Practice Questions

Q1. Histogram of a 3 bits/pixel square image is given in figure-1

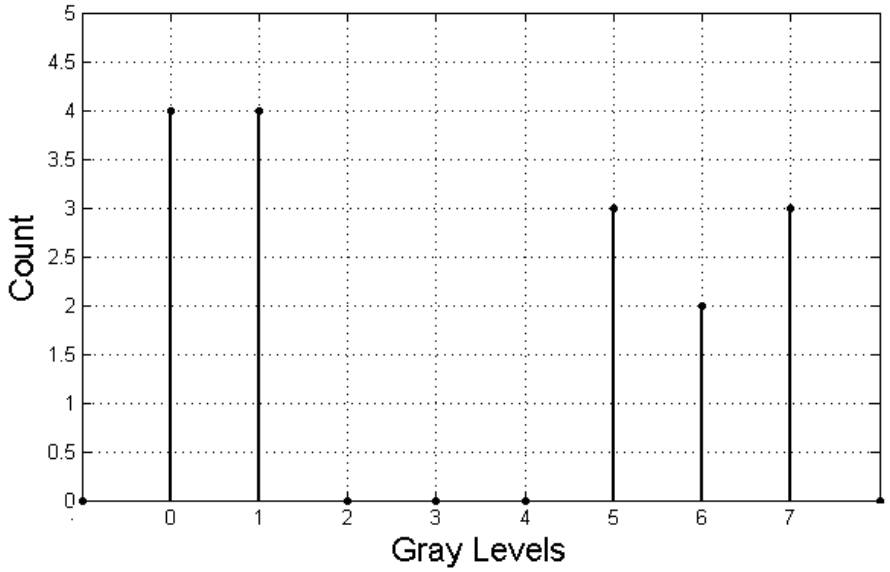


Figure-1:Histogram

a) Find out the size of image and total number of pixels **(3 + 2 = 5)**
b) What would be new histogram if we make MSB (Most significant bit) equal to 1 **(7)**
c) Compute threshold (T) such that $T = m$ where m is the mean gray level value of original image. Apply this threshold and draw new histogram for output binary image **(3 + 5 = 8)**
d) Specified normalized histogram (pdf) is given in figure below. Use histogram specification to generate histogram of enhanced image **(15)**

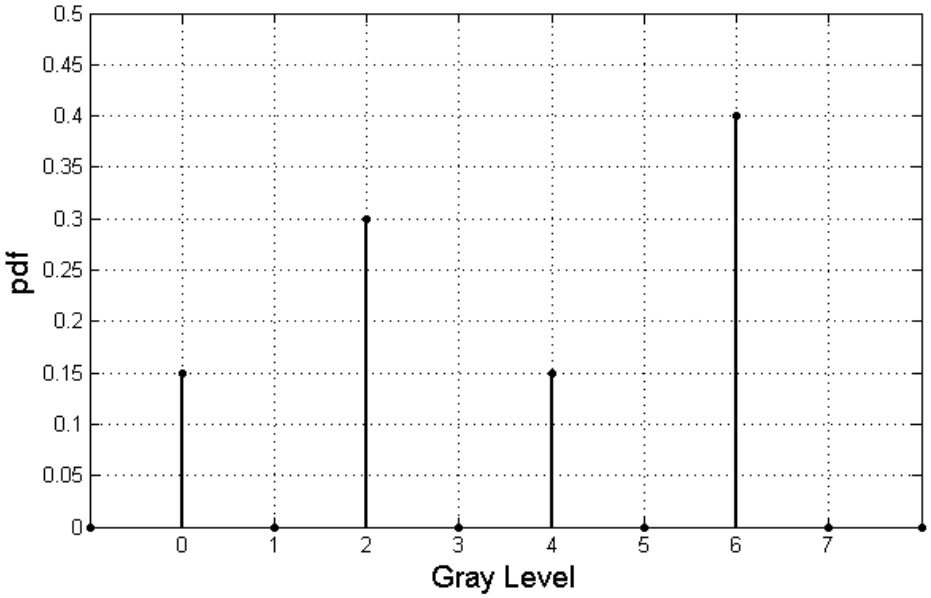


Figure 2: Specified normalized histogram

Q2. An 8x8 image is given in figure-3.

10	143	210	0	0	10	110	170
110	54	60	0	111	211	139	106
60	**63**	111	71	161	105	10	70
10	11	255	0	0	15	255	75
0	50	190	0	**112**	0	6	200
0	130	10	0	115	175	75	200
60	0	150	10	200	61	255	50

255	105	111	41	211	113	201	**106**

Figure-3: Image for question 2

a) Use 8 connectivity to find shortest path between pixels (1,1) with value 10 and (8,8) with value 106, if **(10)**

v = {0,10, 50, 54, 60, 63, 75, 106, 110}

b) A 3x3 mask is given in figure-4. Apply this mask on pixel (3,3) = 111, of image in figure-3 and compute output value for this pixel. **(7)**

-1	-2	-1
0	0	0
1	2	1

Figure-4: Mask for part (b)

c) Apply a 3x3 median filter on pixel (5,5) = 112 and compute output value for this pixel **(8)**

Part-II

Image Compression and Enhancement:

Q4. you are given a 4x4 image with 2 bits per pixel **(fig-1)**. **Marks: (10 + 5 + 5 = 20)**

a. Calculate its entropy and comment whether Huffman coding can be used for compression of this image. Also calculate compression ratio and average number of bits/pixel for this image

b. Can this image be enhanced using histogram equalization? Comment and draw the enhanced image

c. Repeat **complete part a** for image with same specifications but different intensities given in **fig-2**

1	1	2	2
3	3	0	0
2	1	1	2
3	0	3	0

Figure-1

1	3	1	1
1	1	1	3
2	2	2	0
0	2	3	2

Figure-2

Feature Extraction and Classification **Marks: (7 + 8 = 15)**

Q5. Gray level co occurrence matrix (GLCM) is used for extraction of different intensity based features from image and minimum distance classifier is a simple linear classifier which is used to separate different classes using linear boundaries. Training data for minimum distance classifier is given in table-1.

a. Find out the equation of decision boundary for **minimum distance** using training data

b. Consider the image given in **(fig-1 Q.4)**. Construct its GLCM and calculate its homogeneity and uniformity to construct a test feature vector. Use decision boundary which is found in **part a** to find out the class of given texture image.

Table-1: Training data

S No.	Uniformity	Homogeneity	Class
1	0.13	0.39	1
2	0.11	0.35	1
3	0.17	0.53	1
4	0.21	0.71	0
5	0.19	0.69	0
6	0.15	0.41	1
7	0.22	0.75	0
8	0.13	0.38	1

Image Segmentation **Marks: 15**

Q6. Thresholding is a basic step to convert a gray scaled image into a binary image using a specific threshold value. To find this threshold value is the most critical part. Assume that we have designed a basic algorithm to calculate adaptive threshold T. Algorithm for computing **T** is

1. Use initial threshold to put input image gray levels into two bins (classes)

2. Compute Global mean (M_G) for whole image, local means (m_1 and m_2) and scatters (S_1 and S_2) for both bins

3. Compute between class mean(M_B) and scatter (S_B) using abs(m_1 - m_2) and abs(S_1 - S_2)

4. Compute new T using T = M_B + S_B

5. Repeat steps (1-4) to find such T which maximizes the product of M_B and S_B

You are given a 5x5 image in fig.3. Assume initial T = 100. Run one iteration of above mentioned algorithm to find T and draw binary image after first iteration. Show all steps of your processing.

10	70	110	78	115
210	45	51	51	65
209	245	187	71	35
10	195	205	199	201
10			55	65

Figure-3

Image Fundaments **Marks: 10**

Q7. For basic concepts of signal processing, we know that when a discrete signal is upsampled (interpolated), the period of frequency spectrum is disturbed and we get extra copies in frequency domain. To get original interpolated spectrum, a digital low pass filter is applied. Same concept is applicable in case of image interpolation.

A 2x2 image is given in **fig.4**. Interpolate this by a **factor of 2** and fill in the missing values by convolving upsampled image with spatial domain low pass filter given in **fig 5**. For boundary pixels, assume zero padding.

2	3
4	5

Figure-4

0.25	0.5	0.25
0.5	1	0.5
0.25	0.5	0.25

Figure-5

Q1. **(2 + 3 = 5)**

(a) What does an isotropic filter mean? Comment on isotropic property of Laplacian filter.

(b) The difference equation for third order derivative in 1D is given. Use this equation to generate a 2D third derivative mask which can be used to calculate 3rd order derivative of an image.

$$f'''(x) = \frac{-1}{2}f(x-2) + f(x-1) - f(x+1) + \frac{1}{2}f(x-2)$$

Q2. (CLO1 -> PLO1). **(2 + 2 = 4)**

Explain intensity (gray level) and spatial resolutions. Also discuss their base operations which are performed to get each type resolution. **(No marks for lengthy answers)**

Q3. **(5)**

Unsharp masking generates sharped image ($f_{sharped}(x,y)$)by using a smoothed version ($f'(x,y)$) of actual image ($f(x,y)$). The mathematical expressions for unsharp masking are give below

$$f_s(x,y) = f(x,y) - f'(x,y)$$
$$f_{sharped} = f(x,y) + f_s(x,y)$$

Apply unsharp masking on 4x4 image given in figure-1 and draw final sharped image.

10	10	10	10
10	216	210	10
10	209	150	10
10	10	10	10

Figure-1

Q4. (CLO2 -> PLO1). **(4 + 6 = 10)**

Histogram matching is used to enhance image according to the histogram specified by the user. Figure-2 and figure-3 show the cumulative distribution functions (CDF) for original image and user specified histograms respectively. Original image is 3 bits/pixel and of size 5x5.

(a) Construct and draw normalized histogram of original image.

(b) Use your knowledge about histogram matching and construct histogram of output image.

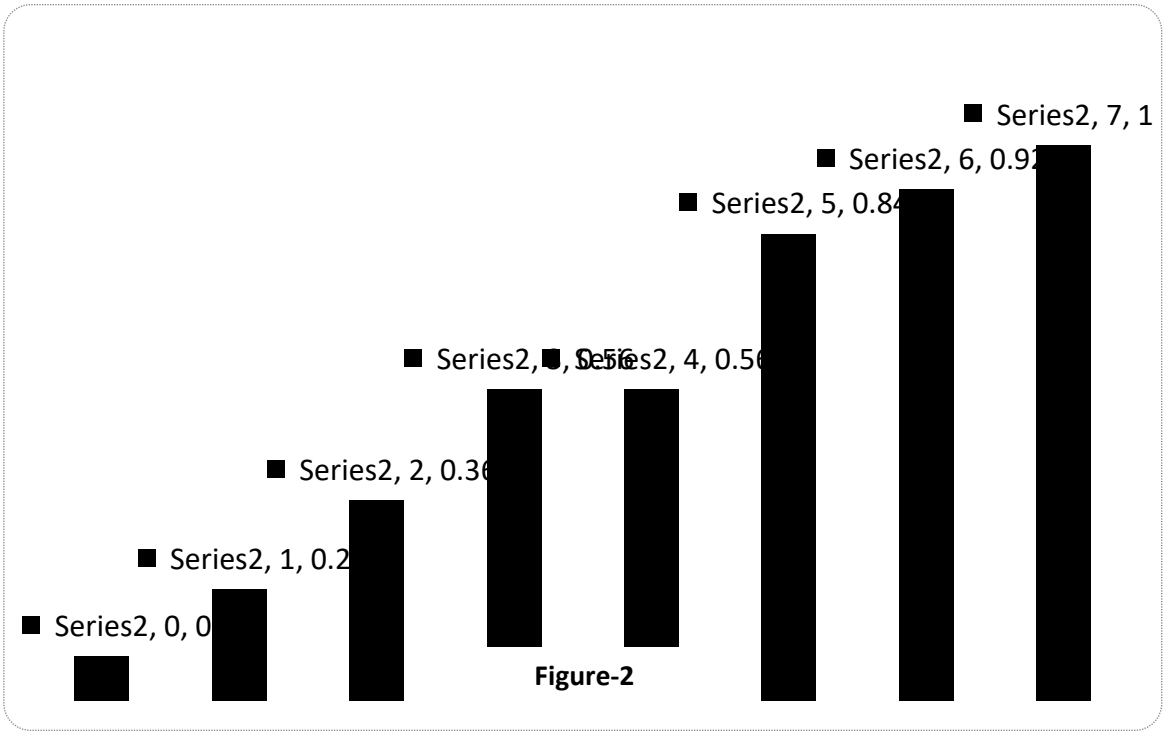


Figure-2

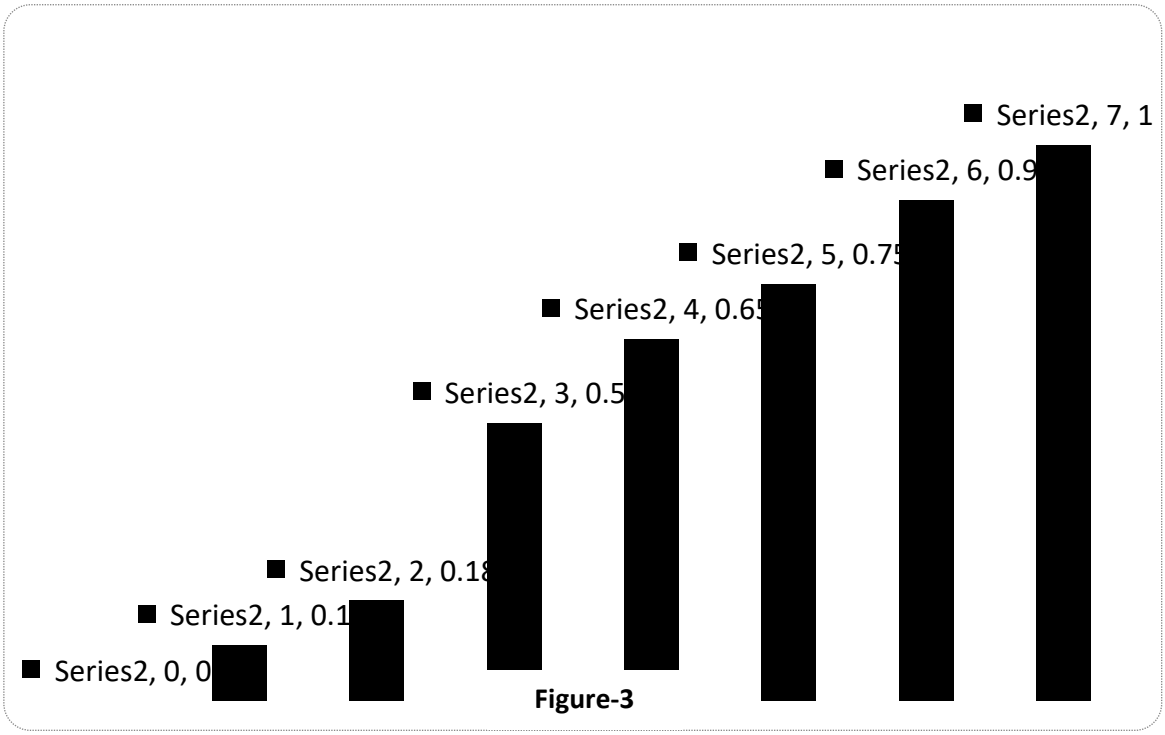


Figure-3

Good Luck

10	28	28	10
28	173	165	27
28	165	132	23
10	27	23	10

Result of Gaussian filter application on image given in figure-1

Q1. **(2 + 2 + 2 = 6)**

You are given H matrices for three randomly selected pixels from an image. Apply Harris corner detector on each of H matrix to check which type of pixels (corner, edge, flat) they represent. Assume k = 0.04.

$$H = \begin{bmatrix} I_x^2 & I_{xy} \\ I_{yx} & I_y^2 \end{bmatrix} \qquad H = \begin{bmatrix} 225 & 120 \\ 30 & 9 \end{bmatrix}$$

$$H = \begin{bmatrix} 256 & 20 \\ 30 & 400 \end{bmatrix} \qquad H = \begin{bmatrix} 25 & 20 \\ 16 & 16 \end{bmatrix}$$

Q2. (CLO2 -> PLO1) **(3 + 3 = 6)**

a. Use discrete Fourier transform to construct 2D DFT for a 4x4 image given below. Assume that indices start from (0,0)

6	6	6	6
6	6	6	6
6	6	6	6
6	6	6	6

b. Construct mathematical proof that multiplication of image by $(-1)^{x+y}$ in spatial domain causes the shifting of low frequencies to middle of Fourier spectrum

Q3. **(3 + 3 = 6)**

Suppose that we have an averaging mask which takes the average of four neighbors of any pixel (x,y) but excludes the point itself

a. Find the equivalent frequency domain filter H(u,v)

b. Show that this is a low pass filter

Q4. **(4)**

An 8x8 image is given in figure. Apply adaptive median filtering algorithm to find out the filtered value for pixel (5,5) with original value = 112. Consider initial window size equal to 3x3 and S_{max} = 7.

10	143	210	0	0	10	110	170
110	54	60	0	111	211	139	102
60	63	111	71	161	105	10	70
10	11	255	0	0	15	255	70
0	50	190	0	**112**	0	6	200
0	130	10	0	115	175	75	200
60	0	150	10	200	61	255	50
255	105	111	41	211	113	201	106

Q5. **(2 + 2 = 4)**

An 5x5 image is given in figure below. Compute the magnitude and phase for pixel (3,2) with original value = 1 using Prewitt edge detectors. Assume that indices start from (1,1).

0	0	0	1
0	0	1	1
0	**1**	1	1
1	1	1	1

Part-II

Feature Extraction and Classification **Marks: (7 + 7 = 14)**

Q4. (CLO3 -> PLO3). Intensity based features are normally based on different histogram properties. Few of them are mean, variance, skewness and range etc. Range of an image is the difference between maximum and minimum intensity values of that image.

10	15	178	192
163	163	155	180
172	171	111	12
153	10	173	10

Train-4

211	199	210	201
132	150	190	180
177	173	171	210
183	190	183	220

181	215	110	191
152	220	230	180
217	213	161	210
203	190	183	220

110	155	18	12
13	13	155	10
132	171	181	172
13	160	173	160

5 mean = 103

161 skewness = - 0.381

range = ?

211	175	160	191
152	120	130	180
70	213	161	190
83	190	23	160

Test

a. Suppose that we are designing a system which uses image mean, skewness and range as features and KNN as classifier to differentiate between two classes of textures. Assume that tran-1 and train-4 images belong to one class of texture and remaining two training images belong to other class of textures. Create complete training dataset containing feature values for all images including their respective labels

b. Use KNN with K = 3 to find the class of test image.

Answer:

Q5. Image Compression **Marks: (7 + 3 = 10)**

1) (CLO2 -> PLO1). Huffman coding is used for lossless image compression. Suppose that we have a 3 bit 3x3 image. This image is coded using variable length Huffman coding and transferred over a wireless channel. The received bit stream and coding booking are given below.

Bit stream: 0 0 0 0 1 0 1 0 0 1 0 0 0 1 1 1 0 1 1

Gray Level	0	1	2	3	4	5	6	7
Huffman Code	001	0000	0001	1	-	-	-	01

a. Use given code book to decode the received bit stream and generate original image. Assumed that the data is transferred pixel by pixel starting from top left pixel which is (1,1). Also assumed that leftmost bit is received first and decoding should start from left most bit.

b. What is the average number of bits/pixel for this data? Use this to calculate compression ratio.

2) Define spatial redundancy with help of an example

Answer:

Q6. Image Filtering **Marks: 6**

An image has been smoothed using 1D kernel: k[1 5 10 10 5 1]. What should be the constant k so that the filter gain is equal to 1? Can repeated convolutions of an image with the kernel ½[1 1] be used to obtain the same result as with the first kernel. If yes, how many convolutions are needed? If no, explain the reasons why.

Answer:

Q7. Textures **Marks: 6**

Rearrange the given values of texture descriptors by matching them to best suitable texture type.

Texture Type	Entropy		Smoothness		Uniformity		Correlation	
Regular	7.132		0.001		0.015		0.891	
Smooth	9.451		0.071		0.031		0.001	
Coarse	4.232		0.019		0.002		0.932	

Q8. Morphological Operations **Marks: (4 + 6 = 10)**

Morphological operations can be used to detect boundary of objects present in a binary image. Which operations are used for this? If we want to extract a 3 pixel wide boundary then what will be the size of structuring element?

Answer:

0	0	0	0	0	0	0
0	1	0	0	0	0	0
0	1	1	**0**	1	0	0
0	1	0	0	0	0	0

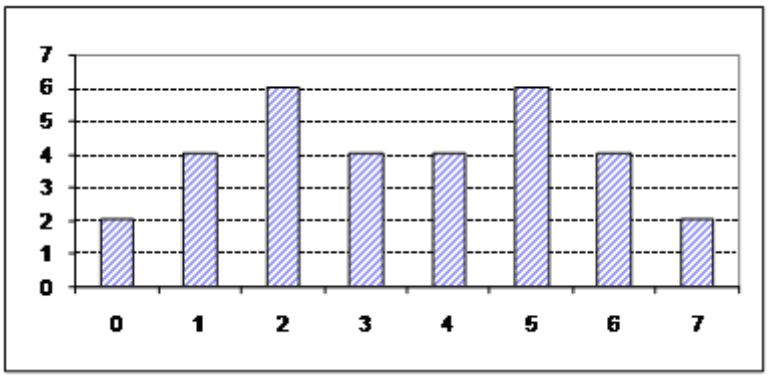
a. Morphological operations are used to fill in the gaps between objects. An 8x8 image is given below. We want to use morphological operations to fill in the gaps present at pixels (3,4) and (6,3). Which operation will be used to fill this gap while keeping rest of the object same. Also give the size and type of structuring element which is suitable for this. Show your final output as well.

0	1	0	0	0	0	0
0	1	**0**	1	1	1	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

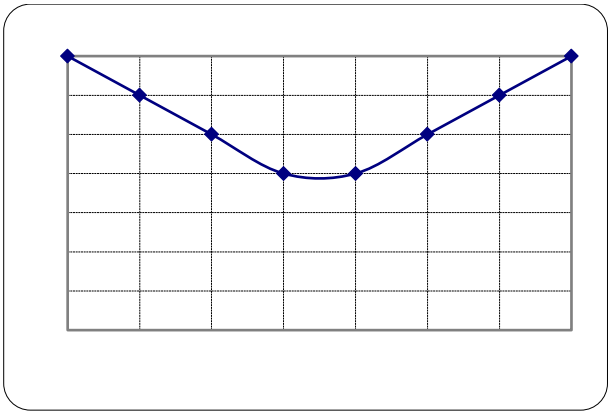
Answer:

Q9. Intensity Transformation (CLO1 -> PLO2). **Marks: 4**

The histogram of a ***3-bit*** image is shown in the following



What would be the histograms of the output image if the following transformation is applied to this image?



Answer:

Q1. **(4 + 4 + 2 = 10)**

a. Run length coding is used to compress images having spatial redundancy. A binary image is encoded using run length code row by row, where “0” represents black, and “1” represents white. The code is given below. Construct original image using this code

Row 1: “1”, 2, 2, 2
Row 2: “1”, 1, 1, 2, 1, 1
Row 3: “0”, 1, 4, 1
Row 4: “1”, 6
Row 5: “0”, 1, 4, 1
Row 6: “1”, 1, 1, 2, 1, 1

b. Huffman coding is used for lossless image compression. Suppose that we have a 4 bit 4x4 image. This image is coded using variable length Huffman coding and transferred over a wireless channel. The received bit stream and coding book are given below.

Bit stream: 0000100001001100011001101111000010011 1

Gray Level	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Code	01	-	-	-	000	-	-	001	-	-	-	10	-	-	-	11

1. Use given code book to decode the received bit stream and generate original image. Assumed that the data is transferred pixel by pixel starting from top left pixel which is (1,1). Also assumed that leftmost bit is received first and decoding should start from left most bit.

2. What is the average number of bits/pixel for this data? Use this to calculate compression ratio.

Q2. (CLO2 -> PLO2) **(7)**

Crossing number method is most commonly used for minutiae extraction from fingerprint images. It takes a thinned binary image as input and minutiae are extracted by scanning the local neighborhood of each ridge pixel (pixel with value = 1) in the image using a 3X3 window (given below). For each center pixel, it uses following equation to find CN value for that pixel. Apply this algorithm on binary image given below and construct an output image containing CN value for each processed pixel.

$$CN = 0.5\sum_{i=1}^{8} | P_i - P_{i+1} |$$

(Note: Run this algorithm for ON pixels only. No need to run it for boundary pixels. Also $P_9=P_1$).

P_6	P_7	P_8
P_5	P	P_1
P_4	P_3	P_2

Q3. **(8)**

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

Median filters are used to remove noise from image especially salt and pepper noise. However, user has to define the window size before applying filter. On the other hand, adaptive median filter changes size of Sxy (the size of the neighborhood) during operation. The algorithm for adaptive median filter is given below.

- Notation

  Zmin = minimum gray level value in Sxy
  Zmax = maximum gray level value in Sxy
  Zmed = median of gray levels in Sxy
  Zxy = gray level at coordinates (x, y)
  Smax = maximum allowed size of Sxy

- Algorithm

Level A: A1 = Zmed - Zmin
A2 = Zmed - Zmax
if A1 > 0 AND A2 < 0, go to level B
else increase the window size
if window size < Smax, repeat level A
else output Zxy

Level B: B1 = Zxy - Zmin
B2 = Zxy - Zmax
if B1 > 0 AND B2 < 0, output Zxy
else output Zmed

An 8x8 image is given in figure below. Apply this algorithm on pixel (5,5) only with original value = 112 image. Give final value for this pixel after applying adaptive median filtering.

10	143	210	0	0	10	110	170

110	54	60	0	111	211	139	102
60	63	111	71	161	105	10	70
10	11	255	0	0	15	255	70
0	50	190	0	**112**	0	6	200
0	130	10	0	115	175	75	200
60	0	150	10	200	61	255	50
255	105	111	41	211	113	201	106

Q4. (CLO1 -> PLO1). **(2x5 = 10)**

Give brief (2-3 lines) answers for following questions. **(No marks for lengthy answers)**

1. Explain the difference between RGB and HSI color spaces

_____

_____

_____

2. Explain the difference between Spatial and temporal redundancy

_____

_____

_____

3. Differentiate between classification and clustering

_____

_____

_____

4. What is the difference between adaptive and empirical thresholding

_____

_____

_____

5. Explain the difference between HIT and FIT operations in image morphology

_____

_____

_____

Q5. (CLO3 -> PLO3). **(8+7=15)**

Gray level co-occurrence matrix (GLCM) is used for extraction of different intensity based features from image considering pixel location as well. One of the image properties which can be computed using GLCM is Contrast of image. We have 9 texture images belonging to 2 different classes. 8 out of 9 are being used as training data and one image is taken out as testing image. Contrast is calculated as feature for training data and is plotted as shown in figure below.

1. Now consider the test image given below. Construct its GLCM by assuming direction vector as next pixel on right and then compute its contrast.

0	0	1	1
2	2	1	0

0	0	0	3
2	3	3	1

2. Use KNN with k = 3 to classify this test image into one of the two classes given above.

Q6. (CLO1 -> PLO2). **(4x6 = 10)**

1. Image thresholding is used to segment different objects from image. In local thresholding, the image is divided into different non overlapping sub images and threshold is calculated and applied on all images independently. You are given 6x6 gray scaled image (f). Divide this image into 4 non overlapping subimages (g_i) of size 3 x 3 each where I = 0, 1, 2, 3. Calculate threhold T_i for each subimage such that $T_i = 0.5*(max(g_i) – min(g_i))$ and apply it on image to generate binary image.

10	98	121	78	63	180
15	80	110	83	105	170
60	87	152	30	62	165
15	210	150	45	48	73
71	105	85	57	59	75
78	10	175	51	53	5

2. Morphological operations are applied on image to make any structural changes. Apply following equation on binary image created in first part. Here A is binary image, B is 3 x 3 structuring element given below. Assume that $X_0 = A^c$ and iterations will stop if $X_{k+1} = X_k$.

$$X_{k+1} = (X_k \ominus B) \cup A$$

0	1	1
0	1	0
0	1	0

Q7. **(7)**

An image has been smoothed using 1D kernel: k[1 5 10 10 5 1]. What should be the constant k so that the filter gain is equal to 1? Can repeated convolutions of an image with the kernel ½[1 1] be used to obtain the same result as with the first kernel. If yes, how many convolutions are needed? If no, explain the reasons why.

Q8. **(5)**

You are given 3 textures and their values for different GLCM based texture descriptors. Fill in the empty cells with image number by analyzing the given value against that cell.

Image-1

Image-2

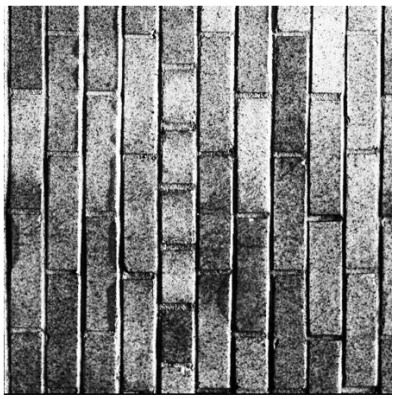
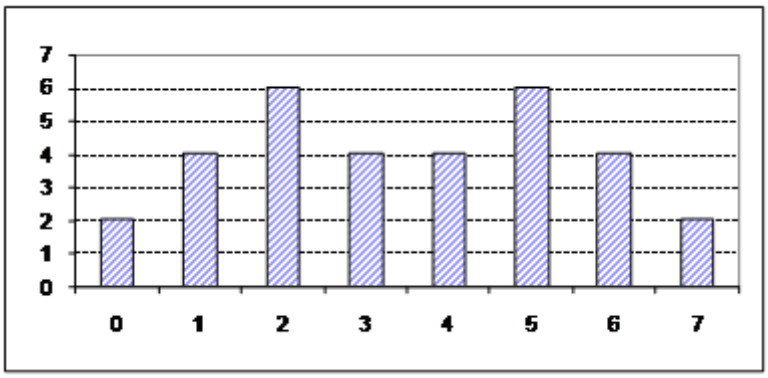


Image-3

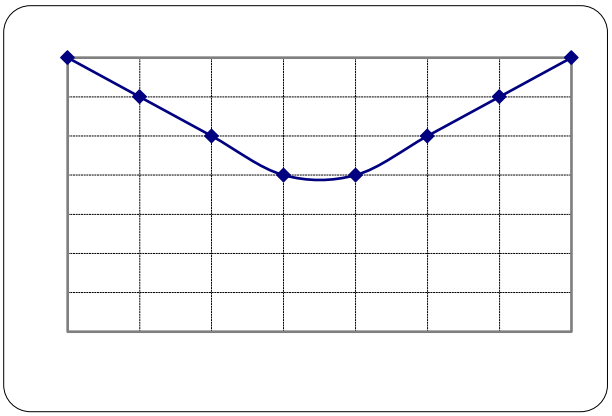
Contrast		Homogeneity		Uniformity	
2.2164		0.9898		0.0316	
0.2415		0.8814		0.2367	
0.1021		0.6347		0.1494	

Q9. **(8)**

The histogram of a ***3-bit*** image is shown in the following



What would be the histograms of the output image if the following transformation is applied to this image?



Q1. **(3 + 2 + 2 = 7)**

Using 8-connectivity, perform Connected Component (CC) labeling on the following binary image and show:

1. The result after first pass of the CC labeling algorithm. Do clearly highlight the preference sequence which you have assume while applying first pass.
2. The equivalence table
3. The final result after the second pass of the labeling algorithm

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

Q2. (CLO1 -> PLO1). **(2 + 2 + 2 = 6)**

Give brief (2-3 lines) answers for following questions. **(No marks for lengthy answers)**

6. Explain Weber ratio with help of its mathematical expression
7. Explain the difference between monochromatic and chromatic light
8. Differentiate between checker board effect and false contouring

Q3. **(4)**

A mask is defined with following mathematical expression

$$f(x-2,y) + 2f(x-1,y) + 2f(x+1,y) + f(x+2,y) + f(x,y-2) + 2f(x,y-1) + 2f(x,y+1) + f(x,y+2) - 12\,f(x,y)$$

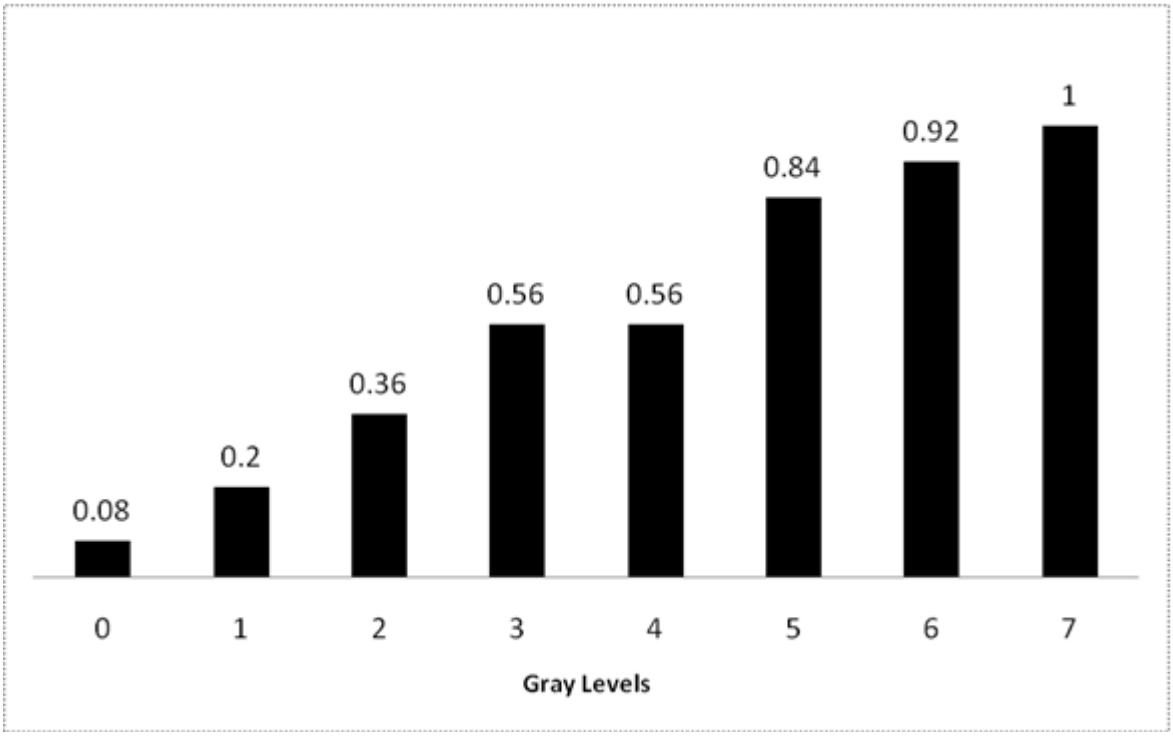
Draw this mask

Q4. (CLO2 -> PLO1). **(4 + 6 + 3 = 13)**

Image histogram shows the distribution of gray levels in an image. Figure below shows the cumulative distribution functions (CDF) for 5x5 image with 3 bits/pixel.

1. Construct and draw original histogram of image.
2. Use histogram equalization to perform image enhancement and draw new equalized histogram

3. How the histogram obtained in part (1) would change if we make least significant bit (LSB) plane = 0. Draw new histogram.



Q1. **(2 + 2 + 2 = 6)**

An 8x8 image is given in figure. Apply 3x3 min, max and median filters on pixel (5,5) with original value = 112. Give output value of pixel (5,5) for all three filters separately.

10	143	210	0	0	10	110	170
110	54	60	0	111	211	139	102
60	63	111	71	161	105	10	70
10	11	255	0	0	15	255	70
0	50	190	0	**112**	0	6	200
0	130	10	0	115	175	75	200
60	0	150	10	200	61	255	50
255	105	111	41	211	113	201	106

Q2. **(2 + 2 + 2 = 6)**

Give brief (2-3 lines) answers for following questions. **(No marks for lengthy answers)**

9. Explain ringing effect in frequency domain
10. Explain the isotropic property of filters
11. Differentiate between butterworth and ideal filters

Q3. (CLO2 -> PLO1) **(4 + 4 + 4 = 12)**

a. Use discrete Fourier transform to construct 2D DFT for 5x5 image given below. Assume that indices start from (0,0)

2	2	2	2	2
2	2	2	2	2

2	2	2	2	2
2	2	2	2	2
2	2	2	2	2

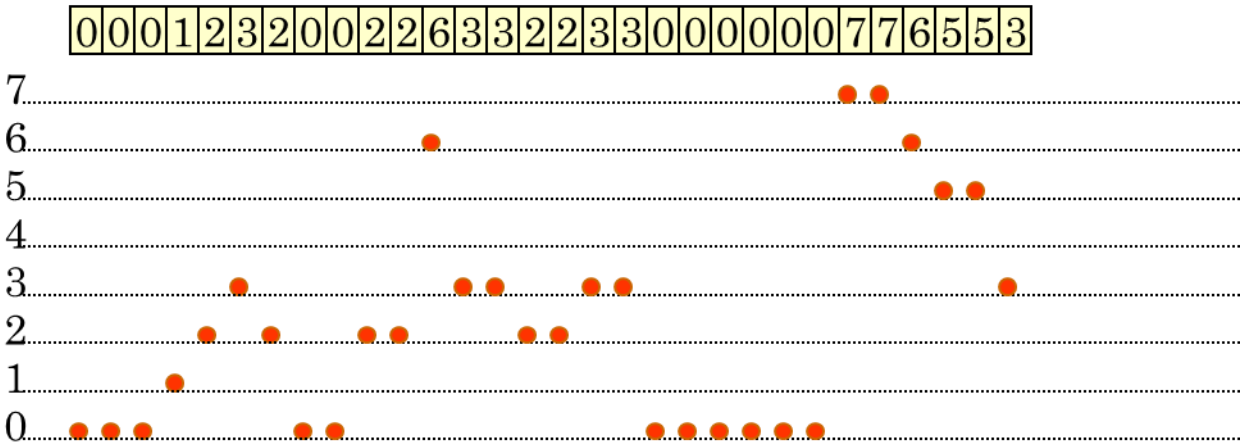
b. Design an ideal low pass filter (LPF) to apply on above given image. Do consider city block distance while designing LPF and $D_0 = 2$.

c. Apply this filter on DFT of given image and then compute the inverse 2D DFT to make final spatial domain image.

(Note: You should not need any extensive computing in this question. Don't waste your time on extra computations. Use your knowledge about DFT and think critically).

Q4. (CLO2 -> PLO1). (3 + 3 = 06)

A 3 bit 5x6 image is reshaped into a 1x30 vector. The intensities and their values are given below. Apply 1st and 2nd order derivatives on it. Fill in the cells given below


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