B.Sc. Engg. CSE 7th Semester 08 December 2023 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION **WINTER SEMESTER, 2022-2023**

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. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

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1. a) How is Histogram Equalization (HE) adapted for local enhancement? Why can local HE bring out more details than its global enhancement counterpart? 5 + 5 (CO2) (PO2)

   b) Opening or Closing with circular structuring element (SE) produces round corners which were sharp before the morphological operation. Describe when and why these inward and outward sharp corners are rounded. 10 (CO1) (PO1)

   c) Prove the validity of the duality expression: $(A \circ B)^c = (A^c \bullet \hat{B})$ 5 (CO1) (PO1)

2. a) Draw the required transformation function(s) for producing the complements of color images using HSI color space. 6 (CO1) (PO1)

   b) In a 24-bit RGB image, the R, G, and B channels have the horizontal intensity profiles shown in Figure 1. What color would a person see in the middle column ($y = N/2$ position) of this image? Here, the column size of the image is N. 6 (CO1) (PO1)

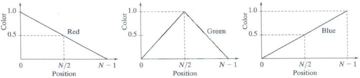

Figure 1: Horizontal intensity profiles for Question 2.b)

   c) A CCD TV camera is used to perform a long-term study by observing the same area 24 hours a day, for 30 days. Digital images are captured and transmitted to a central location every 5 minutes. The illumination of the scene changes from natural daylight to artificial lighting. At no time is the scene without illumination, so it is always possible to obtain an image. Because the range of illumination is such that it is always in the linear operating range of the camera, it is decided not to employ any compensating mechanisms on the camera itself. Rather, it is decided to use image processing techniques to postprocess, and thus normalize, the images to the equivalent of constant illumination. Propose a method to do this. You are at liberty to use any method you wish, but state clearly all the assumptions you made in arriving at your design. 13 (CO3) (PO3)

3. a) Mathematically prove that multiplying an image $f(x, y)$ with $-1^{(x+y)}$ and then applying the Fourier Transform shifts the frequency domain by $(M/2, N/2)$, i.e., 7 (CO1) (PO1)

$$f(x, y)(-1)^{(x+y)} \Leftrightarrow F(u - M/2, v - N/2)$$

Note: Use the term $-1^{(x+y)} = e^{j\pi(x+y)}$

b) A smoothing filter in the Frequency domain has a size of $M \times N$, but its equivalent Spatial domain filter representation has a much smaller size of $m \times n$. Explain why. 10 (CO2) (PO2)

c) In the Frequency domain, design the appropriate filter to remove the following noise: 4 + 4 (CO1) (PO1)

i. Periodic noise

ii. Gaussian noise

4. a) The result obtained by a single pass of 2D mask can be sometimes obtained by two passes of 1D masks, i.e., after the pass of a 1D convolution, another 1D convolution is applied on the first output. These 1D masks can be same or can be different. Determine whether convolution with a 2D Sobel mask can be done with two same/different 1D masks. 7 (CO1) (PO1)

b) For a Laplacian of a Gaussian (LoG) mask $\nabla^2 G(x, y)$, the average of all the filter coefficients is zero. Prove that the average value of any image convolved with this filter is also zero. 8 (CO1) (PO1)

c) The objects and background in the image shown in Figure 2 have a mean intensity of 170 and 60, respectively, on a [0, 255] scale.The image is corrupted by Gaussian noise with 0 mean and a standard deviation of 10 intensity levels. Propose a thresholding method capable of yielding a correct segmentation rate of 90% or higher. (Recall that 99.7% of the area of a Gaussian curve lies in a $\pm 3\sigma$ interval about the mean, where σ is the standard deviation.) 10 (CO3) (PO3)

Figure 2: Corrupted image for Question 4.c)

5. a) Explain why second-order derivative responses are more sensitive than the first-order derivatives while detecting zero-crossing. 5 (CO2) (PO2)

b) Write a Hough Transform (HT) algorithm for counting the number of circular particles (including partially visible, boundary obstructed and merged ones) shown in Figure 3. In case of two particles which have merged with each other, you have to identify each of them and also label them separately. Assume that all particles ideally have a radius of 11 pixels. 10 (CO1) (PO1)

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

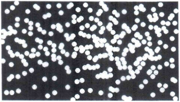

Figure 3: Circular particles for Question 5.b)

6. a) Briefly describe the image degradation/restoration model with the degradation function $h(x, y)$ and additive noise $\eta(x, y)$. 5 (CO1) (PO1)

   b) Consider the two outputs shown in Figure 4, where the left image is a result of using an arithmetic mean filter of size 3×3; the other image is the result of using a geometric mean filter of the same size. $5 + 5$ (CO2) (PO2)

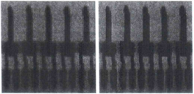

Figure 4: Result of arithmetic mean filler and geometric mean filler for Question 6.b)

   i. Explain why the subimage obtained with geometric mean filtering is less blurred.
   ii. Explain why the black components in the right image are thicker compared to that on the left image.

   c) Consider a Contraharmonic mean filter for removing impulse noise. Answer the followings: 2×5 (CO2) (PO2)
   i. Why the filter is effective in eliminating pepper noise when Q is positive.
   ii. Discuss the behavior of the filter when $Q = -1$ compared to the case when Q is positive.