Final Examination: ESE 558 Digital Image Processing
Date: 5/18/2004, Duration: 2 hours, Spring 2004
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You can refer to only the prescribed text books and the journal paper. No other reference materials are allowed. Show all steps to get full credit.

Part I: Closed-book question. Max time: 60 minutes

1. (Total 10 points)
   (a) (2 points) Give an expression for the Weiner filter with a brief description of the terms.
   (b) (2 points) Name any three color models and their areas of application.
   (c) (2 points) Name three types of data redundancy that are exploited in image compression. Briefly explain each of them.
   (d) (2 points) Explain why DCT is preferred over DFT in transform coding?
   (e) (2 points) State the Fourier Slice theorem and explain how it forms the basis of Computer Assisted Tomography (CAT)?

Part II: Open-book

2. *(4 points) Color Models*
   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: (0.2,0.7), and Blue: (0.2,0.1). Find the percentages of these three primary colors that need to be combined additively to produce the greenish-yellow color specified by the point (0.3,0.4). Solve this problem using either a graphical or an analytical method.

3. *(4 points) Image Restoration*
   The point spread function $h(x, y)$ of a misfocused camera with a square aperture is

$$h(x, y) = \frac{1}{16}\text{rect}(x/4, y/4) \tag{1}$$

   where

$$\begin{aligned} \text{rect}(x/4, y/4) &= 1 \text{ for } -2 \leq x, y \leq 2 \text{ pixels} && (2) \\ &= 0 \text{ otherwise.} && (3) \end{aligned}$$

   Give an expression for restoring the blurred image $g(x, y)$ to obtain the focused image $f(x, y)$ using the Spatial-domain convolution/deconvolution transform. Note: Assume that Equation (6) on page 5 in the journal paper is valid. You should derive $h_{2,0}$ and $h_{0,2}$.

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 -8.
`[ -17 4 0 0 0 -3 EOB ]`

5. *(3+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:		0.02	0.10	0.20	0.15	0.25	0.03	0.05	0.15

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

6. *(4 points) Image reconstruction*
Find the Radon transform $P_0(t)$ (projection onto the x-axis) of a function defined as

$$f(x,y) = |x\ y| \text{ for } -\pi/2 \leq x \leq \pi/2, \textit{ and } -Cos(x) \leq y \leq Cos(x) \quad (4)$$
$$= 0 \text{ otherwise.} \quad (5)$$