Department of Electrical Engineering
Indian Institute of Technology Kharagpur

Digital Image Processing (EE60062)

End-Semester Examination **Autumn, 2022-23**

Credits: 4 Full Marks:100 Duration of Examination: 3 hours
Date: 22 November 2022 Time: 2:00 PM – 5:00 PM

Instructions:

1. All questions are compulsory. Marks are indicated in parentheses. This question paper has been cross checked and no errors exist. Detail all steps of your solution.
2. Please write your name, roll number, subject name and code, date and time of examination on the answer script before attempting any solution.
3. Use of only electronic calculators is permitted.
4. No extra resources viz. graph papers, log-tables, trigonometric tables would be required.

Question 1:

Consider that you are provided with the following color image in RGB format

$$I = \begin{bmatrix} (1,2,3) & (3,2,1) & (0,0,1) & (0,1,0) \\ (4,4,4) & (0,0,0) & (1,0,0) & (1,0,1) \\ (7,6,7) & (6,5,7) & (1,3,1) & (3,1,2) \\ (6,7,6) & (7,7,5) & (1,0,1) & (2,1,3) \end{bmatrix}$$

a) What is the size of this image stored in raw format? Note that each of the color channel information is encoded using the same number of bits, each channel has the same dynamic range, and the number of bits to store each channel is not necessarily in multiple of bytes. (4 marks)

b) What would be the raw sensor data reading (I_{raw}) from which this image (I) has been obtained given the CFA arrangement as below (4 marks)

$$CFA = \begin{bmatrix} R & G & R & G \\ G & B & G & B \\ R & G & R & G \\ G & B & G & B \end{bmatrix}$$

c) Convert the image into its grayscale equivalent represented as integers. (2 marks)

Question 2:

a) Segment the grayscale image obtained in Q1(c) into two classes (0 and 1) using iterative threshold selection scheme. Assume darker intensities correspond to 0 and brighter to 1. (5 marks)

b) Segment the RGB image I into two classes (0 and 1) using iterative mean-shift or the k-means clustering technique. Assume darker intensities of color correspond to 0 and brighter to 1. (5 marks)

Question 3:

a) What would be the global histogram equalized version of the image obtained in Q1 (c). Provide all necessary computation details. (7 marks)

b) Compute the mean squared error (MSE) of the histogram equalized version of the image with respect to the original image. (3 marks)

Question 4:

a) Compute the grayscale intensity of the pixel at $k(7,5) = g(1.5, 1.5) =?$ using bilinear interpolation on the following grayscale intensity image (5 marks)

$$G = \begin{bmatrix} 7 & 0 & 1 & 7 & 4 \\ 4 & 0 & 6 & 7 & 2 \\ 2 & 1 & 1 & 4 & 4 \end{bmatrix}$$

b) Compute the response of a 3x3 median filter at the pixel location (2,2) on the grayscale intensity of the image G? Detail all steps involved. (5 marks)

Question 5:

Consider the following binary image A and the structuring element B and compute:

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

(a) $A \ominus B$ (b)$A \oplus B$ (c) A o B (d) $A \bullet B$ (2+2+3+3 marks)

Question 6:

Consider the following 2-bit grayscale image and perform the following:

$$H = \begin{bmatrix} 1 & 2 & 3 & 0 \\ 0 & 1 & 2 & 3 \\ 3 & 0 & 1 & 2 \\ 2 & 3 & 0 & 1 \end{bmatrix}$$

a) Compute the graylevel co-occurrence matrix using a 1pxNE operator? (5 marks)
b) Compute the energy and entropy of the graylevel co-occurrence matrix? (2+3 marks)

Question 7:

Compute the rotation invariant LBP of 1-pixel radius for H mentioned in Q6, only over the valid range of coordinates of H? (10 marks)

Question 8:

On the following image compute the 4-connected and 8-connected edge map of C using a set of suitable morphological operations with the smallest sized operator? (5+5marks)

$$C = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Question 9:

a) Compute the shape signature and the zero-frequency of Fourier shape descriptor for the edge map of C? (3+2marks)
b) Write the cyclic chain code of the edge map of C in 4-connected CCW? (5 marks)

Question 10:

Consider a two lens system camera, such that focal length of the first lens is f_1 and that of the second lens is f_2. If the distance between the two lens is denoted by Δ, the distance of the camera sensor from the object in focus is D and the distance of the object in focus from the first lens is d, then what is the effective magnification factor m for this camera? Please explain all the steps with supporting diagrams, and appropriately introducing any other variables which you may need to solve this problem. (10 marks)