Spring 2006
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You can refer to only the prescribed text books. No other reference materials are allowed. Full credit will be awarded to a correct answer only if all steps are shown.

Part I: Closed-book questions. Max time: 40 minutes

1. *Paper: Image Restoration:* Consider the problem of restoring a defocused image recorded by a camera with a circularly symmetric Point Spread Function (PSF). In this context, answer the following questions.
   (a) (2+2 points) Give expressions for the Weiner filter and the Spatial domain convolution/deconvolution transform (two non-zero terms for a circularly symmetric PSF). Explain all the terms in your expressions and how they are used in image restoration.
   (b) (2 points) Compare the advantages and disadvantages of the two filters.

2. (4 points) State and prove the *Fourier slice theorem* for image reconstruction from parallel projection.

Part II: Open-book

3. (4 points) The Red, Green, and Blue color points of a computer monitor are specified on the CIE Chromaticity diagram (see Figure 6.5 on page 288 in the GW text book) as Red: (0.6,0.2), Green: (0.1,0.7), and Blue: (0.1,0.1). Find the percentages of these three primary colors that need to be combined additively to produce the light-green color specified by the point (0.2,0.5). Solve this problem using either a graphical or an analytical method. Show all steps.

4. *(4 points) Image compression:* In the JPEG sequential baseline system of compression, find the encoding of the following 1-D DCT block. Show all steps for deriving each entry to demonstrate your understanding. Just writing correct answer is not sufficient. Assume that the DC coefficient of the previous block is -20. : `[ -15 -4 0 0 0 5 EOB ]`

5. *(3+2 points) Image compression:*
   (a) The JPEG sequential baseline system of compression was discussed in class and it is also explained in Section 8.6.2, pages 498 to 505, in the GW text book. In the computational algorithm of this compression technique, describe how each of the following three types of data redundancies are reduced– coding, inter-pixel, and psychovisual. You should point out a particular step in the algorithm for each type of redundancy and briefly describe how/why that step reduces that particular redundancy.
   (b) What would happen to the compression performance if DCT is replaced by DFT and why?

6. *(6=4+2 points) Huffman-Shift code:* The probability of occurence of eight symobls s_1 to s_8 are given below.

Symbol	:	s1	s2	s3	s4	s5	s6	s7	s8
Probability:		0.04	0.01	0.25	0.40	0.10	0.06	0.02	0.12

   (a) (4 pts) Derive the best possible Huffman-shift code with a total of 5 symbols including one shift symbol.
   (b)(2 pt) What is the compression rate (percentage) achieved (excluding the Huffman-shift code table)?

7. *(6 points) Image reconstruction:* Find the Radon transform $P_{45deg}(t)$ (projection onto an axis at 45 degrees to the x-axis) of a function whose value is zero everywhere except 1 inside a region bounded by an outer circle and an inner square. Both the circle and the square are centered at the origin. The diameter of the circle is 4 units. The sides of the square are 2 units each in length, and are parallel/perpendicular to the x/y axes.