Date of Examination: 14 November 2024

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
Department: Computer Science and Engineering
Program: Bachelor of Science in Computer Science and Engineering
Semester Final Examination: Fall 2023
Year: 4th Semester: 2nd
Course Number: CSE 4227
Course Name: Digital Image Processing

Time: 3 (Three) hours **Full Marks: 70**

Instruction: *Answer all the questions. Marks allotted are indicated in the right margin.*

Question 1. Answer any four questions. **[Marks: 4x4=16]**

a) What is the histogram of an image? Can you reconstruct the image from the histogram? How does the histogram differ for the dark, bright, low contrast, or high contrast image? [1+1+2]

b) Write short notes on Negative transformation and Intensity level slicing. [2+2]

c) Draw the RGB color cube using the Cartesian coordinate system. How are different colors and gray scales formed in the RGB color model? [2+2]

d) Why do we need image compression? How many types of data redundancies are there in an image? Give a brief description of each. [1+1+2]

e) Write down the types of image segmentation based on two basis properties of intensity values. How many steps are in Canny Edge detection algorithm and what are the steps? [1+1+2]

Question 2. Answer any four questions. **[Marks: 4x6=24]**

a) Consider the following *Qubits.png* is a 4x4 image segment with 5-bit gray values. [1+1+3+1]

16	30	10	18
25	1	0	12
16	13	9	5
19	14	28	0

i. Calculate the histogram of *Qubits.png*.
ii. Compute and sketch the normalized histogram of the image.
iii. Compute and sketch the equalized histogram of the image.
iv. Sketch the equalization transformation curve.

b) Consider the following image segment *aust.png*. There are some random occurrences of 0 and 255 pixels in aust.png. Now, answer the following questions. Use zero padding to handle boundaries. [1+3+2]

0	12	0	0	23	0
255	145	200	110	17	0
255	160	90	250	15	0
0	255	130	185	15	0
15	20	20	21	21	0

i. Which noise affects the *aust.png*?

ii. Apply the following filters at point (1,1)
- 3x3 Mean filter
- 3x3 Median filter

iii. Is it possible to remove the noise of *aust.png* by applying only the Max or Min filter to the image? Justify, your answers.

c) i. Suppose an image [1,4,3,2,3,4,2,4,5] of 3x3 of 3 bits is compressed by a lossy compression technique; after de-compression, all the pixel values increase by 2. Calculate the Root Mean Square Error as fidelity criteria. [2+4]

ii. Compute the Golomb code for G4(9).

d) Consider the following image A and structuring element B: [1+1+2+2]

0	0	0	0	0	1
0	0	1	1	1	0
0	1	1	1	1	0
0	1	1	1	0	0
1	0	0	0	0	0

A

1
1
1

B

Compute the following:

i. Reflection of B ii. A dilated by B iii. A^c eroded by B

iv. Opening of A by B (and also write the process with mathematical equation)

e) Apply Morphological Hit and Miss transformation to detect any corner from an image. [3+3]

i. Design your four structuring elements for detecting four different corners and explain the process.

ii. Applying your SEs extract all the corners of the Image A. Show your output for each SE and the combined final output.

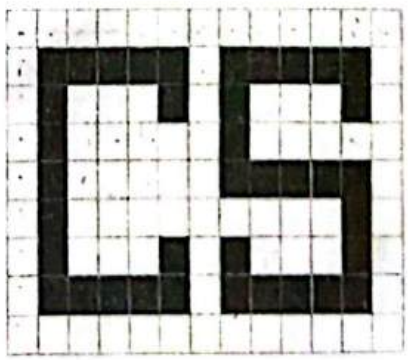


Image A

Question 3. Answer any three questions. **[Marks: 3x10=30]**

a) The Canny edge detector has 5 separate steps. Consider the given 3x3 matrix below which contains the results of the first two steps – Smoothing and Finding gradient magnitude and directions. [5+2+3]

200 ↓	40 ↓	57 ↙
10 →	20 ↑	101 ←
50 ↑	41 ↑	74 ←

i. Complete the remaining 3 steps to detect the actual edges from the given matrix when the high threshold is 100 and the low threshold is 45.

ii. Also, identify if there are any false positive or false negative edges.

iii. What would happen if we chose high threshold 245 and low threshold 10? Explain briefly.

b) i. Suppose, you are working with an image from an automated coin counting system. The coins appear as circular blobs, but some coins are touching each other. What morphological operations would you apply to ensure that the touching coins are separated for accurate counting? Explain why. [5+5]

ii. Consider the following image (Fig.2). Suppose, you are analyzing microscopic images of particles within a container. The goal is to remove small, insignificant particles while keeping only the larger, more relevant ones. The image on the left represents the original image with small particles, and the one on the right shows the desired result after processing. Which morphological operations would you use to remove the smaller particles while preserving the larger ones? Explain briefly mathematically with its applications.

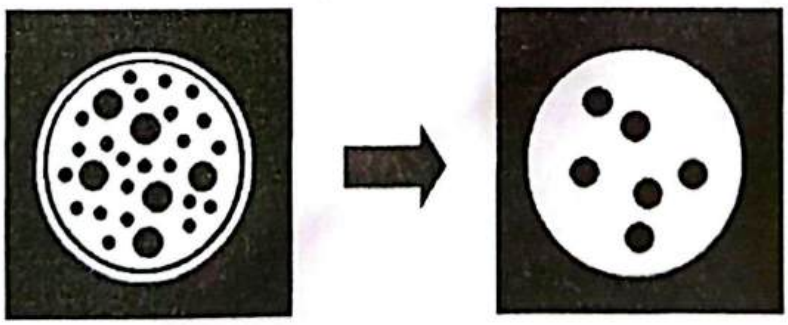


Fig.2

c) Suppose, you want to compress a collection of bitmap images that contain a lot of repeating colors and patterns. For this purpose, you choose the Lempel-Ziv-Welch (LZW) fixed-length coding algorithm. Now, encode the simple 4×4, 8-bit image 2-D array as given on the right and show your step-by-step LZW encoding process. To generate your codebook, use 9 bits. [10]

5	8	40	120
5	8	40	120
5	8	40	120
5	8	40	120

d) Consider the 4x4 image segment {100,105,107,100; 120,125,120,130; 115,117,112,118; 130,140,145,151} of 8-bit have intensity range of [100-151]. Illustrate the output image after contrast stretching it in a new range of [0-255] using s=T(r) where s is the output intensity and r is the input intensity. [5+5]

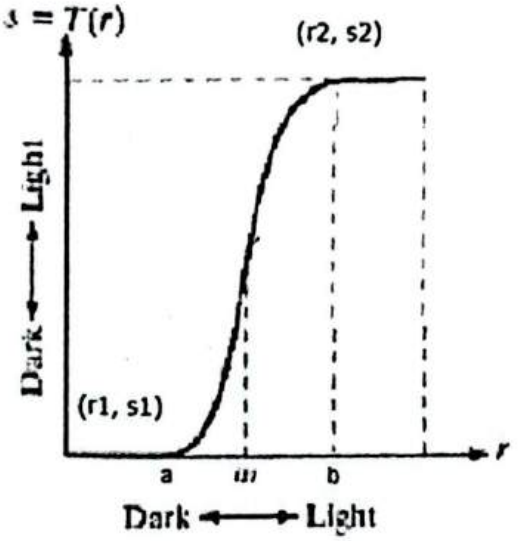


Fig.3

Now consider the contrast stretching graph (Fig.3) where intensity at a=90, b=180, and m=100. Apply this graph to your stretched image considering the following considerations:

- If r is above 180, it becomes 255 in s.
- If r is below 90, it becomes 0,
- If r is between 90, 180, T applies as follows:
  when r < 100, s close to zero (darker)
  when r > 100, s close to 255 (brighter).

Show your final output image.

Good Luck!!!

Date of Examination: 06 March 2024

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Spring 2023

Year: 4th **Semester: 2nd**

Course Number: CSE 4227

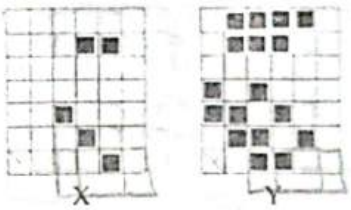
Course Name: Digital Image Processing

Time: 3 (Three) hours **Full Marks: 70**

Instruction: *Question no 1 is mandatory for all. Marks allotted are indicated in the right margin.*

Question 1. Answer all the questions. **[Marks: 9x2=18]**

a) Consider images X and Y as shown on the right with the crossing in the left bottom showing their correspondence where black for 1 and white for 0. [3+2+2+2 = 9]



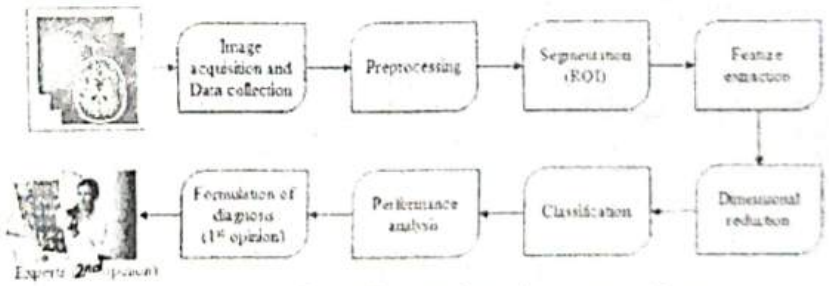
i. To analyze the Morphological basic operation on image X, design an appropriate structure element that image Y can be obtained after dilating image X. Mark the origin of your structure element clearly.

ii. Express the mathematical expression of your dilation process.

iii. Perform the erosion operation on image Y with the same structuring element. Show your eroded image.

iv. Explain the erosion operation mathematically.

b) [2+2+3+2 = 9]



Above figure shows a process flow of tumor detection system. Suppose, you are working on this brain tumor detection from some medical scans image datasets.

i. What method can be applied to remove the noise from scan images in the preprocessing step?

ii. What method can be applied to partition pixels depending on their intensity values in above preprocessing step?

iii. Explain which transformation function can be applied to highlight specific ranges of pixel values in your scans images of tumor detection.

iv. What segmentation method can be applied to group the similar pixels?

Question 2. Answer any *Four (4)* questions **[Marks: 5x4=20]**

a) How many types of data redundancies are there in an image? Give brief description of each. How to calculate the percentage of redundant data after performing the compression technique? [1+1+3 =5]

b) What is histogram of an image? Write the four basic intensity characteristics of image and their corresponding histograms. [1+2+2 =5]

c) What is Chain Code? For the following boundary (in counterclockwise direction) compute the chain code that is invariant to starting point. [1+4 =5]

d) The locations of two points A(r1, s1) and B(r2, s2) control the shape of transformation function in Piecewise Linear Transformation. Now illustrate the relation between (r1,s1) and (r2,s2) for Linear Identity, Thresholding and Contrast Stretching functions. [1+2+2 =5]

e) Consider the following 5x4 image [9, 34, 20, 0, 16, 21, 50, 5, 5, 6, 11, 15, 7, 8, 10, 2, 8, 7, 9, 0] where V = {10, 20, 9, 7, 0, 5, 1, 3}. Answer the following questions: [2+3 =5]

i. Does any 8-path exist between 9th and 19th pixels? Explain your answer.
ii. Find out their City Block, Chess Board, Euclidean Distances.

f) i. What is the objective of sharpening spatial filters? [2+3 =5]
ii. If we convolve an image with a 3x3 matrix as [0, 0, 0, 0, 0, 1, 0, 0, 0], what would be the relation between the original and modified image?

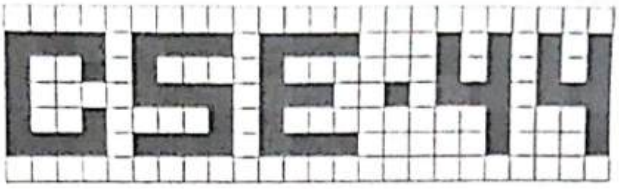
Question 3. Answer any *Four (4)* questions **[Marks: 8x4=32]**

a) Consider the following 4x5, 6 bit image [3, 10, 3, 21, 34, 3, 10, 3, 21, 34, 3, 10, 3, 21, 34, 3, 10, 3, 21, 34] [3+3+2 = 8]

i. Compress the image using Huffman Coding. Calculate Compression Ratio.
ii. How many data was redundant in the input image? Have you lost any data after your compression process?
iii. A 512 X 512 8-bit image with 5.3 bits/pixel entropy is to be Huffman Coding. What is the maximum compression that can be expected?

b) Consider the 4X4 image with 4-bit gray values [1,2,4,7,2,1,3,1,5,2,1,4] [3+3+2 =8]

i. Compute and sketch the histogram and normalized histogram of the image.
ii. Compute and sketch the equalized histogram of the image.
iii. Sketch the equalized histogram transformation function.

c)  [1+4+2+1 =8]

i. Which morphological technique can be used to locate all ends points from above image?

ii. Design four structuring elements (SEs) for detecting four different ends points from any image.

iii. Extract all ends points from the above image using your SEs and explain the process.

iv. How many ends points will be detected in your final output image?

d) i. Apply the Cartesian coordinate system to draw the schematic of the RGB color cube. [3+3+2 =8]

ii. How different colors and gray scale formed in RGB color model?

iii. How many colors can be in a standard RGB image?

e) i. Apply the Canny Edge Detection algorithm to extract the edges from an input image $f(x,y)$ of mxn and draw the schematic diagram of the whole process to get the output image $g(x,y)$. [3+3+2 =8]

ii. Explain the step non-maxima suppression $g_n(x,y)$ OR Hysteresis Thresholding $g_{nH}(x,y)$ & $g_{nl}(x,y)$ of your canny edge detection algorithm.

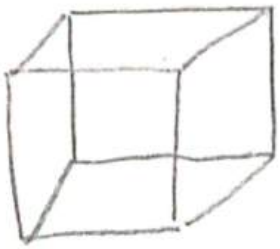
iii. Draw four line detection masks to extract the line of specified four directions, horizontal, +45 degree, vertical and -45 degree respectfully.

f) i. Suppose you have a 3x3 image with values as [2, 5, 8, 5, 1, 3, 4, 7, 2]. How can you smooth this image using an average filter of size 3x3 and zero padding? Show your filtered output image with detailed calculations. [3+3+2 =8]

ii. Obtain the output image by applying a 3x3 Median filter on a 4x4 image with values [0, 2, 1, 0, 5, 2, 3, 8, 0, 1, 3, 4, 3, 0, 7, 2]. Ignore the border pixels during calculations and put zero in the border of the output image.

iii. Derive a positive Laplacian filter mask to enhance an image in a single filtering operation.

Best of Luck!!!



Date of Examination: **25 September 2023**

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Fall 2022

Year: 4th **Semester: 2nd**

Course Number: CSE 4227

Course Name: Digital Image Processing

Time: 3 (Three) hours **Full Marks: 70**

Instruction: *There are two parts, PART A and PART B. Use different script for different part.* ***Question no 1 of PART A is mandatory for all****. Marks allotted are indicated in the right margin.*

PART A

Question 1. Answer all the questions. **[Marks: 9x2=18]**

a) i. Explain how you can smooth an image. If you subtract your smoothed image from the original image, what will happen if you add the subtracted result back to the original image? [3+6]

ii. Suppose, you and your batch mates of *Integer 43* took group selfies during the farewell event, but some of the selfies suffer from salt-and-pepper noise that affects the overall image quality. Apply the de-noising process and explain which filtering is most effective to these group selfies to create clean and clear images that capture the joy of the moment? Describe how this filtering enhances the aesthetics of group photographs and contributes to fond memories.

b) i. Suppose, you are working on tumor detection from some medical scans images. Explain which transformation function can be applied to highlight specific ranges of pixel values in medical scans of tumor detection. [3+6]

ii. The locations of two points (r1, s1) and (r2, s2) control the shape of transformation function in Piecewise Linear Transformation. Now illustrate the relation between (r1,s1) and (r2,s2) for Linear Identity, Thresholding and Contrast Stretching functions.

Question 2. Answer any *TWO (2)* questions **[Marks: 5x2=10]**

a) What do you understand by image compression? Why do we need image compression? How can image compression be implemented? Explain briefly. [1+1+3]

b) What is histogram of an image? Describe how the histogram differs for the dark, bright, low contrast or high contrast image of the same scene. Write the steps of histogram equalization algorithm [1+2+2]

c) What is Structuring Element? What are the effects of Erosion and Dilation operation? Explain briefly with applications. [1+2+2]

Question 3. Answer any *TWO (2)* questions **[Marks: 8x2=16]**

a) Consider the following 4x5, 6 bit image. [3+3+2]

3	10	3	24	35
3	10	10	24	3
3	10	10	24	35
3	10	10	24	35

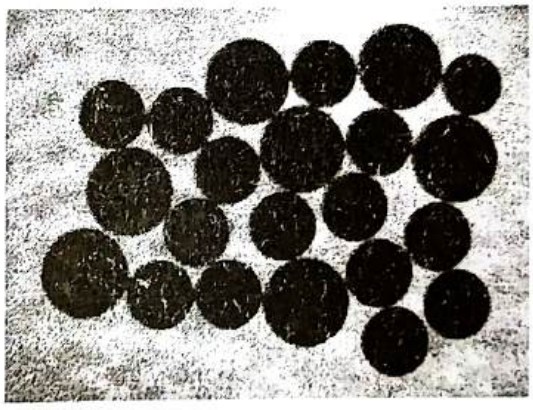
i. Compress the image using Huffman Coding.
ii. Compress the image using Run Length Coding.
iii. Calculate Compression Ratio for (ii) and (iii).

b) Consider the histogram of an image shown in the following table. [2+4+1+1]

Gray levels(r)	0	1	2	3	4	5	6	7
No of pixels	790	1023	850	656	329	245	122	81

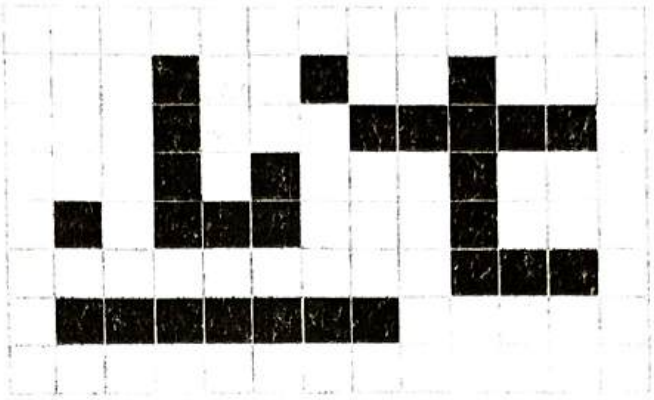
i. Compute and sketch the normalized histogram for it.
ii. Compute and sketch the equalize histogram for it.
iii. Show the mapping of the new gray level values into number of pixels.
iv. Plot the curve of transformation function of (ii).

c) Consider the following image. [4+2+2]



i. Which morphological operation can be used to count the number of coins? Explain briefly your process.
ii. Design Hit-or-Miss transformation SEs for locating 4-connected endpoints of an image.

iii. Locate all the 4-connected endpoints of the following image using SEs obtained from the previous question ii and draw each result with the combined one.



PART B

Question 4. Answer any *TWO (2)* questions **[Marks: 5x2=10]**

a) Write down the types of image segmentation based on two basis properties of intensity values. Explain three main criteria of Canny edge detection algorithm. [2+3]

b) Define Sampling and Quantization. If we want to represent 512 intensities of grayscale, how many bits do we need? Suppose, you have an image named *Integer.png* of size 7x5. What is the Spatial Resolution and Bit Size of *Integer.png*? [2+1+2]

c) Draw the RGB color model. How are different colors formed in RGB color cube? Explain briefly with figure. [1+4]

Question 5. Answer any *TWO (2)* questions **[Marks: 8x2=16]**

a) Derive the limitation in the parameter space of Hough transform algorithm. Consider the following 7x7 image and use Region Growing algorithm to segment the object. The seed for the object is at the center of the image. Region is grown in horizontal, vertical and diagonal direction when the difference between two pixel values is less than or equal to 4. Also apply Region Splitting and Merging algorithm to segment the object from the given image considering T <= 5. [1+2+5]

15	15	15	15	15	15	15
15	15	15	68	69	15	15
64	64	63	67	70	68	15
15	15	70	**65**	61	71	66
15	15	69	73	58	15	15
15	15	15	15	15	15	15
15	15	15	15	15	15	15

b) How Image Restoration is different from Image Enhancement? Consider the following images Fig6(a) and Fig6(b). Fig6(a) represents an image with noise and Fig6(b) represents the histogram of that noisy image. Which noise effects the image? Explain how do you restore the image mentioning the name of the filter you will apply for it. [2+1+5]

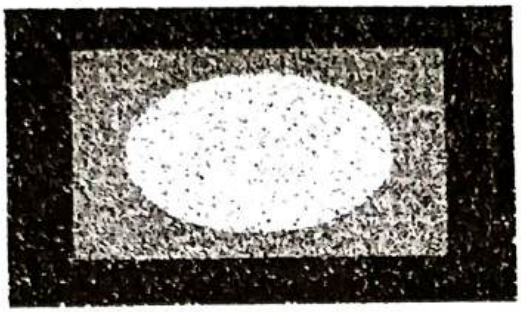


Fig6(a): Image with noise

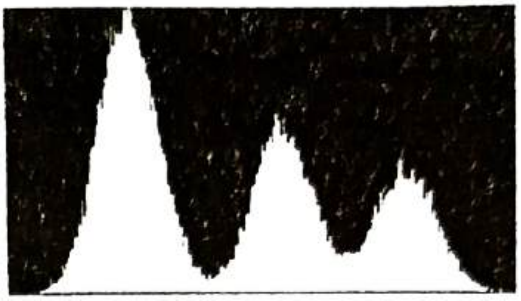


Fig6(b): Histogram of image with noise

c) Explain the HSI color model with appropriate example. What are the differences between additive and subtractive color? How does the combination of cyan, magenta, and yellow pigments create different colors? Explain with examples. [3+2+3]

Best of Luck!!!

Date of Examination: 29 March 2023

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Spring 2022

Year: 4th **Semester: 2nd**

Course Number: CSE 4227

Course Name: Digital Image Processing

Time: 3 (Three) hours **Full Marks: 70**

Instruction: *There are seven (7) questions. **Question#1 is mandatory to answer.** Answer any **other four (4)** questions out of six (6) from question#2 to question#7. Marks allotted are indicated in the right margin.*

Question 1. [Marks: 18]

a) i. Explain with an example how a spatial filter affect an image. [2] [9]

ii. Suppose we have a 3x3 image as [(2, 5, 8), (5, 1, 3), (4, 7, 2)]. Now if we apply an average filter on this image of size 3x3 and zero padding is considered, what would be the filtered output image? [4]

iii. Explain why the output of applying a median filter preserves more edge sharpness in compared to that of applying an average filter. [3]

b) Consider the simple 3x3, 8 bit image as [(3,4,7),(3,4,7),(3,4,7)]. Suppose you want to compress the image using a loss less Lempel-Ziv-Welch (LZW) fixed length coding algorithm. [9]

i. Generate your new codebook using 9 bits and illustrate your step by step LZW encoding process for the above image. [5]

ii. What kind of redundancy of image data it reduces in your encoding process? Explain. [2]

iii. Any compression achieved by employing LZW in your above encoding process? Proof it. [2]

Answer any *FOUR (4)* questions from the following:

Question 2. [Marks: 13]

a) The locations of two points (r1, s1) and (r2, s2) control the shape of transformation function in Piecewise Linear Transformation. Now illustrate the relation between (r1,s1) and (r2,s2) for [5]

i. Linear Identity function. [1]

ii. Thresholding function. [2]

iii. Contrast Stretching function. [2]

b) Consider a 4x4 image with 5-bit gray values [(11,10,12,7),(6,8,7,7),(5,6,11,11), (9,9,7,7)]: [8]

i. Calculate the histogram of image. [1]

ii. Compute and sketch the normalized histogram of the image. [2]

iii. Compute and sketch the equalize histogram of the image. [4]

iv. Sketch the transformation curve. [1]

Question 3. [Marks: 13]

a) i. Mention two techniques those made the digital representation of analog world possible. [3] [5]

ii. "The more intensity level used, the finer level of detail discernible in an image"- explain why? [2]

b) Consider the image below with V = {0, 1, 2, 4} and answer the followings: [8]

	0	1	2	3	
0	1	4	3	4	r
1	2	3	4	7	
2	0	5	1	6	
3	3	4	7	1	q

p (0, 0)
r (3, 0)
q (3, 3)

i. What are the properties of Distance Function for Distance Metrics if there are 3 pixels p, q and r? [2]

ii. Calculate the distances: $D_4(p,q)$, $D_4(p,r)$, $D_8(p,q)$ and $D_e(p,q)$. [2]

iii. Define the terms $N_4(p)$, $N_D(p)$ and $N_8(p)$ of above image. [1.5]

iv. Does 4-path exist between p and q? Explain your answer. [1]

v. Does m-path exist between p and q? Explain your answer. [1.5]

Question 4. [Marks: 13]

a) Describe two different morphological basic operations along with mathematical equations. Explain the effects of them and give examples of their applications. [5]

b) Consider the following image F and structuring element B: [8]

0	0	0	0	0	1
0	0	1	1	1	0
0	1	1	1	1	0
0	1	1	1	0	0
1	0	0	0	0	0

F

1
1
1

B

Compute the followings:

i. Reflection of B

ii. F dilated by B

iii. F^c eroded by B

iv. (F dilated by B) – F

v. Opening of F by B (and also write the process with mathematical equation)

vi. Closing of F by B (and also write the process with mathematical equation)

Question 5. [Marks: 13]

a) i. Why image compression is needed? [1] [5]

ii. How many and what types of data redundancies are there in an image? [2]

iii. A 512 X 512 8-bit image with 5.3 bits/pixel entropy is to be Huffman Coding. What is the maximum compression that can be expected? [2]

b) Consider the simple 3x3, 8 bit image [(18,16,16),(11,11,14),(11,14,16)]. Suppose you want to compress the image using Huffman code algorithm. [8]

i. Illustrate your Huffman encoding process for the above image. [3]

ii. Compute the entropy of the above image. [2]

iii. What kind of redundancy of image data it reduces in your encoding process? Is it a loss less compression technique? [1]

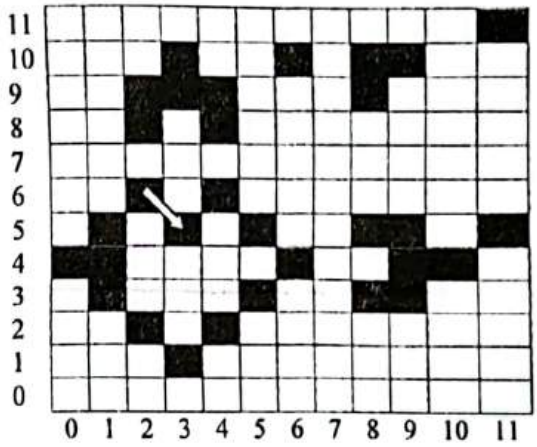
iv. Any compression achieved by employing Huffman coding in your above encoding process? Proof it. [2]

Question 6. [Marks: 13]

a) How many steps are in Canny Edge detection algorithm and what are the steps? Explain any one step of them. What are the false positive and the false negative edge pixels? How canny reduces these errors? [5]

b) i. Suppose we have a 3x3 image with values as [(3, 7, 6), (2, 5, 8), (3, 4, 7)]. Using Sobel operator on the image illustrate the gradient magnitude image. Also, find the edge direction of central pixel. [4] [8]

ii. Consider the following image where each black square denotes a point and the numbers are the coordinates.



Find the Chain Code of the above image that is invariant in starting point and rotation. An arrow marks the reference pixel and the direction. Use 8-neighbor relationship. [4]

Question 7. [Marks: 13]

a) Describe the RGB color model with schematic of RGB color cube. [5]

b) i. Why RGB color model is called ***'Additive'*** where as CMYK is called ***'Subtractive'***? [4] [8]

ii. What is the basic differences between RGB image and Indexed color image? Which representation is preferred in case of storage and transmission? [4]

Date of Examination: 11/10/2022

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Fall 2021

Year: 4th Semester: 2nd

Course Number: CSE4227

Course Name: Digital Image Processing

Time: 3 (Three) hours **Full Marks: 70**

Use separate answer script for each part

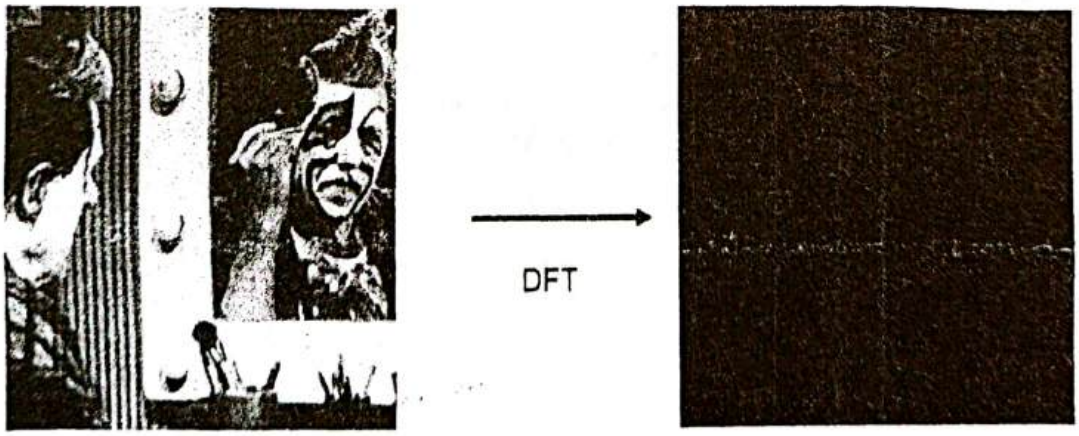
Part A

*[There are 03 (three) questions carrying a total of 14 marks each. **Answer any 02 (two)** questions. Marks allotted are indicated in the right margin.]*

Question 1. [Marks: 14]

a) Suppose you have taken a photo of your grandmother. In that photo, you noticed some wrinkles on your grandmother's skin. You need to reduce the wrinkles from the photo with no ringing effect. Which frequency domain filter will you use? Mention the filter name and justify your answer. Also, define the filter function H(u, v) in the frequency domain with appropriate figures. Besides, describe the reason for the ringing effect. **[8]**

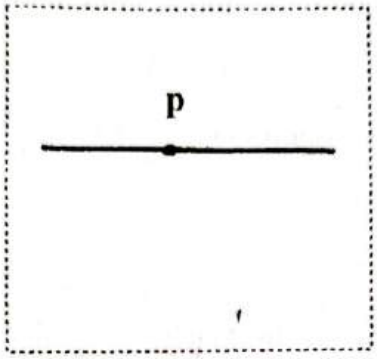
b) Describe the basic steps for filtering in the frequency domain. Explain why the maximum frequency of spatial domain is 0.5. Consider the following image with its DFT. Only DC value is visible in the spectrum. Explain why? Also, discuss the solution of this problem. **[6]**



Question 2. [Marks: 14]

a) What do you understand by image segmentation? How many steps are in Canny Edge Detection Algorithm and what are the steps? Explain the step Non Maximum Suppression. What are the false positive and the false negative edge pixels? How canny algorithm reduces these errors? **[8]**

b) Consider a set of points P(1,4), Q(3,1), R(2,3), S(5,0), T(4,1). Join these points using Hough transform. Is there any problem in the parameter space of the Hough transform algorithm? Justify your answer. Find the value of diameter and the angle from the following line for the point p(20, 25). **[6]**



Question 3. [Marks: 14]

a) Suppose you have bought an inkjet printer recently. Besides, your father has bought a computer for your birthday gift. Describe the color model used in your computer monitor and printer. Among red, green and blue, which light will appear brightest followed by others? Justify your answer. Also, discuss the two major areas of color image processing. **[8]**

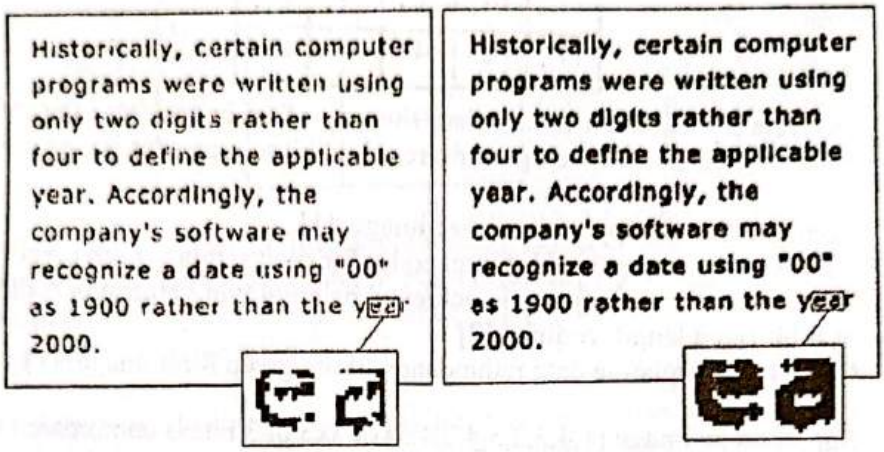
b) Consider, AUST.png is a 256x256 image where the number of gray levels is 64. Calculate the bit depth and size in bytes of AUST.png. Describe Mach Band effect. What do you understand by index image? "The more intensity level used, the finer level of detail discernible in an image"-explain why? **[6]**

Part B

*[There are 04 (four) questions carrying a total of 14 marks each. **Answer any 03 (three)** questions. Marks allotted are indicated in the right margin.]*

Question 1. [Marks: 14]

a) Consider the following image. **[8]**

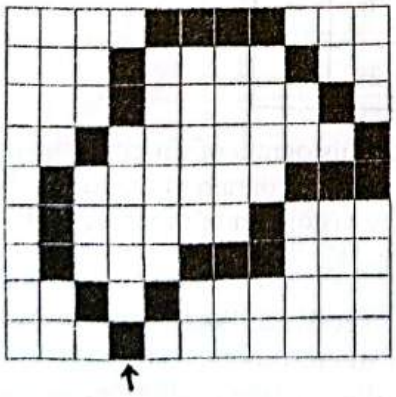


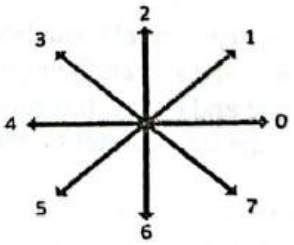
i. Which morphological operation is used to join the broken characters? Explain briefly. [3]

ii. Define Opening and Closing operations mathematically with their applications. [3]

iii. Design four Hit-or-Miss transformation SEs for locating four corners from an image. [2]

b) Consider the following boundary (in anticlockwise direction): **[6]**





i. What is Chain Code? Describe the Problems in Chain Code Representation. [3]

ii. Compute the Chain Code that is invariant to both starting point and rotation. [3]

[Use 8-neighbor relationship]

Question 2. [Marks: 14]

a) Consider the simple 5×5, 8-bit image as in the 2-D array below: [8]

18	16	16	14	12
11	11	12	14	12
11	14	12	12	14
12	16	16	17	17
17	12	11	14	11

i. Derivate the equation to calculate Entropy of an image from the information theory to understand the optimum required bit to represent image information. [2]
ii. Compute the entropy of the above image. [1]
iii. Calculate the respective Huffman codes for each symbol (each pixel value). [2]
iv. What is the compression ratio achieved by employing Huffman coding instead of 8-bit fixed length coding? [2]
v. Calculate the relative data redundancy of the given 8-bit image. [1]

b) i. Supposed an image [1,4,3,2,3,4,2,4,5] of 3x3 of 3 bits is compressed by a lossy compression technique; after de-compression, all the pixel values increased by 2. Calculate the Root Mean Square Error as fidelity criteria. [3] [6]
ii. Compute the Golomb code for $G_4(9)$. [3] → 11001

Question 3. [Marks: 14]

a) Consider Enigma.png is a 4x4 image with 5-bit gray values. [8]

16	30	8	10
25	1	12	0
6	13	9	5
19	14	29	4

i. What is histogram? Calculate the histogram of Enigma.png. [2]
ii. Compute and sketch the normalized histogram of the image. [2]
iii. Compute and sketch the equalize histogram of the image. [3]
iv. Sketch the transformation curve. [1]

b) Contrast Stretching is one type of piecewise linear transformation function. In piecewise linear transformation the locations of points (r1, s1) and (r2, s2) control the shape of transformation function. Now illustrate the relation between (r1,s1) and (r2,s2) for [6]
i. Linear Identity [1]
ii. Thresholding [2]
iii. Contrast Stretching [3]

Question 4. [Marks: 14]

a) The following image shows a 3-bit 4x4 image (left) and a Laplacian filter (right). Now, Find the followings: [8]

	0	1	2	3
0	7	1	0	5
1	6	3	6	2
2	6	4	4	1
3	1	5	7	0

0	1	0
1	-4	1
0	1	0

i. the output of 3x3 mean filter at point (2,2). [2] → 4
ii. the output of 3x3 median filter at point (0,0). [2] → 0
iii. the output of Laplacian filter at point (1,1). [2] → 5, 2

[Use zero padding for edge pixels]

iv. Explain why the output of applying a median filter preserves more edge sharpness in compared to that of applying a mean filter. [2]

b) Consider the two image subsets S1 and S2 and answer the following questions based on these two image subsets. [6]

S1					S2				
0	0	0	3	2	2	1(y)	2	1	2
0	1	0	2	1	1	1	2	2	0
0	0	0	1	1	1	0	2	3	2
0	0	1(x)	0	0	2	2	3	2	2
0	0	1	1	1	0	0	1	1	1

i. Draw a digital path from S1 or S2 and explain? [2]
ii. Does a four path exist between (x) and (y) for V = {1, 2}? [1]
iii. Do four path and m-path exists between (x) and (y) for V = {1, 0}? [2]
[If your answer is yes, draw the path. If no, explain why.]

iv. Determine whether S1 and S2 are 4-adjacent for V={1,2}? [1]

Date of Examination: 12/04/2022

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering

Program: Bachelor of Science in Computer Science and Engineering

Semester Final Examination: Spring 2021

Year: 4th **Semester: 2nd**

Course Number: CSE4227

Course Name: Digital Image Processing

Time: 3 (Three) hours **Full Marks: 70**

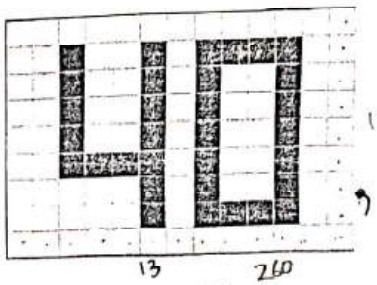
Instruction: *There are seven questions carrying a total of 14 marks each. Answer any five questions. Marks allotted are indicated in the right margin.*

Question 1. [Marks: 14]

a) What is histogram of an image? Describe the histogram equalization algorithm. Consider {(9, 9, 7, 7), (5, 6, 11, 11), (6, 8, 7, 7), (11, 10, 12, 7)} is a 4X4 image with 4-bit gray values. Compute and sketch the equalize histogram of it. [8]

b) Consider Recursive_40.bmp is a 180 × 260 binary image. [6]

i. Calculate the histogram of Recursive_40.bmp.
ii. Calculate the bit size of Recursive_40.bmp.
iii. Describe how the histogram differ for the dark, bright, low contrast or high contrast image of the same scene.



Recursive_40.bmp

Question 2. [Marks: 14]

a) What is Edge? How many steps are there in Canny Edge Detection Algorithm and what are the steps? Explain the step Non Maximum Suppression. What are the false positive and the false negative edge pixels? How does canny reduce these errors? [8]

b) What is region based Segmentation? Explain two techniques of image segmentation: **Region Growing** and **Region Splitting & Merging,** with examples. [6]

Question 3. [Marks: 14]

a) [8]

i. Define the average filter. How does it affect an image?
ii. What can be removed by using smoothing filter?
iii. Suppose we have a 3x3 image with values as [2, 5, 8, 5, 1, 3, 4, 7, 2]. Now if we apply average filter on this image of size 3x3 and zero padding is used, what would be the value of the filtered image?
iv. Suppose we have an image that has salt-and-pepper noise. Which filtering technique will be the best choice to denoising this image? Explain how it works.

b) What is an image gradient operator? Suppose we have a 5x5 image with values as [(3, 7, 6, 2, 0), (2, 5, 8, 5, 1), (3, 4, 7, 2, 4), (1, 4, 3, 4, 2), (3, 7, 4, 5, 2)]. Now if we apply a Sobel operator on the point (3,3) of the image what will be the gradient magnitude of point (3,3) and the gradient direction? Find the edge direction on the same point. [6]

Question 4. [Marks: 14]

a) Define the Power Law intensity transformation function that enhance an image. What is gamma Correction? For a given image using power law transformation function, what will be the effect on output image: [8]

i. if $\gamma > 1$?
ii. if $\gamma < 1$? and
iii. if $\gamma = 1$?

Suppose, you have made a software which performs intensity transformation of a given image using power law transformation. In default setting, it uses $\gamma = 2.5$.

iv. Now if a user changes $\gamma = 5.0$, what will be the effect on the output image?
v. Repeat iv for $\gamma = 0.04$.

b) Define the Bit Plane Slicing method. What are the three main goals of bit plane slicing? Consider I = {(150, 60), (60, 210)} as a 2 X 2 image with 8-bit gray values. [6]

i. Give 8 bit planes of I.
ii. Determine the reconstructed image using bit planes 8 and 7.

Question 5. [Marks: 14]

a) [8]

i. Why do we need image compression?
ii. How many types of data redundancies are there in an image?
iii. Define a loss less compression technique.
iv. Write down the properties of Arithmetic coding.
v. Consider the Table-1 below that represents the five-symbol sources with the probabilities and initial subintervals. What is the Arithmetic code for the sequence $a_1 a_4 a_3 a_4 a_2 a_5$?

Source Symbol	Probability	Initial Subinterval
a_1	0.2	[0.0, 0.2)
a_2	0.2	[0.2, 0.4)
a_3	0.3	[0.4, 0.7)
a_4	0.2	[0.7, 0.9)
a_5	0.1	[0.9, 1.0)

Table-1

b) Given a 5x5 pixel image and respective pixel values (8-bit code for each pixel) below, [6]

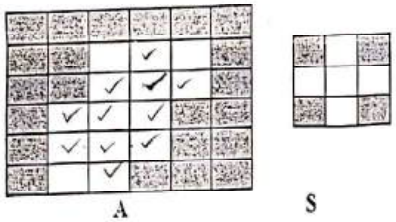
180	160	160	140	120
110	110	120	140	120
110	140	120	120	140
120	160	160	170	170
170	120	110	140	110

An 8-bit Image

i. Compute the entropy of the image.
ii. Calculate the respective Huffman Codes for each pixel value.
iii. What is the compression ratio achieved by employing Huffman Coding instead of 8-bit fixed length coding?
iv. Calculate the relative data redundancy of the given 8-bit image.
v. Compute the effectiveness of the Huffman coding.

Question 6. [Marks: 14]

a) i. Describe two different morphological basic operations along with mathematical equations. Explain the effects of them and give examples of their applications. [8]
ii. Explain if it is possible to achieve edge detection using morphological basic operations. Write down the algorithm of your operation of edge detection.

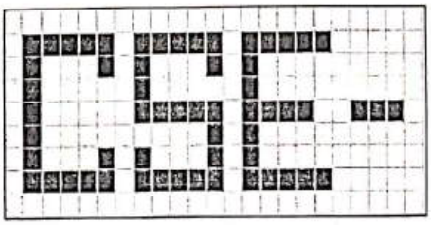


A S

Given an image **A** and a structuring element **S** above. Considering white pixels are foreground and dark pixels are background, compute the followings:

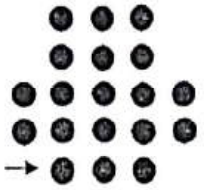
iii. Sketch the result of Erosion of A by S
iv. Sketch the result of Opening of A by S

b) i. What is Hit and Miss transformation in image morphology? [6]
ii. Design four Hit-or-miss transformation structure elements (SEs) for locating four connected endpoints of an image and show them. Perform your all SEs to the image below and use OR/ADD operation to combine the four results. How many corners will be detected in your final output image? Draw your final output image.



Question 7. [Marks: 14]

a) What is image representation? What information we can use to represent an image? What is Chain Code? Describe the Problems in Chain Code Representation. Find the Chain Code of the following image. An arrow marks the reference pixel and the direction. [Use 8-neighbor relationship]. [8]



b) Consider the image segment shown on the table where V be the set of gray level values used to define the connectivity in the image. Compute D_4, D_8 and D_m distances between pixel P and Q for, [6]

i. V= {2, 3}
ii. V= {2, 6}

2(P)	3	2	6	1
6	2	3	6	2
5	3	2	3	5
2	4	3	5	2
4	5	2	3	6(Q)

Date of Examination: 08. 11. 2021

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering
Program: B.Sc. in Computer Science and Engineering
Semester Final Examination: Fall 2020
Year: 4th Semester: 2nd
Course Number: CSE4227
Course Name: Digital Image Processing

Time: 2 (Two) Hours **Full Marks: 50**

Use separate answer script for each part

Instructions:	i)	Answer script should be hand written and should be written in A4 white paper. You must submit the hard copy of this answer script to the Department when the university reopens.
	ii)	You must write the following information at the top page of each answer script: **Part A/Part B** **Department:** **Program:** **Course no:** **Course Title:** **Examination:** **Semester (Session):** **Student ID:** **Signature and Date:**
	iii)	Write down Student ID, Course number and put your signature on top of every single page of the answer script.
	iv)	Write down page number at the bottom of every page of the answer script.
	v)	Upload the scan copy of your answer script in PDF format through provided **google form** at the respective course site (i.e., **google classroom)** using institutional email within the allocated time. Uploading clear and readable scan copy (uncorrupted) is your responsibility and must cover the full page of your answer script. However, for clear and readable scan copy of the answer script student should use only one side of a page for answering the questions.
	vi)	You must avoid **plagiarism,** maintain **academic integrity and ethics**. You are not allowed to take any help from another individual and if taken so can result in stern disciplinary actions from the university authority.
	vii)	Marks allotted are indicated in the **right margin.**
	viii)	Assume any reasonable data if needed.
	ix)	Symbols and characters have their usual meaning.
	x)	Before uploading rename the PDF file as **CourseNo_StudentID_PartNo.pdf** For example, CSE4227_170103001_PartA.pdf CSE4227_170103001_PartB.pdf

PART A

The answer script (**one single pdf file**) of this part (**Part A)** must be uploaded at designated location in the provided **google form link** available in the google classroom.

There are 3 (Three) Questions. Answer any 2 (Two).

Question 1. [Marks: 12.5]

a) Image compression algorithms are developed by taking advantage of the redundancy that is inherent in image data. How many primary types of redundancies are there in an image and what are those? Discuss one redundancy type that can be overcome using variable length code words. [2+4] **[6]**

b) Given a 5x5 pixel image and respective pixel values (8-bit code for each pixel) below, **[6.5]**

180	160	160	140	120
110	110	120	140	120
110	140	120	120	140
120	160	160	170	170
170	120	110	140	110

i. What is Entropy? Give the equation to calculate Entropy. [1+0.5]

ii. Compute the entropy of the image. [1]

iii. Calculate the respective Huffman Codes for each symbol (each pixel value). [2]

iv. What is the compression ratio achieved by employing Huffman Coding instead of 8-bit fixed length coding? [1]

v. Calculate the relative data redundancy of the given 8-bit image. [1]

Question 2. [Marks: 12.5]

a) i. What is the limitations in parameter space representation in Hough transform? [1]

ii. Using Hough transform, show that the points (1,2), (2,2) and (3,4) are collinear. Also find the equation of the line. [5] **[6]**

b) i. Explain the basic three steps of Edge Detection. [3]

ii. What is false positive and false negative edge pixels? How it overcomes in Canny edge detection algorithm? [3.5] **[6.5]**

Question 3. [Marks: 12.5]

a) **[6]**

i. Define Erosion and Dilation with set theory. [3]

ii. The figure shows an 8 × 8 image (A) and a disk structuring element(B)

Image A

0	0	0	0	0	0
0	0	1	1	0	0
0	1	1	1	1	0
0	0	1	1	0	0
0	0	0	0	0	0

Structuring Element B

	1	
1	1	1
	1	

a. Sketch the result of Erosion of A by B. [1]
b. Sketch the result of Dilation of A by B. [1]
c. Sketch the result of Closing of A by B. [1]

b) **[6.5]**

i. Consider the binary image A shown below on the left. Show the result of applying the following (as mentioned the operations on the right) with a 3x3 structuring element S.

$$B = (A \oplus S) \cap A^c$$

$$B = (A \oplus S) \cup A^c$$

Just draw the resulting images B. Indicate it clearly on your drawing the white and black parts. No need to show your calculations. [3]

ii. What is the objective of sharpening spatial filters? The following figure shows a 3-bit image of size 5-by-5 in the square. Calculate the gradient magnitude and angle using **Sobel mask** at the highlighted center pixel. [3.5]

5x5 Image

0	2	6	7	3
1	1	6	4	2
4	5	2	7	4
1	2	6	0	3
2	1	5	7	5

PART B

The answer script (**one single pdf file**) of this part (**Part B)** must be uploaded at designated location in the provided **google form link** available in the google classroom.

There are 3 (Three) Questions. Answer any 2 (Two).

Question 4. [Marks: 12.5]

a) Consider the following matrix, which is part of an image. **[6]**

q	w	
	p	
	u	

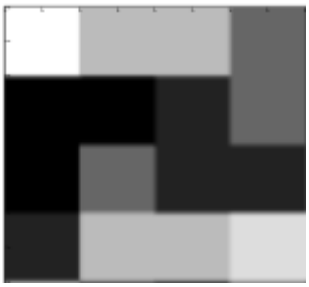
The values of pixels p, q, u and w belong to set V, which is the set of intensity values used to define adjacency.

i. Are pixels p and q 4-adjacent? Are they 8-adjacent? Are they m-adjacent? Provide one answer to each question.

ii. What is the Euclidean distance, the chessboard distance and the city-block distance between pixels q and u?

iii. Is there a 4-path from pixel u to pixel q? If so, what is it?

b) Consider the following 4 × 4 image (at the left) with respective pixel values (at the right). Zoom it to a 6 × 6 image using nearest neighbor interpolation. **[6.5]**



180	160	160	140
110	110	120	140
110	140	120	120
120	160	160	170

Question 5. [Marks: 12.5]

a) An image f(x, y) with dimensions M = 512 and N = 512 has the following 2-D DFT. Find the image f(x, y) and comment on the spatial frequency of the image. **[5.5]**

$$F(u,v) = \begin{cases} 1, & u = 0,\ v = 8 \\ 1, & u = 0,\ v = N - 8 \\ 0, & \text{otherwise} \end{cases} .$$

b) Figure presents the result of applying a filter to an image below. Now answer the following questions. **[3]**

i. What type of filter do you think was used? Justify your answer.

ii. Propose at least one way to improve the result.

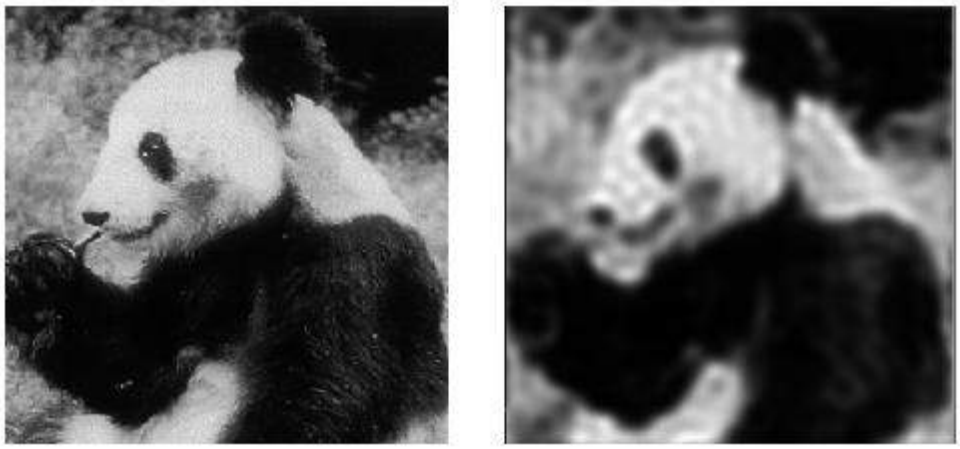


Figure: Image before filtering (left) and after filtering(right)

c) Consider the following 2 x 2 spatial-domain image where the pixel with value 2 has coordinates equal to (0, 0). **[4]**

2	0
0	1

i. Compute the 2-D DFT magnitude and give the result in a 2 x 2 array.

ii. Compute the 2-D DFT phase and give the result in a 2 x 2 array.

Question 6. [Marks: 12.5]

a) **[6]**

An 8-bit digital image has a histogram where the gray levels are equally distributed in the range from 160 to 220 (uniform distribution). Sketch the new histograms and write the transformation functions for each of the following operations. Also, describe the produced effect on the image contrast and brightness.

i. Calculation of the image negative.

ii. Addition of 50 to all pixel gray levels.

iii. Application of a threshold function with a threshold value of 128.

b) **[3]**

Consider the spatial filter H given by

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

Determine the maximum and minimum possible values that a pixel, to which this spatial filter is applied, can have. Do not apply any type of normalization.

c) **[3.5]**

Consider the original and processed image given in Figure below. Explain, which is the most likely processing from the list below to give this result?

i. Edge detection by a Laplacian operator.

ii. Median filtering followed by an edge detection.

iii. Edge detection followed by a median filtering.

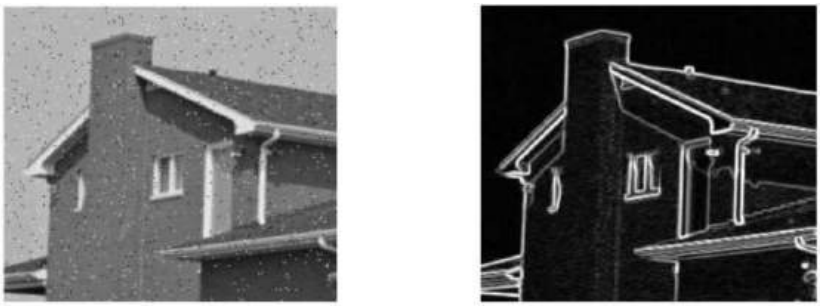


Figure: Original image (left) and processed image (right)

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering
Program: B.Sc. in Computer Science and Engineering
Semester Final Examination: Spring 2020
Year: 4th Semester: 2nd
Course Number: CSE4227
Course Name: Digital Image Processing

Time: 3 (Three) Hours **Full Marks: 60**

Use single answer script

Instructions:	i)	Answer script should be hand written and should be written in A4 white paper. You must submit the hard copy of this answer script to the Department when the university reopens.
	ii)	You must write the following information at the top page of each answer script: **Department:** **Program:** **Course no:** **Course Title:** **Examination:** **Semester (Session):** **Student ID:** **Signature and Date:**
	iii)	Write down Student ID, Course number and put your signature on top of every single page of the answer script.
	iv)	Write down page number at the bottom of every page of the answer script.
	v)	Upload the scan copy of your answer script in PDF format through provided **google form** at the respective course site (i.e., **google classroom)** using institutional email within the allocated time. Uploading clear and readable scan copy (uncorrupted) is your responsibility and you must cover all the pages of your answer script. However, for clear and readable scan copy of the answer script student should use only one side of a page for answering the questions.
	vi)	You must avoid **plagiarism;** maintain **academic integrity and ethics**. You are not allowed to take any help from another individual and if taken so can result in stern disciplinary actions from the university authority.
	vii)	Marks allotted are indicated in the **right margin.**
	viii)	Assume any reasonable data if needed.
	ix)	Symbols and characters have their usual meaning.
	x)	Before uploading, rename the PDF file as **CourseNo_StudentID.pdf** e.g., CSE4227_180104001.pdf

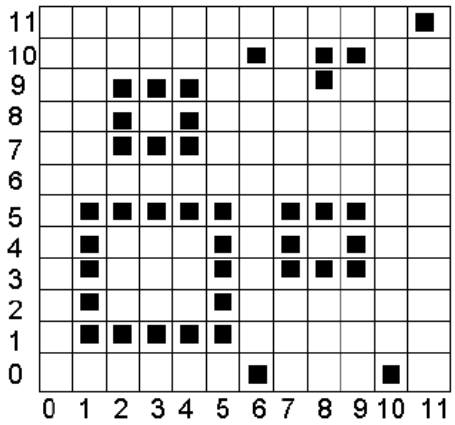
The answer script **(one single PDF file)** must be uploaded at designated location in the provided **Google Form link** available in the Google classroom.

There are 7 (Seven) Questions. Answer any 5 (Five).

Question 1. [Marks: 12]

a) In the Hough Transform, a point (x_0, y_0) in the xy-plane is mapped into a curve in the (ρ, θ)-parameter space. Write down the equation of the curve. **[2]**

b) Consider the following imge where each black square denotes a point and the numbers are the coordinates. **[5]**



If we apply the Hough transform on the image above, what would be the values of the following accumulator cells in the (ρ,θ)-space?

i) (2,0)

ii) (5,$\boldsymbol{0}$)

iii) (2,$\boldsymbol{\pi/2}$)

iv) (5,$\boldsymbol{\pi/2}$)

c) What is edge of an image? Describe the steps of Canny Edge Detection Algorithm in detail. **[5]**

Question 2. [Marks: 12]

a) Define median filter. "Median filtering is much better suited than averaging for the removal of salt-and-pepper noise"- justify the statement. **[2]**

b) i) Derive the following Laplace filter mask. **[5]**

1	1	1
1	-8	1
1	1	1

ii) Apply the following **Laplace** on the highlighted pixel as shown in below.
iii) Apply the following **Laplace 2nd derivative** on the highlighted pixel as shown in below.
iv) Apply a **3 × 3 Mean filter** on the highlighted pixel as shown in below.
v) Apply a **3 × 3 Median filter** on the highlighted pixel as shown in below.

0	−1	0
−1	4	−1
0	−1	0

153	157	156	153	155
159	156	158	156	159
155	158	**154**	156	160
154	157	158	160	160
157	157	157	156	155

c) The histogram of an image is shown in Table 1. Show the histogram table for a desired image where the number of pixel distribution will be in reverse order of the original image. **[5]**

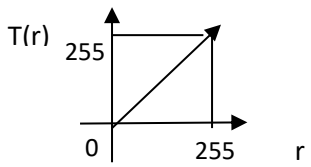
Table 1

Gray Levels (r)	2	18	33	58	67	96	114	152	184	206	220	245
No. of pixels	43	11	47	31	27	49	71	21	14	52	24	10

Sketch the normalize histograms of the original and desired images. What will be the output after applying histogram equalization process on the original image (Table 1)? Show your calculations.

Question 3. [Marks: 12]

a) The following figure illustrates the intensity transformation, T(r) = r. **[2]**



Now illustrate and explain the following intensity transformation functions:
i) T(r) = r + 100
ii) T(r) = r × 10

b) i) Explain a simple image enhancement technique that improves the contrast in an image by stretching the range of intensity values. **[5]**
ii) Define intensity transformation function T(r) for the Thresholding.

c) Consider figure ***I*** as a 2 X 2 image with 8-bit gray values. **[5]**

i. Give 8 bit planes of ***I***.

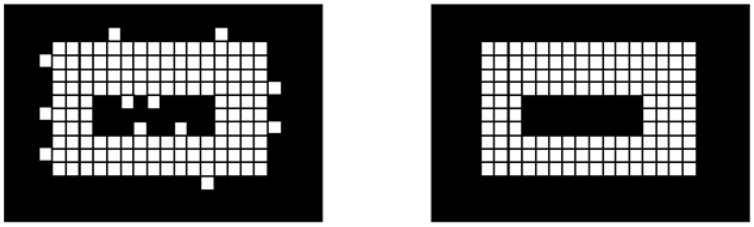
ii. Determine the reconstructed image using bit planes 8 and 7.

120	60
60	250

I

Question 4. [Marks: 12]

a) Consider the following images: **[2]**



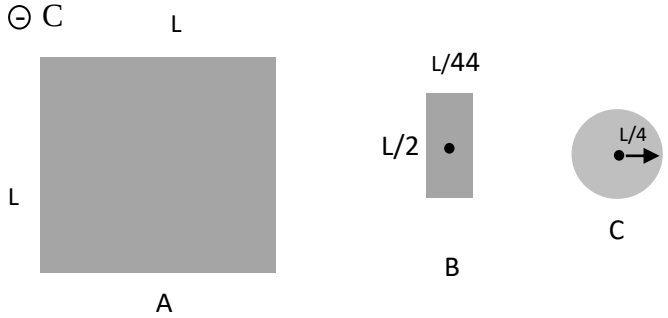
(a) (b)

Now propose a morphological procedure to clear the edge artifacts of the image given in (a) such that the image in (b) is obtained. Clearly state the structuring element(s) and number of iterations that you would use in your procedure.

b) Define the term **Dilation** and **Erosion** in morphological operations of image processing. Sketch the following morphological operations: (must show the calculations.) **[5]**

I. $A \oplus B$

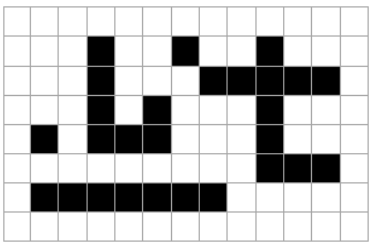
II. $A \ominus C$



c) i. Design Hit-or-miss transformation SEs for locating **4-connected endpoints** of an image. **[5]**

ii. Locate all the 4-connected endpoints of the following image using SEs obtained from the previous question i.

iii. Explain with example, if it is possible to achieve **edge detection** using morphological operations.



Question 5. [Marks: 12]

a) A 1024 X 1024 8-bit image with 5.3 bits/pixel entropy is to be Huffman Coding .What is the maximum compression that can be expected? **[2]**

b) Given a 4x8 pixel image and respective pixel values (8-bit code for each pixel) below, **[5]**

21	21	21	95	169	243	243	243
21	21	21	95	169	243	243	243
21	21	21	95	169	243	243	243
21	21	21	95	169	243	243	243

i. Compute the entropy of the image.
ii. Calculate the respective Huffman Codes for each symbol (each pixel value).
iii. What is the compression ratio achieved by employing Huffman Coding instead of 8-bit fixed length coding?
iv. Calculate the relative data redundancy of the given 8-bit image.
v. Compute the effectiveness of the Huffman coding.

c) i) Suppose we have a grayscale image with most of the values of pixels being same. What can we use to compress the size of the image? **[5]**

In the figure, * is representing the value of last three digits of your Student ID (e.g. for ID 160104001, *** will be 1).**

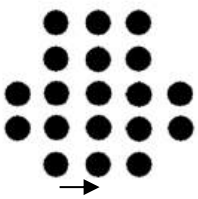
ii) Show your step by step **LZW** encoding process (to generate your codebook, use **4** bits). Any compression achieved by employing **LZW** in your above encoding process?

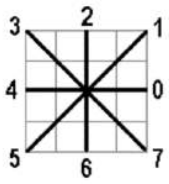
***	**4**	**3**	**7**
***	**4**	**3**	**7**
***	**4**	**3**	**7**
***	**4**	**3**	**7**

Fig. A 3-bit image

Question 6. [Marks: 12]

a) Consider the following image: **[2]**





Compute the chain code that is:
i. Invariant to starting point.
ii. Invariant to both starting point and rotation.

[The reference pixel and the direction are marked by an arrow, use 8-neighbor relationship.]

b) Describe the Region Growing and Region Splitting & Merging technique of image segmentation and illustrate example for each technique. **[5]**

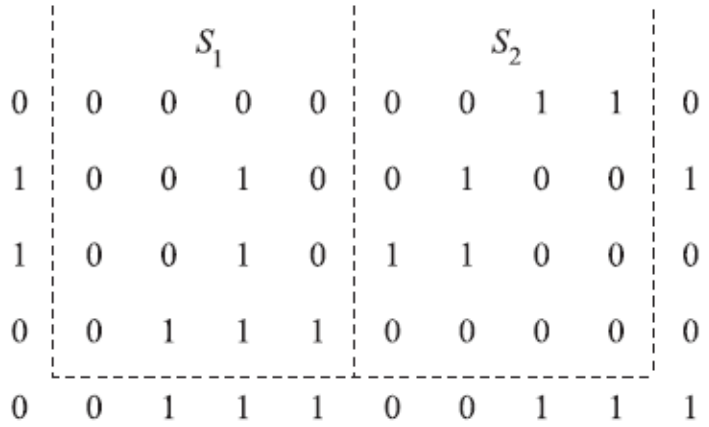
c) Why RGB colour model is called ***'Additive'***? Describe the RGB colour model with schematic of RGB colour cube. **[5]**

Question 7. [Marks: 12]

a) What do you understand by an indexed image? **[2]**

b) For images of the same size, the low detail image may need more pixel depth. Explain the statement. Illustrate key stages in digital image processing with the help of a block diagram. **[5]**

c) Consider the two image subsets, S1 and S2, shown in the following figure. For V = {1}, determine whether these two subsets are 4-adjacent, 8-adjacent or m-adjacent. **[5]**



Best of Luck!

Date: 29 October 2020

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Computer Science and Engineering
Program: B.Sc. in Computer Science and Engineering
Semester Final Examination, Fall-2019

Part-A

Year: 4th **Course No: CSE4227**

Semester: 2nd **Course Name: Digital Image Processing**

Time: 2 (Two) hours **Full marks: 40**

Use separate Answer Script for each section

Instructions:	i)	Answer script should be hand written and should be written in A4 white paper. You must submit the hard copy of this answer script to the Department when the university reopens.
	ii)	Write down Student ID, Course number, and put your signature on top of every single page of the answer script
	iii)	Write down page number at the bottom of every page of the answer script.
	iv)	Upload the scan copy of your answer script in PDF format at the respective site of the course at **google classroom** using institutional email within the allocated time. Uploading clear and readable scan copy is your responsibility and must be covered the full page of your answer script.
	v)	You must avoid **plagiarism,** maintain **academic integrity and ethics**. You are not allowed to take any help from another individual and if taken so can result in stern disciplinary actions from the university authority

Part-A (SECTION-1)

The answer script of this section will be uploaded to the concerned course teacher's Google Classroom.

Instructions:	i)	Before uploading rename the PDF file as **CourseNo_StudentID_PartNo_SectionNo** eg. CSE4227_180107001_partA_section1.pdf CSE4227_180107001_partA_section2.pdf
	ii)	There are **3 (Three) Questions in each section. Answer any 2 (Two) from each section.**
	iii)	Marks allotted are indicated in the **right margin**
	iv)	Assume any reasonable data if needed
	v)	Symbols and characters have their usual meaning

Question 1. [Marks: 10]

a) Suppose we have a grayscale image with most of the values of pixels being same. What can we use to compress the size of the image? **[1+5]**

In Fig 1.1, *** is representing the last three digits of your ID (e.g. for ID 160104001, *** will be 001).

***	40	60	80	100
***	40	60	80	100
***	40	60	80	100
***	40	60	80	100
***	40	60	80	100

Fig 1.1 A 7-bit input image

Show your step by step **LZW** encoding process (To generate your codebook, use **9** bits). Any compression achieved by employing **LZW** in your above encoding process?

b) Assume that, we applied a lossy compression technique to Fig 1.1. After the compression, we decompressed the image in which all the pixel intensity values are increased by two (2) [For example – 40 becomes 42, 60 becomes 62]. Find the Root Mean Square Error and Signal-to-Noise Ratio of the decompressed image. **[4]**

Question 2. [Marks: 10]

a) Image Thinning process subtract the pixels from a shape to thin the line to one pixel width. Thin the image of Fig 2.1 using the given structuring element of Fig 2.2. Show the set of SEs those will be used in your thin process. Illustrate the thinning process and show your results after each passes of your structuring elements until the convergence was achieved and also show your final thinned image after eliminating multiple paths. **[6]**

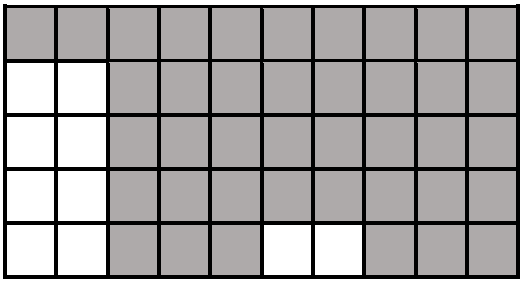


Fig 2.1 A gray-level image (I)

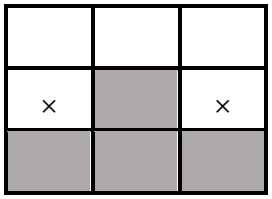


Fig 2.2 Structuring Element (SE)

b) Considering the image of Fig. 2.3 and structuring element of Fig. 2.4, find the output of the following operations: **[4]**

i. $(A \ominus s) \oplus s$

ii. $(A \oplus s) \ominus s$

iii. Prove the duality relationship between Dilation and Erosion.

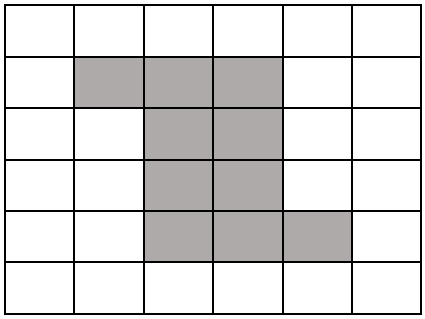


Fig 2.3 6 × 6 Gray-level Image (A)

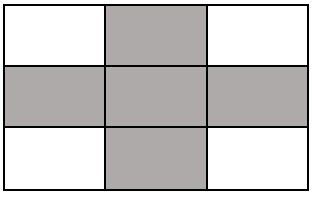


Fig 2.4 Structuring Element (s)

Question 3. [Marks: 10]

a) i. In the following image of Fig 3.1, you can find an **edge** labeled in the red region. Which form of discontinuity creates this kind of **edge**? [1] **[6]**

Fig 3.1

Fig 3.2

5	10	7	9
12	11	8	2
21	32	25	14
30	31	20	21

Fig 3.3

ii. To blur an image, can you use a linear filter? Justify your answer with an example. [1]

iii. Suppose we have a noisy image as in Fig 3.2. The type of noise in the image is called salt-and-pepper noise. What is the best way to denoise this image? Describe your process with explanation. [1]

iv. If we convolve an image with a 3x3 matrix as [0, 0, 0, 0, 0, 1, 0, 0, 0], what would be the relation between the original and modified image? [1]

v. How can you smooth an image? If you subtract your smoothed image from the original image, what will happen if we add the subtracted result back to the original image? [1]

vi. Sharpen the 4x4 image of Fig 3.3 using the second derivative operator and draw your output image (consider zero-padding for the border pixels). [1]

b) The histogram of an image is shown in Table 3.1. Show the histogram table for a desired image where the number of pixel distribution will be in reverse order of the original image. For example – there will be 43 pixels in gray level 2, 11 pixels in gray level 18, and vice-versa. **[4]**

Table 3.1

Gray Levels (r)	2	18	33	58	67	96	114	152	184	206	220	245
No. of pixels	10	24	52	14	21	71	49	27	31	47	11	43

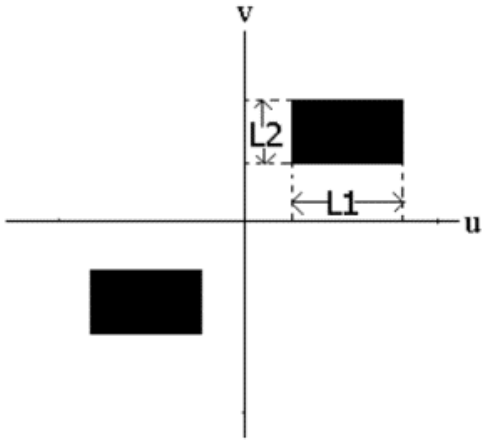
Sketch the normalized histograms of the original and desired images. What will be the output after applying histogram equalization process on the original image (Table 3.1)?

Part-A (SECTION-2)

The answer script of this section will be uploaded to the concerned course teacher Google Classroom.

Question 4. [Marks: 10]

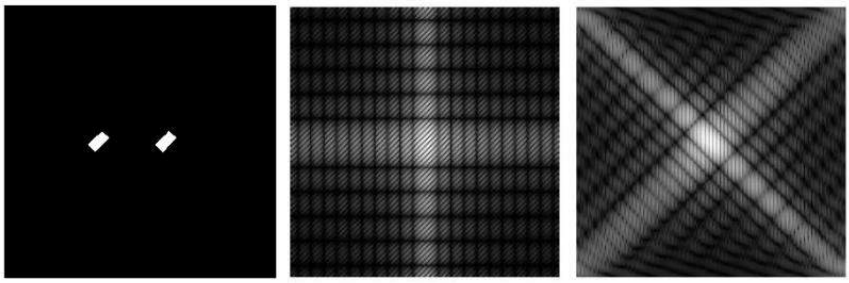
a) The following figure shows the frequency domain representation of a notch filter. Here, the dark area has a value of 0 while the white area has value 1. The centers of the two dark rectangles (which are symmetric with respect to the origin) are (u0, v0) and (−u0, −v0), respectively. The sides of the rectangle are of lengths L1 and L2, respectively. Is this a bandpass or bandreject filter? Explain. Write down the H(u, v) of this notch filter. **[4]**



b) i. Give the Fourier transform of the 2D image, $f(x, y) = 3\cos(0.3x)\cos(0.2y)$. **[6]**

ii. Consider the image shown in Figure (a) below. Two plots of magnitude of Two-Dimensional. Discrete Fourier Transform (2D DFT) are shown in Figure (b) and (c) below. Which one is the magnitude of the 2D DFT of the image of Figure (a)? Justify your answer.

iii. Suppose you are given a sample image of text with broken characters. You need to join the broken texts with no visible ringing effect. Which frequency domain filter will you use? Justify your answer. Also, define the filter function H(u, v) in the frequency domain.

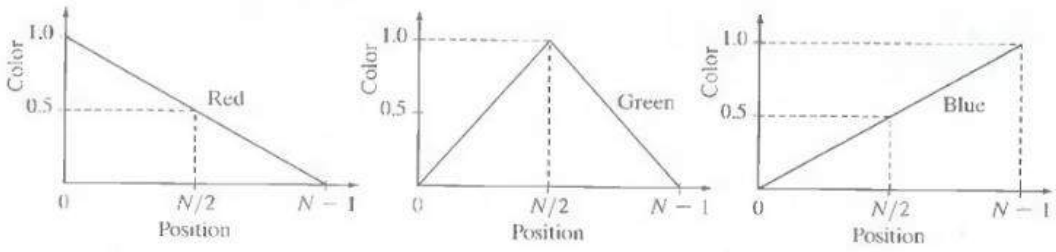


(a) (b) (c)

Question 5. [Marks: 10]

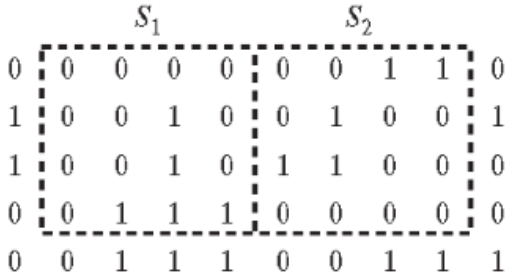
a) i. How many different shades of gray are there in a color RGB system in which each RGB image is an 8-bit image? **[6]**

ii. In a simple RGB image, the R, G, and B component images have the horizontal intensity profiles shown in the following diagram. What color would a person see in the middle column of this image?



iii. Suppose that we replace every color in the RGB cube by its CMY color. This new cube is displayed on an RGB monitor. Label with a color name the eight vertices of the new cube that you would see on the screen. Show your calculation.

b) Consider the two image subsets, S_1 and S_2, shown in the following figure. For V = {1}, determine whether these two subsets are (a) 4-adjacent, (b) 8-adjacent, or (c) m-adjacent. **[4]**

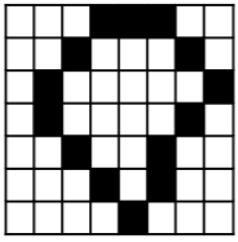


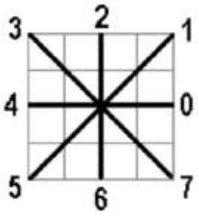
Question 6. [Marks: 10]

a) For the following boundary (in counterclockwise direction) compute the chain code that is: **[4]**

i. invariant to starting point

ii. invariant to starting point and rotation

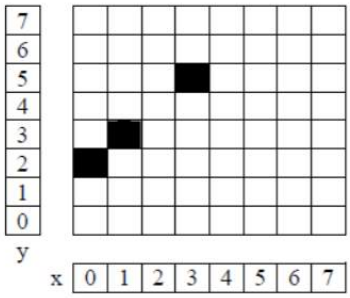




b) Consider the binary image "Aust.jpg". Now, **[2 + 4]**

i. Calculate the votes for the accumulator cells $(\frac{\pi}{4}, 2\sqrt{2})$, $(\frac{\pi}{4}, 4\sqrt{2})$, (0, 3), and $(\frac{\pi}{2}, 3)$.

ii. Identify the cell receiving the most votes (among all the accumulator cells) and deduce the equation of the line in polar coordinates, which connects the 3 points of "Aust.jpg"



Aust.jpg

ρ / θ	0	1	$\sqrt{2}$	2	$2\sqrt{2}$	3	$4\sqrt{2}$	5
0								
π/4								
π/2								
3π/4								

Accumulator

Date: 29 October 2020

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Computer Science and Engineering
Program: B.Sc. in Computer Science and Engineering
Semester Final Examination, Fall-2019

Part-B (Open book exam)

Year: 4th **Course No: CSE4227**

Semester: 2nd **Course Name: Digital Image Processing**

Submission deadline: Next day 6.30 pm **Full marks: 20**

Use separate answer script for each section

Instructions:	i)	Before uploading rename the PDF file as **CourseNo_StudentID_PartNo_SectionNo** eg. CSE4227_180107001_partB_section1.pdf CSE4227_180107001_partB_section2.pdf
	ii)	**Answer all the Questions**
	iii)	Marks allotted are indicated in the **right margin**
	iv)	Assume any reasonable data if needed
	v)	Symbols and characters have their usual meaning

Part-B (SECTION-1)

The answer script of this section will be uploaded to the concerned course teacher's Google Classroom.

Question 1. [Marks: 10]

a) Congratulations to the students of CSE 37th batch for getting an intern project from ICT ministry. The project is an automatic process of transparent water bottle filling and capping on. The process will check that the bottles are filled and capped with pure water, also will count the bottles before packing for the production. All the bottles are placed into the conveyor line for these checking purposes. As the complete process is an automated process, one of the important tasks is to check the completeness of the bottle. As an Artificial Intelligence Engineer, your responsibility is to build a system that can identify four types of bottles — Full Bottle, Empty Bottle, Incomplete Bottle, and consists of stains Bottle (the water is dark / colored). Now propose a system that can detect all these four types of bottles considering the topics that covers in this DIP course. You should state with proper explanation about all the **[6]**

assumptions and other necessary factors you make for the solution. Mention all the names of the DIP techniques you are using into your proposal with justifications.

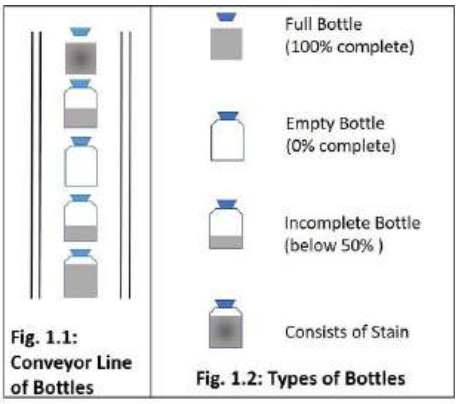


Fig. 1.1: Conveyor Line of Bottles

Fig. 1.2: Types of Bottles

b) Satellite image plays an important role in various kinds of security purposes for a nation. One of the prominent examples can be Road Line Detection. Consider the following Fig. 1.3 of three different satellite images containing road line. Now propose a method which will identify a section of road line from any one of the satellite images from Fig. 1.3. You may use morphological operation, segmentation, edge detection, and/or other image processing techniques for this purpose. A sample identified image is depicted in Fig. 1.4(a) and then 1.4(b). Furthermore, discuss if your method is appropriate to identify road line from all of the images of Fig. 1.3. **[4]**

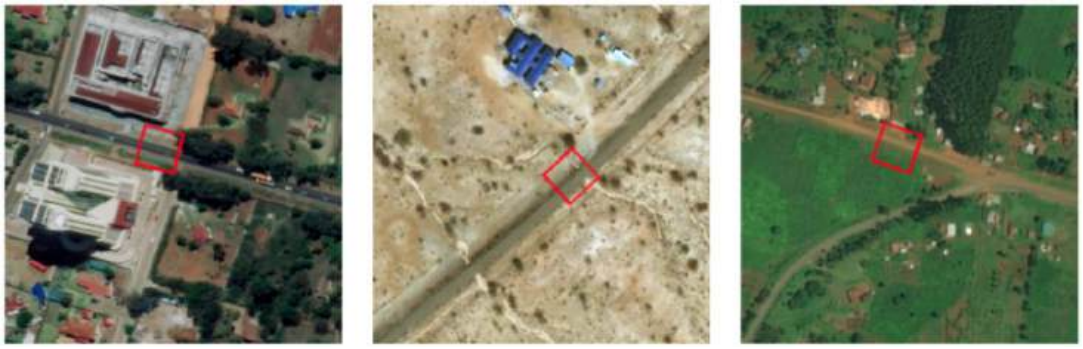


Fig 1.3: Road Satellite Image

(a) (b)

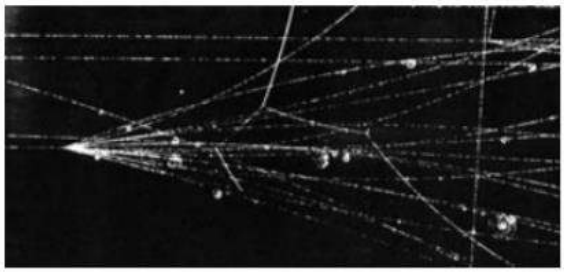
Fig 1.4 Segmented Road Satellite Image

Part-B (SECTION-2)

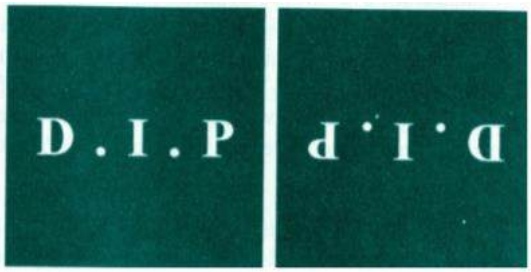
The answer script of this section will be uploaded to the concerned course teacher Google Classroom.

Question 2. [Marks: 10]

a) Suppose you are given the following image consisting of tracks of variable lengths obtained from a scientific experiment. Using Hough Transforms as a basis, propose a segmentation approach for detecting all tracks that contain at least 100 pixels and are angled at any of the following six directions off the horizontal: ±30°, ±60°, and ±45°. For a track to be valid, it must be at least 100 pixels long and not have more than three gaps, any of which cannot exceed 10 pixels. You may assume that the images have been processed so that they are binary and all tracks are 1 pixel wide. **[5]**



b) Consider the images shown. The image on the right was obtained by (a) multiplying the image on the left by $(-1)^{(x+y)}$; (b) computing the DFT; (c) taking the complex conjugate of the transformation; (d) computing the inverse DFT; and (e) multiplying the real part of the result by $(-1)^{(x+y)}$. Explain (mathematically) why the image on the right appears as it does. What will be the difference if we plot – (i) the amplitude and (ii) phase of the two images? **[5]**



Date of Examination :11/12/2019

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

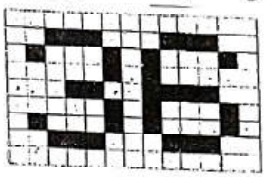
Department: Computer Science and Engineering
Program: Bachelor of Science in Computer Science and Engineering
Semester Final Examination: Spring 2019
Year: 4rth Semester: 2nd
Course Number: **CSE4227**
Course Name: **Digital Image Processing**
Time: 3 (Three) hours Full Marks: 70

[There are seven (07) questions carrying a total of 14 marks each. Answer any five (05) questions. Marks allotted are indicated in the right margin.]

1. a) What is histogram of an image? Describe how the histogram differ for the dark, bright, low contrast or high contrast image of the same scene. [3]

L-6 S-24,26

b) Consider ***Corei_36.bmp*** is a ***180 × 260*** binary image. [2]



i. Calculate the histogram of ***Corei_36.bmp*** and sketch it.
ii. Calculate the bit size of ***Corei_36.bmp.***

c) What do you understand by cumulative histogram? Explain the histogram equalization algorithm. [3]

L-6

d) Consider the histogram of an image as shown in following table. [6]

Gray levels (r)	0	1	2	3	4	5	6	7
No of pixels	**790**	**1023**	**850**	**656**	**329**	**245**	**122**	**81**

i) Compute and sketch the normalized histogram of it.
ii) Compute and sketch the equalize histogram of it.
iii) Show the mapping of the new gray level values into number of pixels.
iv) Plot the Histogram Equalization Transformation function.
v) Show that a second pass of histogram equalization (on the histogram equalized image) will produce exactly the same result.

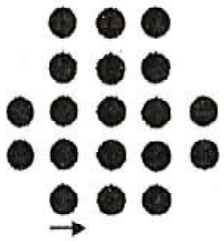
2. a) Define the following terms: [4]

L-3

i) Digital Image ii) Resolution iii) Sampling and Quantization

• refers to the no. of pixels in an image.
Resolution = Total no. of pixels = M x N

b) What is Chain Code? Find the Chain Code of the following image. The reference pixel and the direction are marked by an arrow. [Use 8-neighbor relationship]. [4]



c) Find the number of bits required to store a 256 X 256 image with 32 gray levels. Write the expression to find the number of bits to store a digital image. [2]

d) Write the three major goals of image enhancement in spatial domain. Why do we need the processing in frequency domain where spatial domain is quite easy to understand? [4]

3. a) What is data redundancy? How many types of redundancies are there in an image? Give brief description of each. [4]

b) Why do we need image compression? Consider the simple 4×8, 8-bit image: [6]

2	2	2	9	16	24	43	43
2	2	2	9	16	24	43	43
2	2	2	9	16	24	43	43
2	2	2	9	16	24	43	43

i. Compute the entropy of the image.
ii. Compress the image using Huffman coding.
iii. Compute the compression achieved and the effectiveness of the Huffman coding.

c) Define the compression technique **Golomb** code of a nonnegative integer n with respect to a positive integer m denoted by $G_m(n)$. Compute Golomb code for $G_4(9)$. [4]

4. a) What is edge detection? Describe the steps of **Canny edge detection** algorithm in detail. [7]

b) Describe the Region Growing and Region Splitting & Merging technique of image segmentation. [4]

c) Assume Canny edge detection is used into an image **f(x,y)** to find the edges. The gradient magnitude **M(x,y)** matrix image and the edge direction of each pixel with the arrow is shown in figure on the right side. **Calculate and Show** the normalized image $g_n(x,y)$ matrix after performing nonmaxima suppression. [3]

203 ↓	34 ↓	59 ↙
150 →	21 ↓	200 ↑
37 ↗	111 ↗	23 ↖

5. a) Consider the following image:

	0	1	2	3 (3,0)
0	3	1	2	1(a)
1	2	2	0	2
2	1	2	1	1
3 (0,3)	1(b)	0	1	2

[5]

Assume that V = {0,1}.

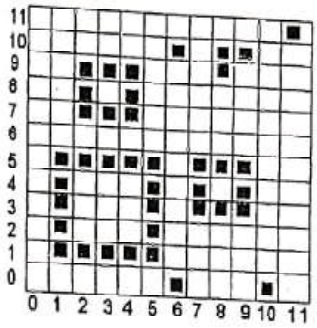
i) Does a 4 – path exists between a and b.

ii) Does a m – path exists between a and b.

(Explain your answers)

iii) Calculate the distances, $D_4 = ?$, $D_8 = ?$, $D_e = ?$ for the point (a) & (b).

b) Write the procedure steps for Hough transform. Consider the following image where each black square denotes a point and the numbers are the coordinates. [7]



If we apply the Hough transform on the image above, what would be the values of the following accumulator cells in the (ρ,θ)-space? Determine the lines for the correnponding values.

i) $(5,\pi/2)$ ii) $(2,\pi/2)$ iii) $(5,0)$ iv) $(2,0)$

c) The following figure shows a 3-bit image of size 5-by-5 image in the square, with x and y coordinates specified. [2]

y \ x	0	1	2	3	4
0	3	7	6	2	0
1	2	4	6	1	1
2	4	7	2	5	4
3	3	0	6	2	1
4	5	7	5	1	2

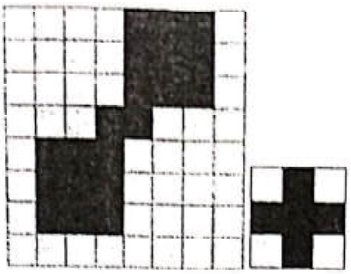
Calculate G and θ at (2,2) using sobel masks.

6. a) Define **Erosion** and **Dilation** mathematically. [2]

b) Explain with an example, if it is possible to achieve **edge detection** using morphological operation. [2]

c) Design Hit-or-miss transformation **structuring elements** for locating **all four corners** of an image. [4]

d) The following figure shows an 8 ×8 image (A) and a disk structuring element (B) [6]



(A) (B)

i. Sketch the result of **Erosion** of **A** by **B**.
ii. Sketch the result of **Dilation** of **A** by **B**.
iii. Sketch the result of **Opening** of **A** by **B**.
iv. Sketch the result of **Closing** of **A** by **B**.

7. a) What does Mean or Box filter do? Design a weighted average filter mask where each of the 4-neighbor gets half of the weight and each of the diagonal neighbor gets one fourth of the weight of the center pixel. [4]

b) The following figure shows [7]
A. a 3-bit image of size 5-by-5 in the square, with x and y coordinates specified,
B. a Laplacian filter and
C. a low-pass filter.

y \ x	0	1	2	3	4
0	3	7	6	2	0
1	2	4	6	1	1
2	4	7	2	5	4
3	3	0	6	2	1
4	5	7	5	1	2

A

Laplacian filter

0	1	0
1	-4	1
0	1	0

B

Low pass filter

0.01	0.1	0.01
0.10	0.56	0.10
0.01	0.1	0.01

C

Now find,
i. The output of a 3 × 3 mean filter.
ii. The output of a 3 × 3 median filter.
iii. The output of the 3 × 3 Laplacian filter shown above at (2,3).
iv. The output of the 3 × 3 low-pass filter shown above at (3,4).
[For dealing with edge pixels use zero padding and put zero at the border in the output image]

c) Image enhancement using Laplacian involves the following two steps: [3]

i. Finding the Laplacian of an image using the following Laplacian mask,
ii. Subtract the Laplacian result from the original image.

0	1	0
1	-4	1
0	1	0

Now derive a filter mask, which reduces above two steps into a single filtering operation. L-8

Date of Examination 07/05/2019

AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department: Computer Science and Engineering
Program: Bachelor of Science in Computer Science and Engineering
Semester Final Examination: Fall 2018
Year: 4th Semester: 2nd
Course Number: CSE4227
Course Name: Digital Image Processing
Time: 3 (Three) hours Full Marks: 70

Use separate answer script for each part

Part A

*[There are 03 (three) questions carrying a total of 14 marks each. **Answer any 02 (two) questions.** Marks allotted are indicated in the right margin.]*

1. a) i) "A digital image is always only an approximation of a real world scene" - why? Mention two techniques those made this digital representation of analog world possible. [4]
ii) What is the basic differences between RGB image and Indexed color image? Which representation is preferred in case of storage, transmission and rendering a large size image?

b) Consider two image subsets S_1 and S_2 (Figure: 01). For V= {0} determine whether the regions are i) 4 adjacent ii) 8 adjacent iii) m adjacent. [4]

S_1				S_2			
1	1	1	1	1	1	0	0
1	1	0	1	1	0	1	1
1	1	0	1	0	0	1	1
1	0	0	0	1	1	1	1

Figure: 01

c) Consider the image segment shown below (Figure: 02) where V be the set of gray level values used to define the connectivity in the image. Compute D_4, D_8 and D_m distances between pixel P and Q for, [6]
i) V= {2, 3}
ii) V= {2, 6}

2(P)	3	2	6	1
6	2	3	6	2
5	3	2	5	5
2	4	3	5	2
4	5	2	3	6(Q)

Figure: 02

2. a) Write the reasons that Fourier based techniques have become so popular in the fields of modern engineering. In which cases Frequency Domain filtering is useful and outperforms the spatial one? [3]

b) Compare the effects of Ideal, Gaussian and Butterworth Low pass filters in terms of their transfer functions. Write the significance of order n (Butterworth) and D (others) on their characteristics. If we vary n and D how this filters will react on the images? (Show with proper graphical representation). [6]

c) i) Combining high frequency-emphasis and histogram equalization is an effective method for achieving edge sharpening and contrast enhancement. Show whether or not it matters which process is applied first, explain your answer logically in brief. What will be the effect if the order is jumbled up? [5]

ii) Write a gray level point processing function which can also be applied as a segmentation on an image. Write the application of Gamma correction for representing digital image.

3. a) What is Pigment? Why is it used for? Why RGB color model is called *'Additive'* where as CMYK is *'Subtractive'*? [3]

b) i) How HSI/HSV color model is different from RGB? What is meant by "Point of Equal Energy" in Chromaticity diagram (Figure: 03)? [6]

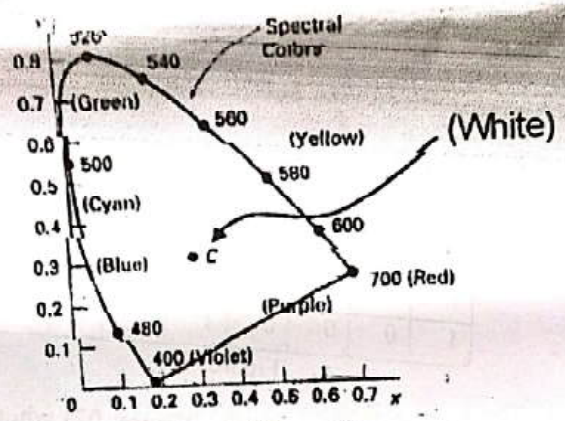


Figure: 03

ii) ***"No color is possible to represent using a fixed wavelength"*** briefly explain the reason using chromaticity diagram. What will happen if we assign a fixed value of wavelength for the primary colors in Chromaticity diagram? Write the major application of Pseudo-color image processing.

c) Suppose two pixels in RGB color space having RBG value (0, 0, 1) and (1, 1, 0). Find the corresponding pixel value both in CMY and HSI color space for these two pixels. [5]

Part B

There are [illegible] carrying a total of [illegible] marks each. Answer any 03 (three) questions. Marks allocated are indicated against each question.]

4. a) What is Hit and Miss transformation in image morphology? Design four Hit-or-miss transformation structure elements (SEs) for locating all corners of an image. Perform all SEs to the image of fig 4(a) and use OR operation to combine the four results. How many corners will be detected in your final output image? Show your output images. [4]

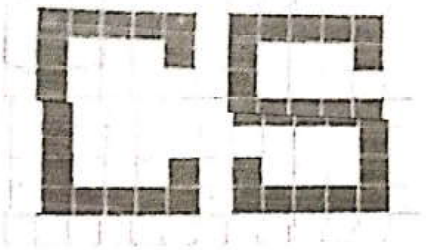
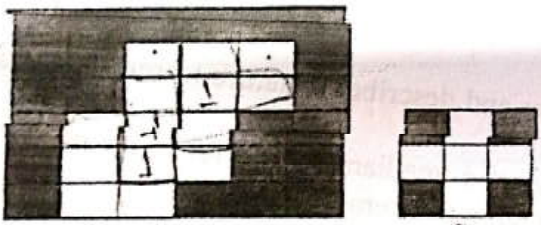


Figure 4(a)

b) What do you understand by Erosion and Dilation operations? Explain the effects of them and give examples of their applications. Explain if it is possible to achieve edge detection using morphological operation. Write down the expression. [5]

c) Given the image A and structuring element S fig4(c). Considering white pixels are foreground and black are background, compute the followings: [5]



i) A^c
ii) (A dilated by S)
iii) (A eroded by S)
iv) (A dilated by S) - A
v) A - (A eroded by S)

Figure 4(c)

5. a) How many types of redundancies are there in an image? Give brief description of each. [4]

b) i. What is lossy compression? Describe the objective fidelity criteria of an image. [5]

ii. A 512 X 512 8-bit image with 5.3 bits/pixel entropy is to be Huffman Coding. What is the maximum compression that can be expected?

iii. An image of size 10x10 has only 3 colors. 50 pixels in the image are black (0), 30 pixels are white (255) and 20 pixels are gray (120). Using Variable Length Coding, the following codes are assigned to these three colors as shown in fig.5(b). Find the average number of bits per pixel required to encode this image.

Color	Code
0	1
255	0
120	111

Figure 5(b)

c) Given a 4x7 pixel image and respective pixel values (8-bit code for each pixel) in table 5(c) [5]

21	21	21	95	16	43	43
21	21	21	95	16	43	43
21	21	21	95	16	43	43
21	21	21	95	16	43	43

Table 5(c)

i) Compute the entropy of the image.
ii) Calculate the respective Huffman Codes for each symbol (each pixel value).
iii) What is the compression ratio achieved by employing Huffman Coding instead of 8-bit fixed length coding?
iv) Calculate the relative data redundancy of the given 8-bit image.
v) Compute the effectiveness of the Huffman coding.

6. a) What is image segmentation? How to detect the line in a specified direction using a mask? Draw four line detection masks to extract the line of specified four directions, horizontal, +45 degree, vertical and -45 degree respectfully. [4]

b) What is edge point in digital Image? How many steps are in Canny Edge Detection Algorithm and what are the steps? Explain the step Non Maximum Suppression. What are the false positive and the false negative edge pixels? How canny reduce these errors? [5]

c) The derivative of digital function is defined in terms of difference. Then, define the first order and second order derivative of a one-dimensional function f(x). How to calculate the gradient vector of a particular pixel of an image using first order derivative? Is it possible to calculate using Sobel mask? Show the Sobel mask for detecting horizontal and vertical edge. [5]

7. a) i) What is image restoration? [4]
ii) Define the term Harmonic mean filter and describe its nature to remove noise in restoration process.
iii) Explain why the output of applying a median filter preserves more edge sharpness in compared to that of applying an averaging filter.

b) What is histogram of an image? Consider **sample.bmp** is a 4X4 image with 8-bit gray values as in fig.7(b). Provide the final intensity mapping table for performing histogram equalization on the image **sample.bmp**. Sketch the equalized histogram and the transformation curve. [5]

20	240	150	60
60	150	60	150
150	60	210	150
150	20	150	20

Figure 7(b): Sample.bmp

Show that a second pass of histogram equalization (on the histogram equalized image) will produce exactly the same result.

e) i) What is the principle objective of Spatial filtering? Give the mathematical equation representing the convolution of a filter $w(x,y)$ with an image $f(x,y)$ to explain the mechanics of Spatial filtering. [5]

ii) Consider a 3-bit image of size 5-by-5 and a Laplacian filter as in the fig.7(c) Find the filtered output image using this **Laplacian filter** and a 3x3 **Mean** filter. Ignore the border pixels in calculation and put zero in the border of the output image.

5x5 Image

0	2	6	7	3
1	1	2	3	2
4	3	2	4	4
1	2	0	1	3
2	1	5	7	5

Laplacian filter

0	1	0
1	-4	1
0	1	0

Figure 7(c)

iii) Explain why the output of applying a median filter preserves more edge sharpness in compared to that of applying an averaging filter.