

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

<i>Date</i>	Time 2 Hrs
Autumn Semester, 2023-24	Full Marks: 60
Sub No. CS40019	UG students
	Sub. Image Processing
No. of Students	56

Section A (All questions)

1. Highlight the radiometric factors of image formation at a point by providing the mathematical relationship. 3
2. Provide the expression for City-block distance in 2-D and compute the distance between $(1, 2)$ and $(-3, 4)$. 3
3. State whether the following statements are true or false with justification. 3
 - (a) The saturated colors are at the periphery of the CIE xy chromaticity curve.
 - (b) Any color can be represented as a linear mixing of three primary colors.
 - (c) It is possible to display any color as superposition of three primary colors.
4. Given the value of pixel in CMY space as $(128, 94, 211)$. What will be the representation in RGB space assuming 24-bit representation of a color pixel (8-bit for each color plane)? 2
5. How distance transform is used to perform Medial Axis Transform of binary images. 3
6. For removing unwanted structures in a binary image what morphological operations you need to carry out. State with justification. 3
7. What are the mathematical properties that a pixel mapping function should have for its application to contrast enhancement. 3

Section B (Any two)

8. Consider an image of size 4×4 represented in the form of a 2-D matrix A . The coordinates of pixels of the image are given by respective row and column numbers of the matrix. The row index of the first row starts with 1 and similarly the column index also starts from 1.

$$A = \begin{bmatrix} 50 & 50 & 51 & 50 \\ 52 & 58 & 56 & 70 \\ 53 & 50 & 60 & 65 \\ 50 & 54 & 64 & 68 \end{bmatrix}$$

Answer the following:

- (a) Write the histogram stretching function so that the dynamic range of the image becomes from 0 to 255. Compute the mapped pixel value at $A(2, 2)$. 4+2
 - (b) Estimate the horizontal and vertical gradient values using the Sobel operator. 3+3
 - (c) Considering a flat structuring element of a disk of 4-Neighbor distance of radius 1. Compute the processed value at $A(3, 2)$ after performing gray scale morphological opening operation with the structuring element. 8
9. Consider a bilevel image of size 8×8 represented in the form of a 2-D matrix B . The coordinates of pixels of the image are given by respective row and column numbers of the matrix. The row index of the first row starts with 1 and similarly the column index also starts from 1. The object points are denoted by 1 and the background points by 0.

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

Answer the following:

- (a) Consider the object points are 4-connected. Explain why background pixels require to be 8-connected for satisfying the condition of Jordan's curve theorem in the discrete grid. 6
 - (b) Suppose it is required to eliminate structures of width less than 3. What morphological operations are required to be carried out for that purpose? 6
 - (c) Give an example of a 8-connected shortest path from $B(3,3)$ to $B(7,6)$. State how many shortest paths are possible with justification. 4+4
10. (a) Consider a surface point P in the 3D space is at $(70, 80, 90)$. Given the optical center of the camera is at $(0, 0, 0)$ and the projection plane is at $Z = 10$, compute the coordinates of the projected image point of P . 10
- (b) State the tri-chromacy law of color vision. Explain why this law is applicable for human visual system. 5+5