ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION **WINTER SEMESTER, 2021-2022**

DURATION: 3 HOURS **FULL MARKS: 150**

CSE 4733: Digital Image Processing

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer **all 6 (six)** questions. Marks of each question and corresponding CO and PO are written in the right margin with brackets. Symbols have usual meaning taught in class.

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1. a) Suppose you have a gray-scale image, f upon which you have applied morphological opening operation with a structuring, B, and have obtained an output, g. Now you applied another opening operation and obtained h. Differentiate the changes that may be observed between g and h with explanation. — 7 (CO2) (PO2)

   b) Show the validity of the duality expression: — 5 (CO1) (PO1)

$$(A \bullet B)^c = (A^c \circ \hat{B})$$

   c) Suppose your image is suffering from non-uniform illumination problem and your foreground is dark objects against a brighter background. How can you solve this illumination problem? — 5 (CO1) (PO1)

   d) Consider the following binary image shown in Figure 1. Determine the area of each dark object. Assume there are only objects of two sizes only. — 8 (CO1) (PO1)

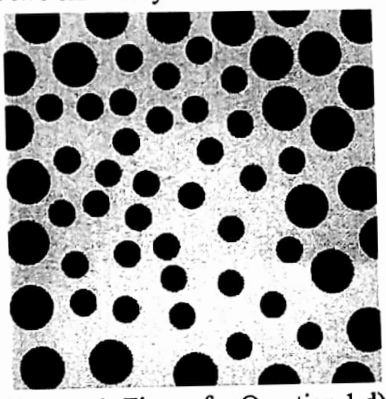

Figure 1: Figure for Question 1.d)

2. a) Mathematically show that can you compute the 2D Fourier Transform by first computing a 1D Fourier transform along the individual rows of an input image, followed by another 1D Fourier transform along the columns of the results from the output of the first transform. — 8 (CO1) (PO1)

   b) Design a filter in the Frequency Domain applying which can give you the output equivalent to applying a high-boost filter in the Spatial Domain. — 7 (CO3) (PO3)

   c) The dc term, $F(0, 0)$ of a DFT is proportional to the average value of its corresponding spatial image, f. Here, DFT is computed using the following equation: — 5+5 (CO2) (PO2)

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \exp[-j2\pi(ux/M + vy/N)]$$

Assume that the image is of size M×N. Suppose that you pad the image with zeros to $P \times Q$ size, where P and Q are greater than M and N, respectively. Let $F_P(0, 0)$ denote the dc term of the DFT of the padded image.

   i. What is the ratio of the average values of the original and padded images?

   ii. Is $F_P(0, 0)$ equal to $F(0, 0)$? Justify your answer.

3. a) Explain why second-order derivative responses are more sensitive than first-order derivatives when detecting zero-crossing? 5 (CO1) (PO1)

b) Find the edges corresponding to the minimum-cost path in the image shown in Figure 2. 10 (CO1) (PO1)

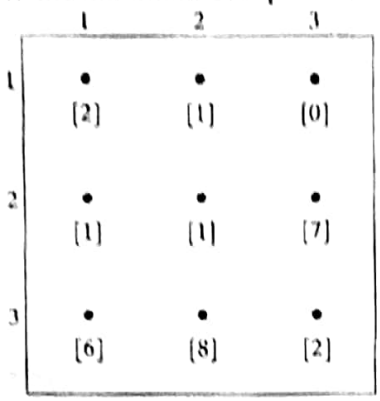

Figure 2: Figure for Question 3. b)

The numbers in brackets are gray levels and the numbers outside the image are spatial coordinates. Assume the edge starts in the first column and ends in the last column.

c) Design a 3×3 filter for performing Laplacian of Gaussian (LoG) in a single pass. Derive first the mathematical expression for the LoG mask. 10 (CO3) (PO3)

4. a) Suppose you have applied a Sobel mask which produces strong responses for horizontal edges but none for vertical edges. Why does this mask also produce weak responses for +45° and -45° oriented edges? 5 (CO1) (PO1)

b) Show that Hough Transform can detect partially occluded circles of fixed radius r. 10 (CO1) (PO1)

c) When considering the $\rho\theta$-parameter space, show that the number of operations required to implement the accumulator cell for Hough Transform is linear in n, the number of foreground points in the image plane (i.e., the xy-plane). 10 (CO1) (PO1)

5. a) Suppose you have applied Global Histogram Equalization (GHE) technique on an 8-bit gray-scale image. What will be average intensity value of the output image? Justify you answer. 10 (CO1) (PO1)

b) Suppose that you filter an image, $f(x,y)$ with a spatial filter mask, $w(x,y)$, using convolution, where the mask is smaller than the image in both spatial directions. Show that, if the coefficients of the mask sum to zero, then the sum of all the elements in the resulting convolution array (filtered image) will also be zero (you may ignore computational inaccuracies). Also, you may assume that the border of the image has been padded with the appropriate number of zeros. 10 (CO1) (PO1)

c) What is an isotropic filter? Show that a Gradient mask can be considered isotropic if only 180° rotations happen (Ignore the sign change effect). 5 (CO1) (PO1)

6. a) Compare between HSI and RGB color models. 10 (CO2) (PO2)

b) What problems will occur if you detect edges in color images using channel-wise gradients? How can you solve this problem? 5+5 (CO1) (PO1)

c) Smoothing a color image in the vector-space using linear filter is equivalent to smoothing the individual color channels – justify this statement. 5 (CO2) (PO2)