Indian Institute of Space Science and Technology Trivandrum

I SEMESTER , **2025**

ExamType: EnD Sem Exam

DEPARTMENT OF AVIONICS

Digital Image Processing

(Time allowed: THREE hours)

NOTE: Read all questions first. **There are questions worth 50 marks. Attempt all questions** If something is missing in a problem description, clearly mention your assumptions with your solution. If require, use sketches to illustrate your findings.

1. Explain Huffman Coding. Now, you have given a 5×5 pixel image and respective pixel values (8-bit code for each pixel) below, (5 marks)

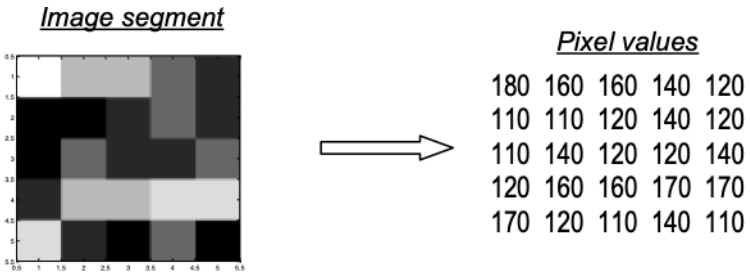

Figure 1: Huffman image compression

(a) Calculate the respective Huffman Codes for each symbol (each pixel value) of the given image,

(b) What is the compression ratio achieved by employing Huffman Coding instead of 8-bit fixed- length coding,

(c) Calculate the relative data redundancy of the given 8-bit image and comment on the type of the redundancy used by Huffman coding,

(d) Calculate the entropy and the bpp(bits per pixel) of the image after Huffman Coding

2. Explain Hough Transform? What are the uses of Hough Transform. How to use Hough transform for detecting circles. (3 marks)

3. Now Suppose that the Hough transform is applied to the image shown in fig.2 for line detection and answer following. {hint:Use inspection method no need to perform full Hough Tansform} (2 marks)

(a) What is the maximum value in the accumulator cells?

(b) What are the corresponding values of (ρ, θ)? As shown, the origin lies at the top left corner.

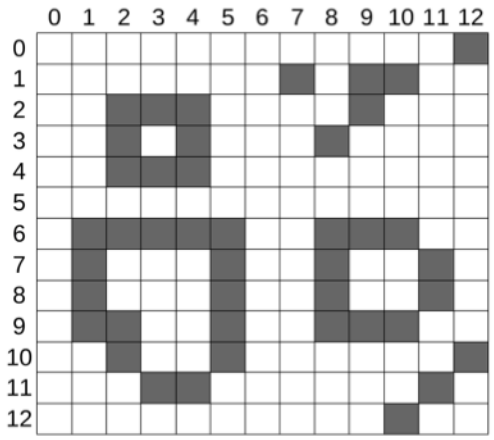

Figure 2: Hough Transform :black and white image

4. The gamma transformation is represented by $s = cr^{\gamma}$, where c and γ are constants. Is this transformation a linear operator? Provide a proof of your answer. What is the use of gamma transformation in image processing. (3 marks)

5. Consider the region A and the structuring elements B, C and D, shown below. Also consider

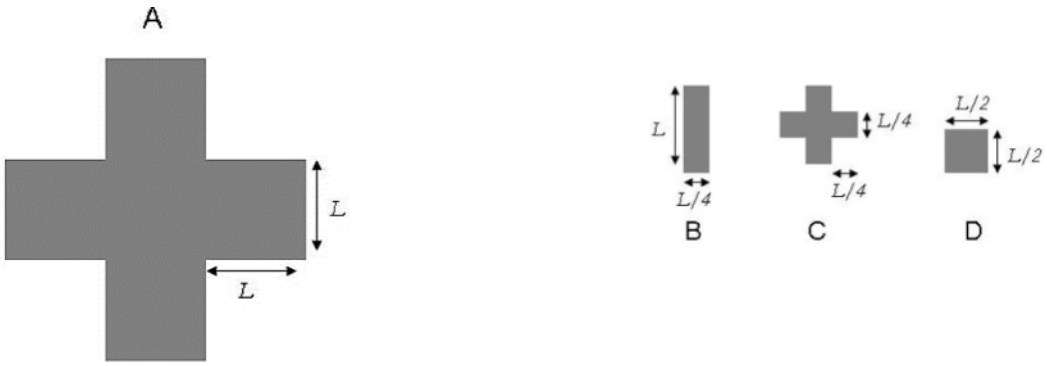

Figure 3: Morphological Operation

the following six regions: E, F, G, H, I and J, shown below: (3 marks)

Now Answer following

(a) The dilation and erosion of A with B would result in which of the following?

(i) E and H
(ii) F and H
(iii) E and J
(iv) F and J

(b) G is the result of:

(i) Erosion with C
(ii) Dilation with C

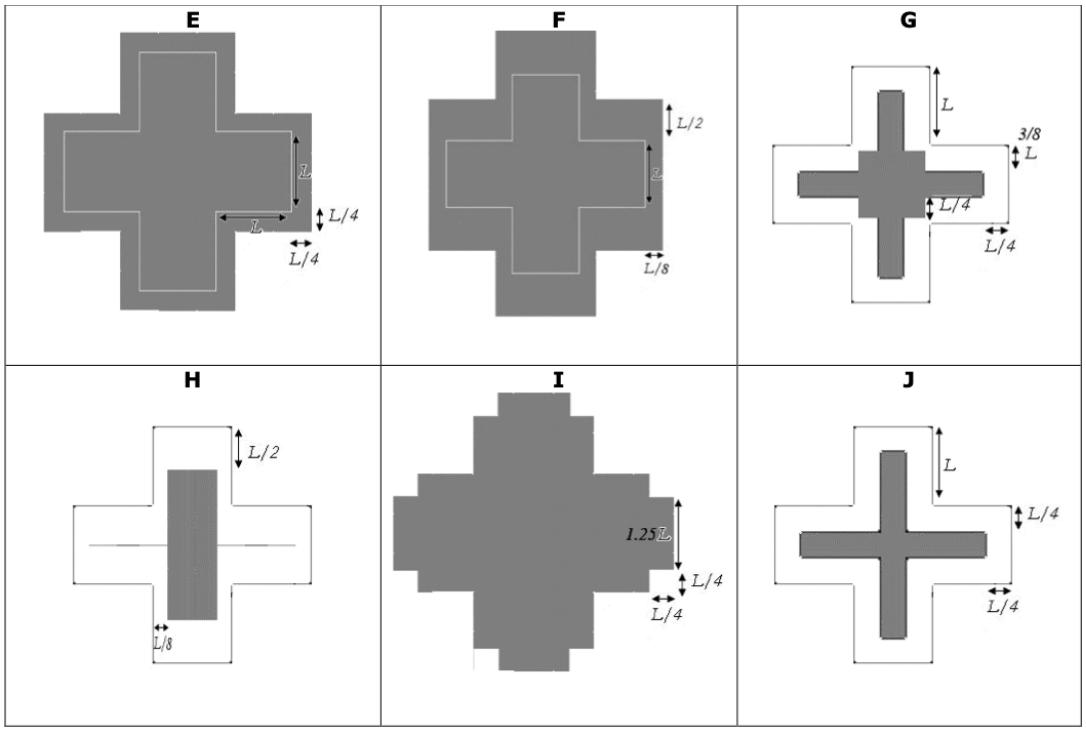

Figure 4: Morphological Operation results

(iii) Erosion with B
(iv) Dilation with D

(c) The dilation of G with C will have a shape similar to:
(i) I
(ii) E
(iii) F
(iv) H

6. Explain Hit and Miss Transfrom. What are the applications of Hit or Miss Transform. (2 marks)

7. Consider an $M \times M$ -pixel gray level image f(x,y) which is zero outside $0 \leq x \leq M-1$ and $0 \leq y \leq M-1$. The image intensity is given by the following relationship

$$f(x,y) = c, x = x1, x = x2, 0 \leq y \leq M-1$$

$$f(x,y) = 0, otherwise$$

where c is a constant value between 0 and 255 and x1 , x2 $x1 \neq x2$ are constant values between 0 and M-1. (5 marks)

(a) Plot the image intensity.
(b) Find the $M \times M$ -point Discrete Fourier Transform (DFT) of f (x, y) .

(c) Compare the original image and its Fourier Transform.

$$Hint : The following result holds : \sum_{k=0}^{N-1} a^x = \frac{1-a^N}{1-a}, |a| \leq 1$$

8. Draw the block diagram for JPEG compression schemes. Explain different modules of JPEG compression. What changes required to be made in JPEG compression for making it a Loss less compression scheme. (5 marks)

9. Explain the Canny edge detection algorithm. What is non-maximum suppression and why is its useful in canny edge detection. (3 marks)

Answer following questions. (2 marks)

(a) The Canny edge detector depends on a:
   (i) Gradient based operator
   (ii) Curvature based operator
   (iii) none of the above

(b) The Canny edge detector removes spurious edges by:
   (i) Hysteresis
   (ii) Non-maxima Suppression
   (iii) Low pass filtering
   (iv) Finding zero crossings

10. Consider the DFT of the two images shown below (2 marks)

Figure 5: DFT

(a) The amplitude plot of these two images are
   (i) Related by a scale factor
   (ii) Related by a shift
   (iii) Identical to each other
   (iv) Flipped

(b) The phase plot of these two images are
   (i) Related by a scale factor
   (ii) Identical to each other

(iii) Related by a shift

(iv) Flipped

11. image segmentation: What is normalised cut? Explain the working of graph based image segmentation scheme. (3 marks)

12. Explain how homomorphic filtering works. What is the reason that we first apply the log() function on the image. (3 marks)

13. Short questions with a very brief reasoning. No marks will be awarded if only True or false answer given. (3 marks)

(a) Arithmetic coding requires knowledge of pixel intensity frequencies.{True or False}

(b) Inverse filtering will yield as good results as Wiener filtering when processing an image which has been degraded by motion blurring only .{True or False}

(c) Median filtering can be implemented efficiently using convolution. {True or False}

14. Histogram of a 3 bit image is shown in the following table

$$Gray\ level = \begin{bmatrix} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{bmatrix}$$

$$number\ of\ pixels = \begin{bmatrix} 2 & 3 & 2 & 1 & 2 & 3 & 2 & 1 \end{bmatrix}$$

Find optimal threshold using Otsu. (3 marks)

15. Let f(x,y) denote the following constant 4×4 digital image that is zero outside $0 \leq x \leq 3, 0 \leq y \leq 3$, with r a constant value. (3 marks)

$$\begin{bmatrix} r & r & r & r \\ r & r & r & r \\ r & r & r & r \end{bmatrix}$$

(a) Give the standard Hadamard Transform of f(x,y) without carrying out any mathematical manipulations.

(b) Comment on the energy compaction property of the standard Hadamard Transform.