National University of Computer and Emerging Sciences

FAST School of Computing   Spring-2024   Islamabad Campus

CS-4055: Digital Image Processing

Serial No:

2nd Sessional Exam

Total Time: 1 Hour

Total Marks: 50

Thursday, 04th March, 2024

Course Instructor

Usman Haider

-(10,5,5)

Signature of Invigilator

0263 / 47.5
0286 / 47.5
0327 / 27
0324 / 28.5
0298 / 39
0372 / 19
0312 / 45 (Late)
0275 / 23

Solution

DO NOT OPEN THE QUESTION BOOK OR START UNTIL INSTRUCTED.

Instructions:

1. Attempt on question paper. Read the question carefully, understand the question, and then attempt it.
2. No additional sheet will be provided for rough work.
3. Verify that you have **six (6)** different printed pages, including this title page. There are **three (3)** questions.
4. Calculator sharing is strictly prohibited.
5. Use permanent ink pens only. Any part done using a soft pencil will not be marked and cannot be claimed for rechecking.
6. Ensure that you do not have any electronic gadgets (like mobile phones, smart watches, etc.) with you.

0347 ⇒ 25
0322 ⇒ 41.5
2719 → 38
0344 → 25.5
0256 → 43

Thought of the day:

"Believe in yourself and all that you are.
Know that there is something inside you
that is greater than any obstacle."
~Christian D. Larson

	Q-1	Q-2	Q-3	Total
Marks Obtained				
Total Marks	20	15	15	50

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Question 1 [20 Marks]

1. Write an example of a 3x3 isotropic sharpening filter. [2 marks]

0	1	0
1	-4	1
0	1	0

2. Let the number of bits to represent each pixel in an image be b = 8, and the number of bits to represent each pixel in a compressed image is b'=2.4. Find the compression ratio (C) and redundancy (R). [3 marks]

C = 8/2.4 =3.33
R =1 – 1/C = 1-1/3.33 = 0.699 ≈ 70%

3. Consider the following image of size 5x5. What kind of redundancy is there in this image? Suggest a way to compress it. [3 marks]

10	10	10	10	10
10	10	10	10	10
10	10	10	10	10
10	10	10	10	10
10	10	10	10	10

This image has Irrelevant information. We can compress such image using only three pieces of information:
Width, height, and value of the pixel.
(5, 5, 10) this triplet is enough to hold information about this image

4. Calculate the Entropy of the following image: [4 marks]

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

$$H(X) = -\sum_{i=1}^{n} P(x_i) \cdot \log_2(P(x_i))$$

$n = 8$

$$H(x) = -\Big[\frac{5}{25} \cdot \log_2\left(\frac{5}{25}\right) + \frac{6}{25}\log_2\left(\frac{6}{25}\right) + \frac{4}{25}\log_2\left(\frac{4}{25}\right) + \frac{4}{25} \cdot \log_2\left(\frac{4}{25}\right) + \frac{2}{25}\log_2\left(\frac{2}{25}\right) + \frac{1}{25}\log_2\left(\frac{1}{25}\right) + \frac{2}{25}\log_2\left(\frac{2}{25}\right) + \frac{1}{25}\log_2\left(\frac{1}{25}\right)\Big]$$

$$= -\big[0.2 \times (-2.322) + 0.24(-2.2516) + 0.16(-2.644) + 0.16(-2.644) + 0.08(-3.644) + 0.04(-4.644) + 0.08(-3.644) + 0.04(-4.644)\big]$$

$$= 2.8054$$ bits per pixel.

5. Apply the given filters on the following input image in the spatial domain. Assume zero padding for border pixels. [3+1, 3+1 = 8 marks]

245	10	0
1	1	60
50	250	0

Filter	Filter Name	Transformed Image
$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$	Sobel	$\begin{bmatrix} 3 & 63 & 121 \\ -150 & 285 & 240 \\ -3 & -63 & -121 \end{bmatrix}$
$\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$	Prewitt	$\begin{bmatrix} 11 & -186 & -11 \\ 261 & -236 & -261 \\ 251 & 9 & -251 \end{bmatrix}$

Rough Work

$$\sum_{x} \sum_{y} (x-\bar{x})(y-\bar{y})^{\circ} f(x,y)$$

Question 2 [15 Marks]

1. The following is a binary image 'I' and a structuring element 'S.' Assume that the origin of S lies at its center. Assume the blank cells in 'I' and 'S' have pixel values of 0. (04+04 = 08 marks)

I:

	0	1	2	3	4	5	6	7	8	9
0										
1										
2			1	1	1	1	1	1		
3					1	1	1	1		
4			1	1	1	1		1		
5			1	1	1	1	1	1		
6			1	1	1	1	1	1		
7			1	1	1	1	1	1		
8										
9										

S:

	1	
1	1	1
	1	

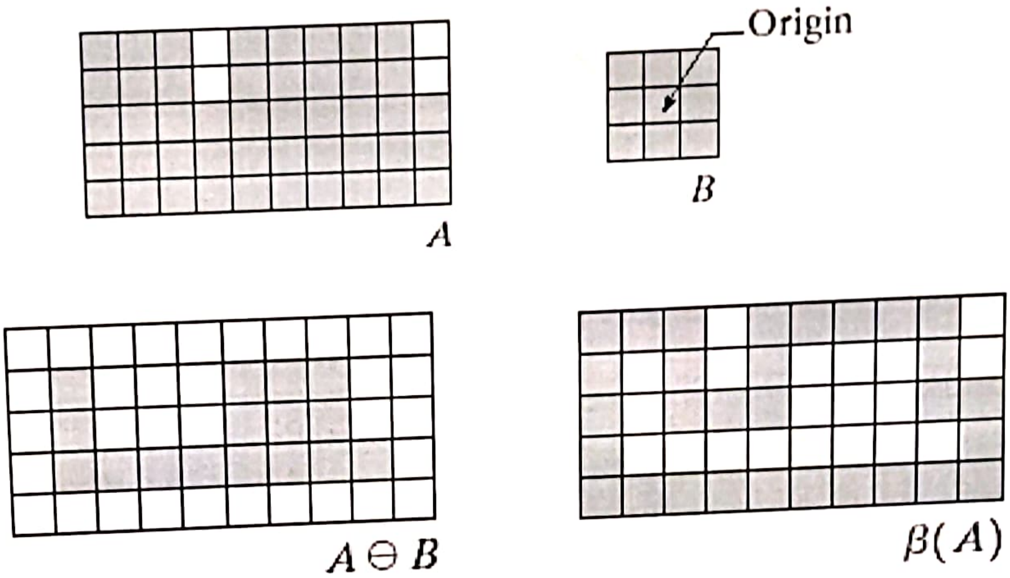
a. Predict the result of dilating I with S.

	0	1	2	3	4	5	6	7	8	9
0										
1			1	1	1	1	1	1		
2		1	1	1	1	1	1	1	1	
3			1	1	1	1	1	1	1	
4		1	1	1	1	1	1	1	1	
5		1	1	1	1	1	1	1	1	
6		1	1	1	1	1	1	1	1	
7		1	1	1	1	1	1	1	1	
8			1	1	1	1	1	1		
9										

b. Predict the result of eroding I with S.

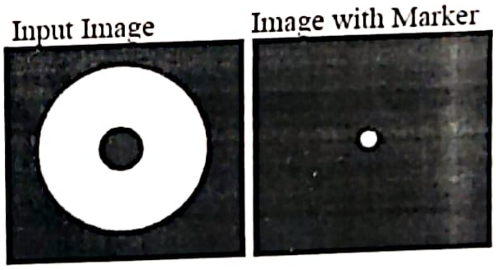
	0	1	2	3	4	5	6	7	8	9
0										
1										
2										
3						1				
4					1					
5				1	1	1				
6				1	1	1	1			
7										
8										
9										

2. Write the expression for the following boundary extraction. [3 marks]



$\beta(A) = A - (A \ominus B)$

3. An input image and a marker point inside the hole of the circular object are given below. Write a pseudocode to fill this hole using morphological operations. [4 marks]



Consider the marker image be X0. Repeat dilating the image and find its intersection with inverse of the original image to contain the output within the hole.

$$X_k = (X_{k-1} \oplus B) \cap A^c, \quad k = 1, 2, 3, \ldots$$

The algorithm terminates when Xk=Xk-1.
The set union of Xk and A contains all the filled holes and their boundaries.

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Question 3 [15 Marks]

1. Compress the image using Huffman coding. Also, calculate the average number of bits/pixels needed for Huffman coding. You must show all the coding steps in the table given. And show final codes. [10 marks]

3	1	2	7	3
1	1	2	3	4
3	4	4	2	1
5	2	2	1	3
7	7	2	7	3

Pixels	Prob.	Pixel		Steps			
1	$\frac{5}{25} = 0.2$	2	0.24 01	0.24 01	0.32 00	0.44 1	0.56 0
2	$\frac{6}{25} = 0.24$	3	0.24 10	0.24 10	0.24 01	0.32 00	0.44 1
3	$\frac{6}{25} = 0.24$	1	0.20 11	0.2 11	0.24 10	0.24 01	
4	$\frac{3}{25} = 0.12$	7	0.16 000	0.16 000	0.20 11		
5	$\frac{1}{25} = 0.04$	4	0.12 0010	0.16 001			
7	$\frac{4}{25} = 0.16$	5	0.04 0011				

Avg/bit $= (0.24 \times 2) + (0.24 \times 2) + (0.2 \times 2) + (0.16 \times 3) + (0.12 \times 4) + (0.04 \times 4) = 2.48$

2. What are some common techniques used for image segmentation, and how do they differ in their approaches? [5 marks]

Several techniques are used for image segmentation, each with its approach and suitability for different types of images and applications. Some common techniques include:

Thresholding: Thresholding segments an image by dividing pixels into two groups based on a specified threshold value. Pixels with intensity values above the threshold are assigned to one segment, while pixels below the threshold are assigned to another. Thresholding is simple and efficient but may not be suitable for images with complex backgrounds or varying illumination.

Region Growing: Region growing starts with seed points and iteratively merges neighboring pixels that have similar characteristics until certain criteria, such as intensity or texture, are met. It's effective for segmenting homogeneous regions but may be sensitive to seed selection and prone to over-segmentation or under-segmentation.

Edge Detection: Edge detection identifies abrupt changes in intensity, such as edges or boundaries, and uses them to segment the image. Common edge detection algorithms include Sobel, Canny, and Prewitt. Edge-based segmentation is useful for images with well-defined boundaries but may be sensitive to noise and may not capture all desired regions accurately.

Clustering: Clustering techniques, such as k-means clustering or Gaussian mixture models, group pixels into clusters based on similarity in feature space, such as color or texture. Clustering is versatile and can handle complex image data but may require manual tuning of parameters and may only sometimes produce satisfactory results, especially in images with overlapping regions.

Black n white

Image

Matrix.

$\square \rightarrow \square$

No. of pixels
$(w \times H) = N$

~~No~~ value of black $= 0$
value of white $= 255$

$\boxed{F_1, F_2, F_3 \dots F_{332}} \rightarrow$ Label

For RGB

3 pixel matrices.

Average and append $\longrightarrow$ Label.

X

Prune to problems

1- noise → variation in background, colour & expression lead to noise.

2- Computationally expensive

3- System ~~in~~ ~~~~

crucial & non redundant data

~~HoG~~ :

Plots images pixel orientations and gradients on an histogram

Histogram of Oriented Gradients

20 degrees bin

0	20	40	60	80	100	1[illegible]

20 up-angle	40 angle ~~low~~ - low

~~low~~ bin width

~~low~~ bin width

1- Preprocessing -

Resize image ⇒ 32X64

HoG cell size : 4X4

Recommended ⇒ 64X128.

cell — 8X8 / 16X16

2- 4x4 → C8, C16.

121	10	72	9	
43	15	6	1	5
154	214	90	8	

54 2.

$G_x = 89 - 78$
$= 11$

Grad in y
$= 64 - 56$
$= 8$

$\sqrt{11^2 + 8^2}$
$= 13.6$

$\tan^{-1}(G_y/G_x)$
$= 38$ deg