Final Examination: ESE 558 Digital Image Processing

Date: 5/11/99, Duration: 2 hours, Spring 1999
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This test is open-text books (RK and GW). No other reference materials are allowed. In answering the following questions write down all the important steps to get full credit.

1. (3+2 points) Image enhancement
Do Excercise 4.9(a) in the GW text book on page 250 for interior pixels of an image (i.e. ignore operations on pixels near the border of the input image).
(a) In particular, given the sum of products centered at the pixel [i][j] of an image f[i][j], give the program code to obtain the new sum of products at the pixel [i][j+1].
(b) For a 5×5 filter, what is the ratio of the number of multiplication operations with your efficient algorithm to that with the straight-forward algorithm.

2. (3+2 points) Image compression
A 3 bits/pixel 100x100 image is compressed by Huffman-shift coding the gray level values. 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:	100	400	2000	3000	2500	1500	300	200

   (b) What is the total size of the compressed image? (excluding the Huffman-shift code table).

3. (3+2 points) Image compression
In the JPEG sequential baseline system of compression, find the encoding and decoding of the following 1-D DCT blocks. Show all steps for deriving each entry to demonstrate your understanding. For both blocks, the DC coefficient of the previous block is 20.
Encode: [10, 0, 0, -6, EOB]
Decode: [1 0 1 0 0 0 0 1 1 0 0 0 1 0 1 0]

4. *(3+2 points) RK Ch 7 : Image Restoration*
(a) The Line Spread Function of a camera is $l(x) = 1 - |x|$ for $-1 \leq x \leq 1$ and zero otherwise. Find the corresponding Edge Spread Function.
(b)An image $f(x, y)$ moving with uniform velocity V along the x-axis is recorded by a camera with an exposure period T. The power spectrum of the camera noise is $e^{-c(u^2+v^2)}$ where c is a known constant. Give an expression for the Weiner filter to restore this motion blurred image and briefly (a few sentences) list the computational steps involved in applying the filter.

5. *(3+2 points) Ch. 8 Image reconstruction*
(a) The value of a function $f(x, y)$ is y^2 inside a region enclosed by the curves $y = Cosine(\pi x)$ and $y = -Cosine(\pi x)$ in the range $-0.5 \leq x \leq 0.5$ and zero outside. Find the Radon transform $P_0(t)$ of $f(x, y)$ (i.e. find the projection onto the x-axis).
(b) For the Filtered Backprojection algorithm, list the input, output, and the computational steps necessary to transform the input data to output data.