UNIVERSITY OF CALGARY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ENEL697 DIGITAL IMAGE PROCESSING
TEST NO. 1
WINTER 2003 SESSION
3 March 2003

Instructions:

1. This is a closed-book, closed-notes test.
2. The use of only a non-programmable calculator with no text storage facilities is permitted.
3. Answer all five questions.
4. Total marks = 20.
5. Time permitted = 90 minutes.

Question 1: Distinguish between gray-scale dynamic range and simultaneous contrast. Explain the effects of the former on the latter. (2 marks)

Question 2: You are given the test image

$$f(m,n) = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 10 & 10 & 10 & 0 \\ 0 & 10 & 10 & 10 & 0 \\ 0 & 10 & 10 & 10 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}.$$

(a) Compute the horizontal derivative (difference) as given by $g_1(m,n) = f(m,n) - f(m-1,n)$. Assume the image to be zero outside the given array.
(b) Compute the vertical derivative as given by $g_2(m,n) = f(m,n) - f(m,n-1)$.
(c) Compute the result if the two operators in (a) and (b) are applied in series (cascade).
(d) Compute the result if the two operators in (a) and (b) are applied in parallel and their outputs are added.
Give all the results as 5×5 arrays. (4 marks)

Question 3: Draw schematic diagrams of the Fourier magnitude spectra of images with
(a) a circle of radius R;
(b) a circle of radius 2R; and
(c) a circle of radius R/2.
The value of R is not relevant. Explain the differences between the three cases in both the space domain and the frequency domain. (3 marks)

Question 4: (a) Derive the expression for the Fourier transform of $\frac{\partial f(x,y)}{\partial x}$ in terms of the Fourier transform of $f(x,y)$. Show and explain all steps. (Hint: Start with the definition of the inverse Fourier transform.)

Explain the effect of the differentiation operator in the space domain and the frequency domain.

(b) Based upon the result in (a), what is the Fourier transform of $\frac{\partial^2 f(x,y)}{\partial x^2}$? Explain.

(c) Based upon the result in (a), state the relationship between the Fourier transform of $[\frac{\partial f(x,y)}{\partial x}]^2$ and that of $f(x,y)$. State all properties that you use.

(d) Explain the differences between the operators in (a), (b), and (c) and their effects in the both the space domain and the frequency domain.

(8 marks)

Question 5: Compute the result of convolution of the test image in Question 1 with the Laplacian operator

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}.$$

Explain the effect of the operator on the image.

(3 marks)

******