Department of Electrical Engineering
Indian Institute of Technology Kharagpur

Digital Image Processing (EE60062, MM61503)

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

Credits: 4 Full Marks: 70 Duration of Examination: 2 hours
Date: 26 September 2022, Monday Time: 9:00 AM - 11:00 AM

Instructions:

1. All questions are compulsory. Marks are indicated in parentheses. This question paper has been cross checked and no errors exist.
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 a color image sensor with Bayer pattern filter for RGB color sensing. The voltage reading of each sensor element is recorded using an 8-bit ADC, then compute the following:

a) RGB matrix corresponding to this pattern? (9 marks)

$$CFA = \begin{bmatrix} R & G & R \\ G & B & G \\ R & G & R \end{bmatrix}, I_{raw} = \begin{bmatrix} 10 & 5 & 10 \\ 5 & 99 & 5 \\ 10 & 5 & 0 \end{bmatrix}$$

b) Size of the RGB image data after CFA interpolation? (1 mark)

Question 2:

Consider the following RGB color image

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

a) Compute the histogram and the pdf of the color image I? (6 marks)
b) Represent the intensity of I casted as uint8? (2 marks)
c) Compute the histogram and the pdf of the intensity of I casted as uint8? (2 marks)

Question 3:

If we interpolate the image I in **Question 2** above to create another image G following the bilinear interpolation rule such that the pixel $\boldsymbol{g}(2,3) = \boldsymbol{i}(1.7,1.3)$, then find the value of RGB value at $\boldsymbol{g}(2,3)$? Show all the steps in the derivation. Consider that the location (1,1) is on the top-right and rows increase top-bottom and columns increase left-right. (10 marks)

Question 4:

The histogram of a 3-bit grayscale image is $h = \{8,3,2,9,4,1,0,8\}$.

a) Using this information compute the zero-frequency DFT component of the image? Derive and detail the steps involved in the process. (4 marks)
b) What can be the possible sizes of the grayscale image with this histogram? (2 marks)
c) Numerically compute the local maxima and minima points in h? (4 marks)

Question 5:

a) What would be the global histogram equalized version of the following image? Provide all necessary computation details. (7 marks)

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

b) Compute the mean squared error (MSE) of the histogram equalized version of G with respect to G? (3 marks)

Question 6:

a) Derive the Gaussian kernel of size 5×5 with $\sigma = 1$? (5 marks)

b) Laplacian of Gaussian (LoG) is an operation by which the image is filtered by convolution with a Gaussian kernel followed by Laplacian operation on the resultant filtered image f which is defined as $\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$. These operations can be combined such that the resultant is produced by convolution of the image with a LoG kernel. Derive such an LoG kernel of size 5x5 with $\sigma = 1$? (5 marks)

Question 7:

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)