

Final Examination: ESE 558 Digital Image Processing

Date: 5/20/2003, Duration: 2 hours, Spring 2003

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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: 30 minutes

1. *Paper: Image Restoration*

(4+3 points) 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) 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) Compare the advantages and disadvantages of the two filters.

Part II: Open-book questions

2. *(3+2 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 (0.7,0.2), (0.1,0.8), and (0.2,0.1) respectively. The natural color of a flower has color coordinates (0.1,0.2). This color cannot be displayed by the computer monitor correctly as it lies outside the RGB triangle of the monitor.

(a) Find the coordinates of the color “closest” to that of the flower which can be displayed on the monitor. Use Euclidean distance metric in the CIE diagram space to determine the closest point. You are permitted to use either an analytic approach or a geometric approach, but briefly explain your computational steps.

(b) Find the percentages of R,G, and B, that can be mixed to produce the closest color determined by you. Add brief comments to your computational steps.

3. *(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 -7.

[-29 5 0 0 0 0 -4 EOB]

4. *(4+2 points) Huffman-Shift code*

A 3 bits/pixel gray-level image is compressed by Huffman-shift coding the gray level values. (a) Derive the best possible Huffman-shift code with a total of 5 symbols including one shift symbol. The histogram of the image is given below.

Gray value	:	0	1	2	3	4	5	6	7
Frequency count:		200	1000	2500	3600	1400	800	400	100

(b) What is the compression rate (percentage) achieved (excluding the Huffman-shift code table)?

5. (~~4~~+4 points) *Image reconstruction*

(a) The value of a function $f(x, y)$ is $|y|$ inside a circle of radius R and zero outside. Find the Radon transform $P_0(t)$ of $f(x, y)$ (i.e. find the projection onto the x -axis).

(b) Show that the Radon transform of the PSF of a camera is equal to a Line Spread Function (LSF) of the camera. (Hint: First prove this for the special case of $P_0(t)$ and the LSF corresponding to the line light source along the y axis. Then generalize the result.)