MILITARY COLLEGE OF SIGNALS
MIDTERM EXAM
BESE 13, 14A & 14B
EE 481 Digital Image Processing

Instructor: A/P Dr. Imran Siddiqi **Time: 90 Minutes**
Max Marks: 30

Note: This question paper comprises **3** pages.

(3+1+1)

1. You need to send your ***16-digit*** credit card number to your agent through email. Since writing the card number in textual form may not be secure, you decide to hide this number in **4x4** grayscale (***8-bit***) image.

a. List the steps (or show a block diagram) that you will follow to perform this operation.

Solution

The image has a total of 16 pixels and the card number comprises 16 digits. So each pixel in the image can carry one digit. A digit can have a value from 0 to 9 which requires 4 bits for its representation. You may then use the following procedure:

For each pixel in the image
    Shift Right by 4
    Shift Left by 4
    Perform logical OR with the digit to encode

b. Assuming that the value of the first pixel in the image is ***255***, what would be the value of this pixel if you hide a value of ***4*** in it.

Solution

Pixel value:	**1111 1111**
Pixel value after Shift Right:	0000 **1111**
Pixel value after Shift Left:	**1111** 0000
Digit value:	0100
Encoded value:	**1111** 0100

c. What operation your agent will need to perform to extract the credit card number?

Solution

Left Shift Image by 4
Right Shift Image by 4

Example

Encoded value:	**1111**	0100
Left Shift by 4:	0100	0000
Right Shift by 4:	0000	0100

(5+3)

2. **a.** Using 4-connectivity, perform Connected Component (CC) labeling on the following binary image and show:

i. The result after first pass of the CC labeling algorithm

ii. The equivalence table

iii. The final result after the second pass of the labeling algorithm

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

Solution

After Pass 1

0	0	0	0	0	0	0	0
0	0	0	0	**1**	**1**	0	0
0	0	**2**	**2**	**2**	**2**	0	0
0	**3**	**3**	0	0	**2**	0	0
0	0	0	0	0	0	0	0
0	0	0	**4**	**4**	**4**	0	0
0	0	0	0	0	**4**	**4**	0
0	0	**5**	**5**	**5**	**5**	0	0

Equivalence Table

1 =2=3

4=5

After Pass 2

0	0	0	0	0	0	0	0
0	0	0	0	**1**	**1**	0	0
0	0	**1**	**1**	**1**	**1**	0	0
0	**1**	**1**	0	0	**1**	0	0
0	0	0	0	0	0	0	0
0	0	0	**4**	**4**	**4**	0	0
0	0	0	0	0	**4**	**4**	0
0	0	**4**	**4**	**4**	**4**	0	0

b. Give short answers to the following:

i. Recognizing individual alphabets in an example of clustering or classification?

This is an example of classification, you have to assign a given alphabet to one of the classes (A to Z)

ii. Which of these is a linear operator: *Max*, *Add*

Add is a linear while *Max* is a non-linear operator

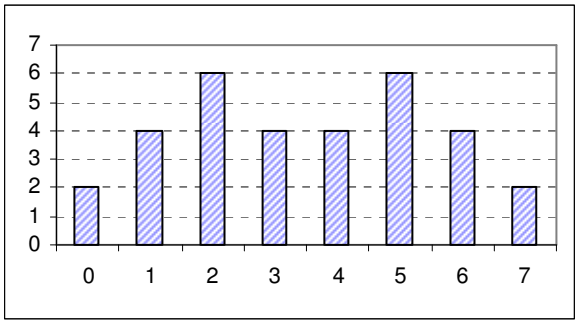
iii. For a ***4-bit*** image of size ***M***x***M*** and histogram ***h***, what does the following expression give:

$$\sqrt{\sum_{k=0}^{15} h(k)}$$

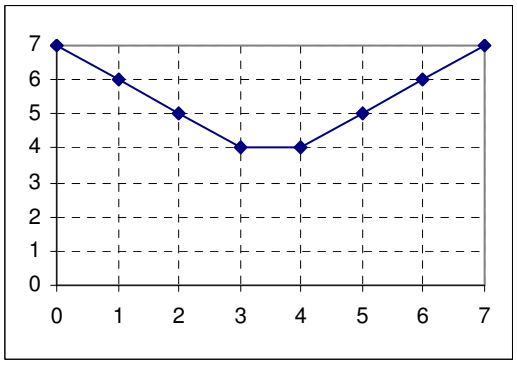
Without the square root, this expression is the total number of pixels in the image which MxM. Taking square root gives you M.

(3+3)

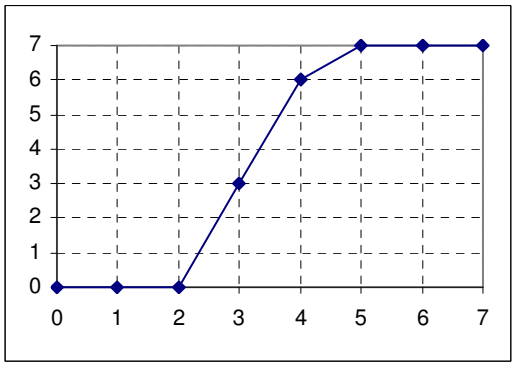
3. **a.** The histogram of a ***3-bit*** image is shown in the following:



What would be the histograms of the output image if the following transformations are applied to this image?

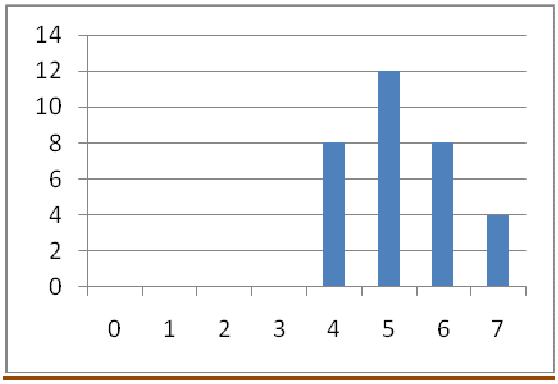


T1

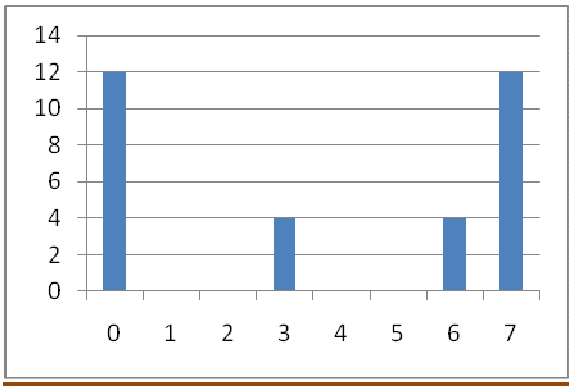


T2

Solution

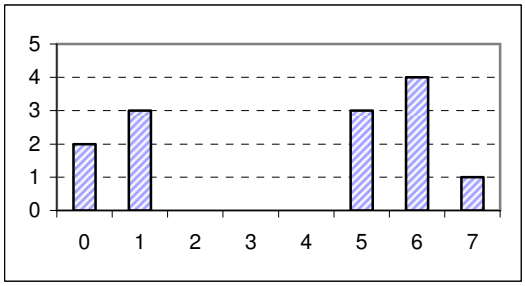
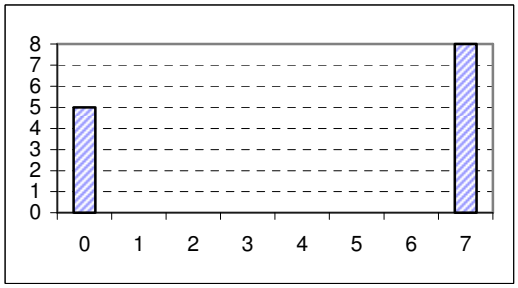
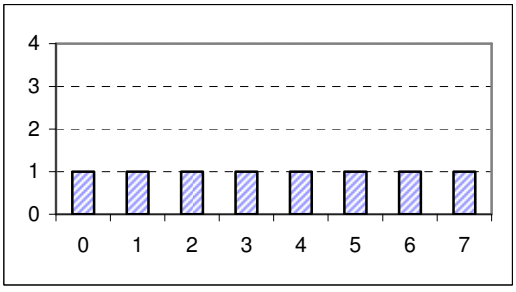
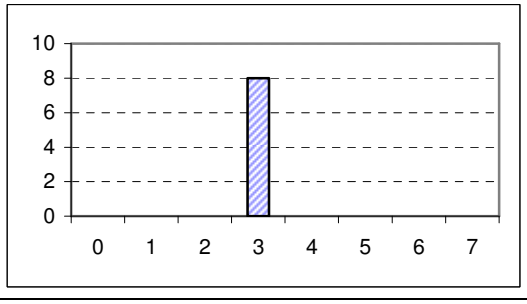


(T1)

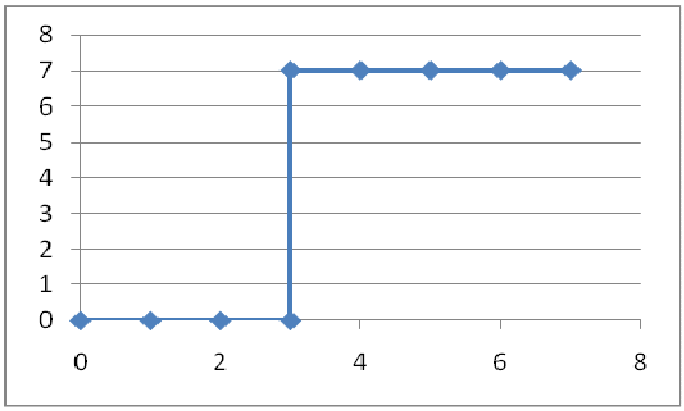


(T2)

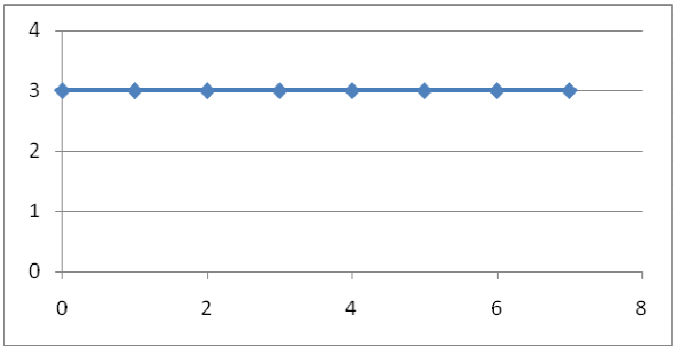
b. In the following are shown the histograms of two ***3-bit*** images ***A*** and ***B*** in the left column. Transformation ***T1*** is applied to image ***A*** and ***T2*** to image ***B*** and the histograms of the output images are shown in the right column. Show the transformation functions (graphs) ***T1*** and ***T2***. (Since the solution is NOT unique, you may show any of the possible transformations)

	
Histogram of original image A	Histogram of transformed image A
	
Histogram of original image B	Histogram of transformed image B

Solution



(T1)



(T2)

(5+4+2)

4. **a.** Perform histogram equalization on the following ***8-bit*** image and show the histogram of the resulting image.

10	20	50	100	200
10	20	50	100	200
10	20	50	100	200
10	20	50	100	200
10	20	50	100	200

Solution

Histogram of the image is:

10	5
20	5
50	5
100	5
200	5

Cumulative Histogram is:

10	5
20	10
50	15
100	20
200	25

Transformation:

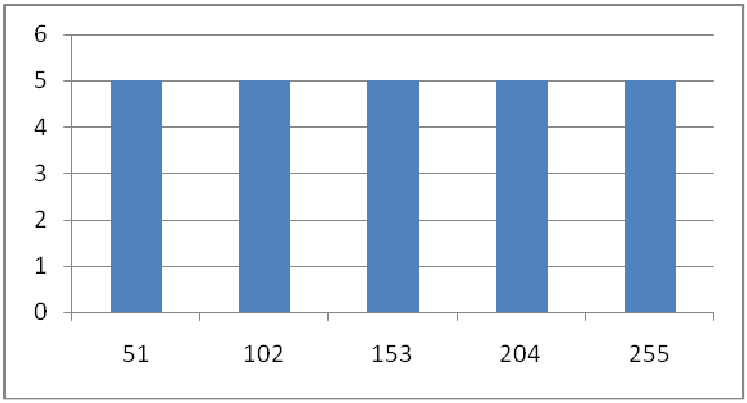
$$s = round(255 * cdf(r)/(Total\ Pixels))$$

Original Value	Transformation	New Value
10	255 * (5/25)	51
20	255*(10/25)	102
50	255 * (15/25)	153
100	255 * (20/25)	204
200	255 * (25/25)	255

New Image

51	102	153	204	255
51	102	153	204	255
51	102	153	204	255
51	102	153	204	255
51	102	153	204	255

Histogram of New Image



b. The cumulative histograms (cdf) of two ***3-bit*** images are shown below. Illustrate the histograms of these images.

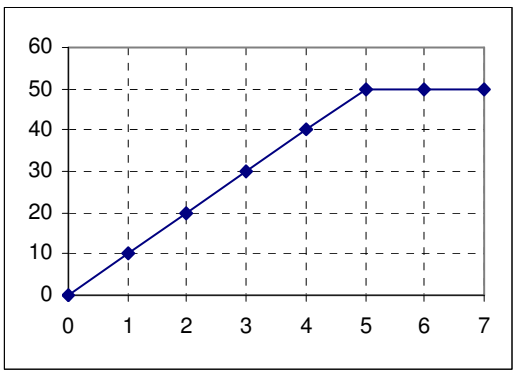


Image A

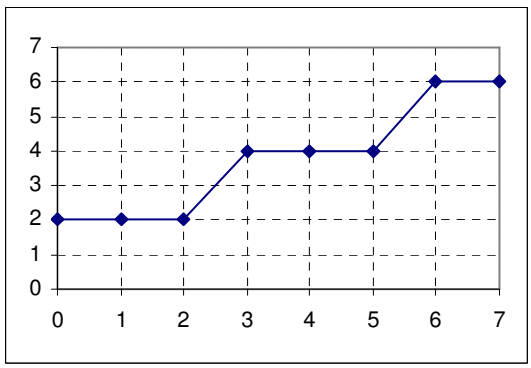
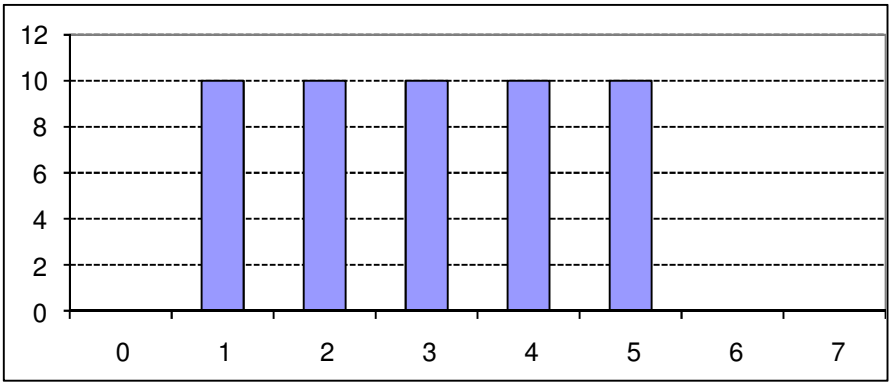
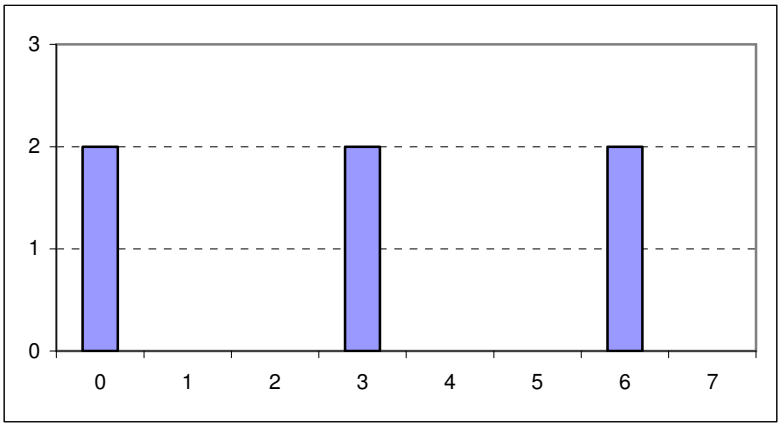


Image B

Solution



(Image A)



(Image B)

c. Show the convolution masks/filters to implement the following:

i. 2f(x,y) – f(x+1,y+1) – f(x-1,y-1)

ii. f(x-2,y-2) + f(x+2,y+2) – 2f(x,y)

Solution

-1		
	2	
		-1

(i)

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

(ii)

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