The LNM Institute of Information Technology

ECE and CCE

ECE4141: Introduction to Image Processing

Mid Term

Time: 90 minutes **Date:** 27/09/2018 **Max. Marks: 30**

Instructions: *1) Start each answer on a fresh page of your answer book and highlight your answer number.*
*2) Check that your Question paper has **3 sections and 13 Questions**.*

Q1 Answer all questions **[6 X 1M = 6M]**

a) How will the frequency domain content (DFT) change if the input image is rotated by an angle of 'A' in spatial domain?

Ans: The frequency domain content is also rotated by an angle of 'A' (DFT property)

b) Given following 3 x 3 image (**Fig. 1**) which has 8 intensity levels in it. It is required to do bit plane slicing of the given image. What is the 2^{nd} bit plane of the image?

5	7	3
0	5	0
1	0	2

Fig. 1

Ans:

0	1	1
0	0	0
0	0	1

c) What is the storage space required to save 512 x 1024 image having 512 intensity levels.

Ans: 512 x 512 x 9

d) If the pixel of an image are shuffled, then which of the following parameters may change?

i) Histogram ii) Mean
iii) Entropy iv) Covariance

Ans: Covariance

e) Small value of gamma (less than 1) will produce ____________ image. (darker/brighter)

Ans: brighter

f) How is an image digitized? Briefly explain the steps.

Ans: Sampling → digitization of the coordinates
Quantization → digitization of the intensity values

Q2 Answer any 3 questions **[3 x 3M=9M]**

a) Let V = {0, 1}. Show the shortest 4-path, 8-path and m-path between ‘p’ and ‘q’ shown in **Fig. 2**. Also find the chessboard distance and city-block distance between ‘p’ and ‘q’.

	3	1	2	1 ← q
	2	2	0	2
	1	2	1	1
p →	1	0	1	2

Fig. 2

Ans:

When V={0, 1}, 4-path does not exist. The shortest 8-path has length = 4 (as shown in blue line fig. 1a) and the shortest m-path has length = 5 (as shown in red line in fig. 1a).

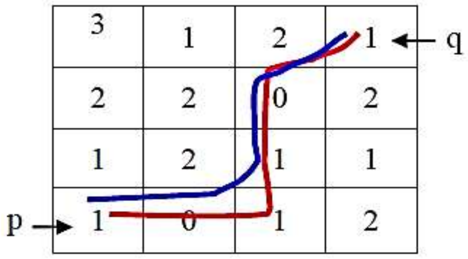


Fig. 1a

Chessboard distance : 3
City block distance : 6

b) Explain how image compression can be achieved through K-L Transform.

Ans:

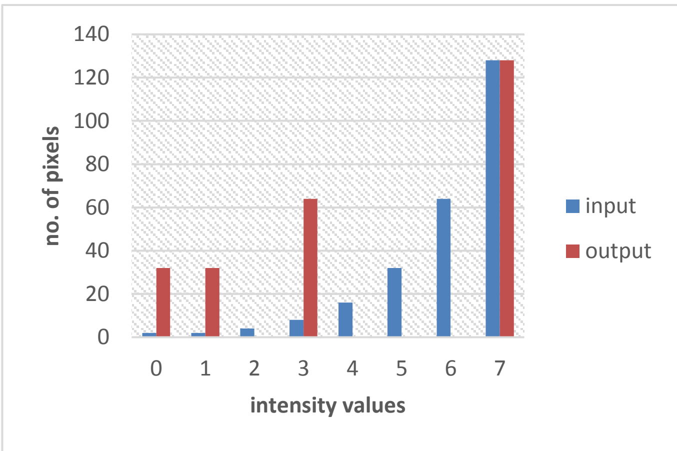
- The input matrix ‘X’ will be formed by considering each row/column of the given image.
- Find the mean
- Find covariance from the mean and the input matrix
- Find the eigen values and corresponding eigen vectors from the covariance
- The eigen vectors are arranged in the decreasing order of the eigen values.
- A matrix ‘A’ of the eigen vectors are formed column wise in which the first column of eigen vector corresponds to highest eigen value and then it is arranged in decreasing order.
- KLT formula: $Y = A(X - \mu_x)$
- The eigen vectors with highest value has the maximum information of the image. In ‘A’ matrix, we shall remove some insignificant eigen vectors at the end by making it 0. The new matrix is ‘A^T’
- Then we apply inverse KLT formula $X = A^T Y + \mu_x$ to achieve the desired compressed image.

c) Consider the histogram (2, 2, 4, 8, 16, 32, 64, 128), where the number of gray levels is 8. What is the output of histogram equalization? Explain using result how histogram equalization enhances the contrast of an image.

Ans:

Input intensity	No. of pixels	PDF	CDF	Output intensity
0	2	0.0078	0.0078	0
1	2	0.0078	0.0156	0
2	4	0.0156	0.0312	0
3	8	0.0313	0.0625	0
4	16	0.0625	0.1250	0
5	32	0.1250	0.2500	1
6	64	0.2500	0.5000	3
7	128	0.5000	1	7
Total:	256			

Thus histogram for input and output is given as follows:



Histogram equalization distributes pixel values throughout a range, thus, equalizing and making the histogram more "normal" shaped. It transform the data/contrast level to spread through the spectrum of 0-255 equally by using CDF. This process boost the lower contrast of the darker region thus making parts of an image more 'visible'.

d) In the following image (**Fig. 3**), all pixels with value '1' constitutes a region.

i. Mark the boundary pixels of the region using 4-connectivity and 8-connectivity.

ii. Also show the different 'm' path possible between pixels 'p' and 'q'.

			p			
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	1	1	0	0
0	1	1	1	1	1	0
0	1	1	1	1	0	0
0	1	1	1	0	0	0
0	1	0	1	0	0	0
0	0	0	0	0	0	0
			q			

Fig. 3

Ans:

(i)

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

Using 4 connectivity

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

Using 8-connectivity

(ii)

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

M path (2 path has been shown – many such path is possible)

Q3 Answer all questions **[3 X 5M =15M]**

a) Given following 4 x 4 image (**Fig. 4**). Show the output of the image after applying:

i) unsharp masking
(using 3 x 3 median filter for smoothening, apply zero padding for boundary pixels)

ii) high boost filtering with A = 2
(can be shown for 1st row only)

8	4	4	5
6	3	3	2
1	5	4	3
2	5	1	2

Fig. 4

Ans:

i) Steps:

- Blur the image (done by median filter)

0	3	3	0
3	4	4	3
2	3	3	2
0	1	2	0

- $f_{sharp} = 2f(x,y) - f_b(x,y)$

16	5	5	10
9	2	2	1
0	7	5	4
4	9	0	4

ii) The high boost filtering mask (A=2) will be:

0	-1	0
-1	6	-1
0	-1	0

Applying it in 1st row, we get

38	9	12	24

b) Perform the intensity level slicing on the following 3 bit image (**Fig. 5**). Let $r_1 = 3, r_2 = 5$ and $s = 7$, where r_1 and r_2 are the input intensities and s is the output intensity for input between r_1 and r_2. Obtain the image:

i) with background transformation (i.e. background = 0)

ii) without background transformation.

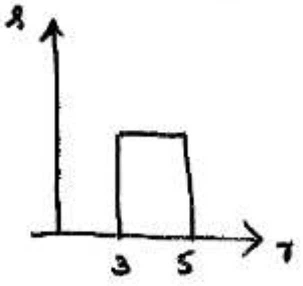
2	1	2	2	1
2	3	4	5	2
6	2	7	6	0
2	6	6	5	1
0	3	2	2	1

Fig. 5

Also show the transformation plots used in this question.

Ans:

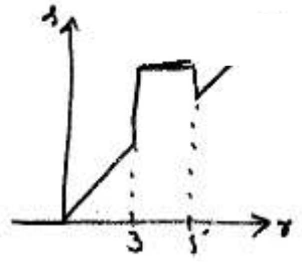
i) The transformation function is:



Output image:

0	0	0	0	0
0	7	7	7	0
0	0	0	0	0
0	0	0	7	0
0	7	0	0	0

ii) The transformation function is:



Output image:

2	1	2	2	1
2	7	7	7	2
6	2	7	6	0
2	6	6	7	1
0	7	2	2	1

c) Determine the 2D DFT of the following image (**Fig. 6**)

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

Fig. 6

Ans:

First we perform the 1D DFT on the rows: (you may also start with column first)

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 5 \\ -3 \\ 1 \\ -3 \end{bmatrix}$$ ->DFT of 1st row

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 2 \end{bmatrix} = \begin{bmatrix} 8 \\ -2 \\ 0 \\ -2 \end{bmatrix}$$ ->DFT of 2nd row

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 3 \\ 3 \\ 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 11 \\ 1 \\ -1 \\ 1 \end{bmatrix} \text{-> DFT of } 3^{rd} \text{ row}$$

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 2 \end{bmatrix} = \begin{bmatrix} 8 \\ -2 \\ 0 \\ -2 \end{bmatrix} \text{-> DFT of } 4^{th} \text{ row}$$

Hence we have an intermediate output:

$$\begin{bmatrix} 5 & -3 & 1 & -3 \\ 8 & -2 & 0 & -2 \\ 12 & 1 & -1 & 1 \\ 8 & -2 & 0 & -2 \end{bmatrix}$$

Next, we find the 1D DFT on the columns of the above matrix:

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 5 \\ 8 \\ 11 \\ 8 \end{bmatrix} = \begin{bmatrix} 32 \\ -6 \\ 0 \\ -6 \end{bmatrix} \text{-> DFT of } 1^{st} \text{ column}$$

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} -3 \\ -2 \\ 1 \\ -2 \end{bmatrix} = \begin{bmatrix} -6 \\ -4 \\ 2 \\ -4 \end{bmatrix} \text{-> DFT of } 2^{nd} \text{ column}$$

Similarly it is performed for 3^{rd} and 4^{th} column.

The final result is:

$$\begin{bmatrix} 32 & -6 & 0 & -6 \\ -6 & -4 & 2 & -4 \\ 0 & 2 & 0 & 2 \\ -6 & -4 & 2 & -4 \end{bmatrix}$$

-- *Good Luck* --