Text book

9.5, 9.6, 9.7, 9.8, 9.14, 11.17, 11.18, 11.19, 12.1, 12.2, 12.3, 12.11

Q1. Answer following short mathematical questions **Marks: 24**

c. 2D Fourier transform of a 3x3 spatial mask is given as

$$H(w_1,w_2) = 2j(\sin(w_1) + \sin(w_2))$$

Find out the spatial mask and fill the following 3x3 grid. Also comment whether it is a highpass or lowpass filter. Assume that the coordinates of center pixel are (0,0).

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Q2. Answer following questions briefly and within the allocated space. **No marks for lengthy answers** **Marks: (2 x 9 = 18)**

b. What is the major difference between K-means clustering and KNN classifier?

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i. Can Fourier transform be used to detect translation between objects? If not then why?

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

Q4. 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)**. Construct its GLCM by assuming direction operator as next pixel on right side 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.

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

Figure-1

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 Fundaments **Marks: 7**

Q5. A 2x2 image is given in **fig.2**. 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 3**. For boundary pixels, assume zero padding.

2	3
4	5

Figure-2

0.25	0.5	0.25
0.5	1	0.5
0.25	0.5	0.25

Figure-3

Algorithm Designing **Marks: 10**

Q8. Design an algorithm which computes the width of a non uniform tube at each pixel from a binary image. Assume that ON pixels represent a tube and OFF pixels represent background.

Q1 Design Problem **Marks: (2 + 2 + 4 + 2 + 10 + 10 + 5 + 10 = 45)**

Most of image processing based algorithms consist of three phases i.e. Preprocessing, feature extraction and classification. Based on this we are asked to design an algorithm for detection of different lesions from colored medical images. The medical problem which we are dealing with consists of two types of lesions i.e. bright and dark. The designed system consists of following steps

1. **Preprocessing:**

In preprocessing we generate a binary map for input image containing all possible lesion objects. It consist of following steps

I. Extracting green channel from colored image as it is giving the best contrast for images under consideration
II. Applying threshold on green channel to get binary image
III. Removing objects with area less than 10 pixels to form final binary image

2. **Feature Extraction:**

In feature extraction, each region in binary image is represented with a number of features to ease the classification stage. Four features are extracted for each region

I. Area (F1): which is the total number of 'on' pixels any region have in binary image.
II. Mean green channel intensity (F2): It is the mean value of green channel intensities for all pixels inside any region.
III. Normalized Energy (F3): It is the calculated by computing the sum of squares of green channel intensities and dividing it by total number of pixels any region have.
IV. Mean Saturation (F4): It is the mean value of saturation for all pixels inside any region. Saturation is calculated from original colored image using expression given below

$$S = 1 - \frac{3}{(R+G+B)}\left[\min(R,G,B)\right]$$

3. **Classification:**

The last stage is classification for which we have two options available i.e. knn classifier. We are using these two because the data is linearly separable. This stage classifies each region in one of the possible output class which are dark or bright

Table -1 shows the training dataset for training of classifier

Table-1: Dataset for question-1

F1	F2	F3	F4	Class
10	30	937	0.98	Dark
15	25	840	0.65	Dark
11	33	1015	0.93	Dark
9	29	947	0.85	Dark
15	98	1432	0.75	Bright
21	118	1120	0.79	Bright
24	121	1590	0.83	Bright
18	101	1005	0.78	Bright

Now a test colored image of size 10x10 is given to you in figure-1. Each pixel contains three values (R, G, B). For example for pixel (1,1), Red = 212, Green = 9 and Blue = 114. You have to apply the proposed system explained above to detect lesions from this image. Do following things

I. Extract Green channel from given image
II. An empirical threshold value of 24 for green channel is calculated. Apply this threshold to get binary image from green channel.
III. Use 8-connectivity algorithm to find number of objects from binary image
IV. Remove all those objects which have area less than 10 pixels
V. Now for each object, calculate all four features and represents each object with a feature vector
VI. Classify test data using knn classifier with k = 5.

212, 9, 114	102, 10, 181	37, 22, 185	217, 3, 44	110, 20, 69	111, 15, 69	42, 7, 121	65, 17, 236	109, 21, 4	215, 2, 252
46, 34, 209	113, 18, 212	125, 25, 0	126, 28, 0	128, 30, 1	131, 33, 4	2, 1, 86	234, 11, 189	156, 21, 40	230, 8, 156
34, 24, 26	40, 16, 9	127, 28, 0	126, 28, 0	130, 32, 3	134, 37, 5	197, 21, 249	194, 4, 145	219, 2, 121	240, 17, 65
225, 8, 220	84, 12, 194	126, 28, 0	129, 31, 2	128, 31, 0	131, 34, 1	196, 4, 142	227, 19, 248	172, 14, 139	208, 13, 34
12, 9, 8	81, 12, 245	8, 12, 24	92, 22, 170	219, 1, 174	174, 1, 174	108, 22, 216	18, 7, 211	134, 22, 16	1, 25, 139
176, 22, 230	229, 24, 88	193, 22, 7	171, 117, 27	173, 119, 29	172, 121, 30	176, 124, 38	174, 124, 37	176, 126, 37	1, 19, 212
188, 9, 230	63, 3, 163	179, 12, 126	174, 123, 34	173, 122, 33	174, 122, 36	173, 121, 37	173, 123, 38	175, 125, 40	23, 15, 214
112, 4, 134	80, 7, 88	55, 13, 71	174, 122, 36	174, 122, 38	169, 117, 34	167, 115, 32	167, 115, 32	172, 121, 38	67, 8, 213
97, 13, 31	105, 12, 56	174, 13, 87	177, 125, 42	171, 118, 38	169, 113, 36	164, 108, 31	155, 102, 24	167, 114, 36	6, 7, 52
250, 22, 46	181, 15, 201	143, 6, 74	65, 10, 158	134, 16, 16	139, 23, 8	137, 17, 134	128, 1, 233	227, 20, 72	109, 23, 139

Figure-1: Colored image for question 1

Q2. Colored Based Image Clustering
Marks: 10

Colored based image clustering is used to put pixels having similar color shades in one cluster. Suppose we want to convert the colored image given in figure-1 into three color clusters (C1, C2, C3). The centers for these clusters are given.

C1 = (210, 20, 45)   C2 = (45, 198, 15)   C3 = (21, 15, 183)

You are asked to place **pixels (1, 5) and (10,10)** of image given in figure-1 in one of these three clusters. Use K-means clustering and given cluster centers to solve this.

Assume that the first pixel in top left corner is (1,1).

Q3. Image Compression
Marks: 10

Rainbow colors has following probabilities

V=0.3   I=0.3   B=0.13   G=0.1   Y=0.12   O=0.05

Carry out Huffman coding of above events and decode the following string from left to right

0000111010110001000000111

Image Morphology **Marks: 8+7 = 15**

Q 1. (a) You are given a morphological operation

$$X = (A \ominus B) \cup A^c$$

where A and B are binary image and structuring element respectively. Find out X by filling empty images given below

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

A

0	1	0
1	1	1
0	1	0

B

A^c

$(A \ominus B)$

X

(b) A 7x7 gray scale image (f) is given. Apply top hat transformation at pixel (3, 3) by using a flat structuring element (b) of size 3x3.

Assume that row and col indices start from 1.

$$T_{hat}(f) = (f - (f \circ b))$$

10	10	15	5	20	50	40
30	10	10	10	10	10	50

10	30	**30**	30	30	20	45
100	30	30	30	10	25	35
20	30	0	20	20	30	30
20	0	10	0	20	10	10
40	40	50	45	30	20	10

Edge Detection
Marks: 10
Q 2. Consider the image given below. Find out gradient magnitude and angle for pixel (3, 3) by applying sobel operators**.** Also find out the direction of edge for same pixel.
Assume that row and col indices start from 1.

10	10	15	5	20	50	40
30	10	10	10	10	10	50
10	30	**30**	30	30	20	45
100	30	30	30	10	25	35
20	30	0	20	20	30	30
20	0	10	0	20	10	10
40	40	50	45	30	20	10

Q 4. Gray level co-occurrence matrix (GLCM) is used for texture analysis. A 2 bits/pixel texture image is given below. Construct its GLCM if position operator is defined as **"one pixel to right and one pixel down".**

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

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	191	15	55	65

Q1. A 5x5 gray scaled image is given in figure-1. This image contains a bright region on a relatively dark background. Apply following steps to extract that region properly **(2 + 7 + 3 = 12)**

191	110	115	207	171
159	90	207	206	179
155	210	175	145	210
147	205	177	192	191
160	165	192	191	90

Figure-1: Image for Q1

a. Find a threshold T to convert this image into binary such that

$$T = max(f(x,y)) - k*min(f(x,y))$$

where *max(f(x,y))* and *min(f(x,y))* are maximum and minimum gray levels in image respectively and *k = 0.3*

b. Use morphological region filling operation to fill gaps if present in binary objects obtained from **part a**

c. Apply a proper morphological operation on **output of part b** with suitable structuring element to remove small objects while keeping only main bright region. Draw final output binary image

Q2. Edge detection algorithms are normally based on image gradient. You are given two 3x3 gradient images which are generated by applying horizontal (fig-2) and vertical (fig-3) sobel operators on same image. **(4 + 6 = 10)**

-30	-190	-330
-150	-450	-450
30	190	330

Figure-2: Horizontal sobel output

-30	-150	30
-190	-450	190
-330	-450	330

Figure-2: Vertical sobel output

a. Use these gradient images to find out gradient magnitude image and generate a binary edge map by applying threshold on gradient magnitude image. The threshold is set in such a way that edges with top 25% gradient magnitude value are kept and rest all are ignored.

b. *K means clustering* is applied on gradient magnitude image which is generated in part a with $K = 2$ and centers of both clusters (C_A, C_B) are found. $C_A = 610$ and $C_B = 550$ are centers for cluster A and cluster B respectively. Cluster A consists of all corner pixels and cluster B contains all other pixels. Use these cluster centers and gradient magnitude image to find the location of corner pixels. Draw output binary image showing corner pixels with '1' and other pixels with '0'.

Q3. Differentiate the followings **(Your answer should not be longer than 3 lines.) (2 + 2 = 4)**

a. Median filtering and adaptive median filtering