Final Examination: ESE 558 Digital Image Processing
Date: 5/17/2005, Duration: 2 hours, Spring 2005
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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.

1. *(5=2+3 points) Color Models*
   (a)(2 points) Describe how the human visual system perceives a large number of different colors although, physically, visible light spectrum consists of a much smaller number of pure colors.
   (b) (3 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-pink color specified by the point (0.5,0.2). Solve this problem using either a graphical or an analytical method.

2. *(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 -10.
   `[ -16 -5 0 0 0 4 EOB ]`

3. *(3 points) Image compression*
   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.

4. *(5=4+1 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:	0.01	0.04	0.40	0.30	0.10	0.08	0.02	0.05

   (a) (4 pts) Derive the best possible Huffman-shift code with a total of 5 symbols including one shift symbol.
   (b)(1 pt) What is the compression rate (percentage) achieved (excluding the Huffman-shift code table)?

5. *(6=4+2 points) Image reconstruction*
   (a) (4 points) 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 inside a circle of radius 3 units centered at the origin. Inside this circle, it is 1 everywhere except inside an interior circle of radius 1 centered at (1,1) inside which the value of the function is 0.
   (b) (2 points) Give a flow chart that clearly outlines a computational algorithm for implementing the Filtered Backprojection algorithm for image reconstruction from parallel projection data. Clearly identify the input, output, and the intermediate steps that transform the input to output.