Digital Image Processing
Course Code: CSE395
Spring Semester Exam.

BME Program - Level 300
Exam Date: 30-3- 2019
Allowed Time: 1 Hour

Attempt all questions. Assume any missed data. Full mark is 20

Q.1) Give a *detailed answer* to each of the following questions: **[12 Marks]**

i. If you have a 512x512 grey-scale image, determine its size. How can you transform it into a binary image? Will the size change? If yes, determine the size of the binary image.

ii. *"We can perform lightening or darkening of an image by addition, subtraction, multiplication, and division"*. Sketch the characteristics of a grey-scale image if we, add 100. Compare your results with the characteristics obtained if we divide by 2.

iii. *"The result of applying a linear filter may be values outside the range (0-255)"*. Suggest two different methods to overcome this problem.

iv. "*The Fourier transform is of fundamental importance to image processing*". Justify this statement. Write the two equations that define forward and inverse 2D-DFT .

Q.2.a) Given a 5x5 image segment '*X*'

$$X = \begin{bmatrix} 170 & 240 & 010 & 080 & 150 \\ 230 & 050 & 070 & 140 & 160 \\ 040 & 060 & 130 & 200 & 220 \\ 100 & 120 & 190 & 210 & 030 \\ 110 & 180 & 250 & 020 & 090 \end{bmatrix}$$

Apply an average filter to the image? Adjust output values. Select a threshold to transform the output image into a binary one. **[6 Marks]**

Q.2.b) Suppose a 4-bit grey-scale image has the following grey values distribution:

i	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
n_i	20	100	200	90	160	80	40	20	0	0	0	0	0	0	0	100

i. Sketch the histogram of this image. What do you expect about the image appearance?

ii. Use histogram equalization to improve the image. Sketch the result. **[6 Marks]**

☺ ***Best wishes*** ☺

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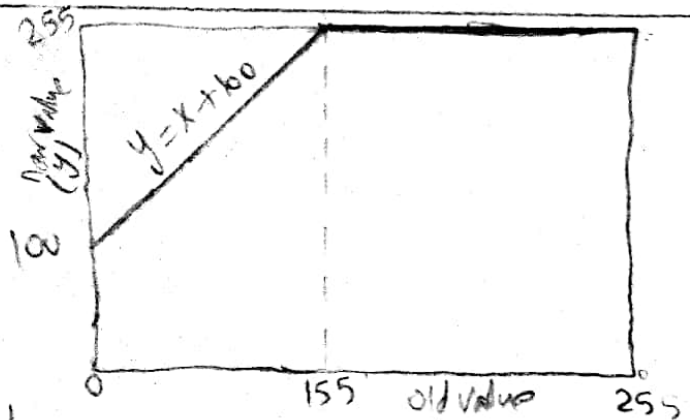
Q.1 i) size = 512 * 512 * 8 = 2097152 bits
= 262144 bytes
= 262.144 Kilobytes

→ to transform the image to a binary image we would choose a threshold T, and for each pixel if its gray value > T make the pixel binary 1 (white), and if the pixel gray value < T make the pixel binary 0 (black)

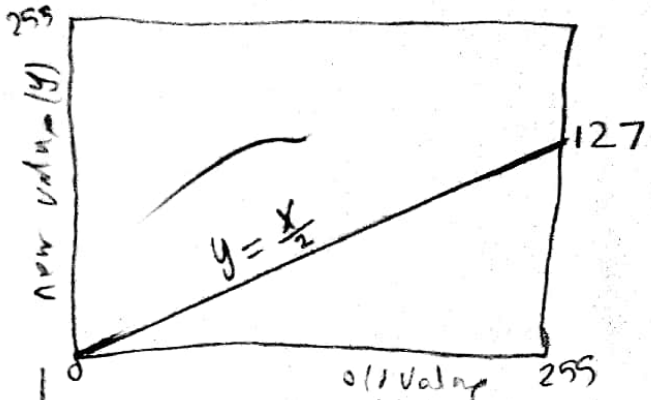
→ the size will change because each pixel would use one bit instead of 8

→ the new size = 512 * 512 * 1 = 262144 bits
= 32768 bytes
= 32.768 Kilobytes

ii)



↳ image lightning



↳ image darkening

(iii) method 1: by clipping: make the gray values which a negative zero, and the gray values which are > 255 = 255

$$F(x,y) = \begin{cases} 0 ; & F(x,y) < 0 \\ F(x,y) ; & 0 < F(x,y) < 255 \\ 255 ; & F(x,y) > 255 \end{cases}$$

method 2: use a scaling factor:

$$F(x,y) = 255\left(\frac{i - g_L}{g_H - g_L}\right)$$

where g_L : the minimum value of output.

g_H : the maximum value of output.

IV) Fourir transform importance!

1- applying filters in the Frequency domain is more efficient than spatial filters.

2- It's used to apply High pass Filter and low pass Filter to a great degree of precision.

3- it allows us to isolate and process a specific frequency.

Fourir equations: * $F(u,v) = \sum_{M=0}^{M-1} \sum_{N=0}^{N-1} f(x,y) \exp\left[-2\pi i\left(\frac{xu}{M} + \frac{yv}{N}\right)\right]$

* $f(x,y) = \frac{1}{MN} \sum_{M=0}^{M-1} \sum_{N=0}^{N-1} F(u,v) \exp\left[2\pi i\left(\frac{xu}{M} + \frac{yv}{N}\right)\right]$

Q2.a) filter = $h = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ (3x3)

eration 1: $i = \frac{1}{9}(170 + 240 + 10 + 230 + 50 + 70 + 40 + 60 + 130) = 111.111$

eration 2: $i = \frac{1}{9}(240 + 10 + 80 + 50 + 70 + 160 + 60 + 130 + 200) = 108.888$

teration 3: $i = \frac{1}{9}(10 + 80 + 150 + 70 + 160 + 160 + 130 + 200 + 220) = 128.888$

teration 4: $i = \frac{1}{9}(230 + 50 + 70 + 60 + 60 + 130 + 100 + 120 + 190) = 110$

teration 5: $i = \frac{1}{9}(50 + 70 + 160 + 60 + 130 + 200 + 190 + 120 + 210) = 130$

eration 6: $i = \frac{1}{9}(70 + 160 + 160 + 130 + 200 + 220 + 190 + 210 + 30) = 150$

teration 7: $i = \frac{1}{9}(40 + 60 + 130 + 100 + 120 + 190 + 110 + 180 + 250) = 131.111$

tation 8: $i = \frac{1}{9}(60 + 130 + 200 + 120 + 190 + 210 + 180 + 250 + 20) = 151.111$

teration 9: $i = \frac{1}{9}(130 + 200 + 220 + 190 + 210 + 30 + 250 + 20 + 90) = 148.888$

the new image (without padding) $= \begin{bmatrix} 111 & 109 & 129 \\ 110 & 130 & 150 \\ 131 & 151 & 149 \end{bmatrix}$

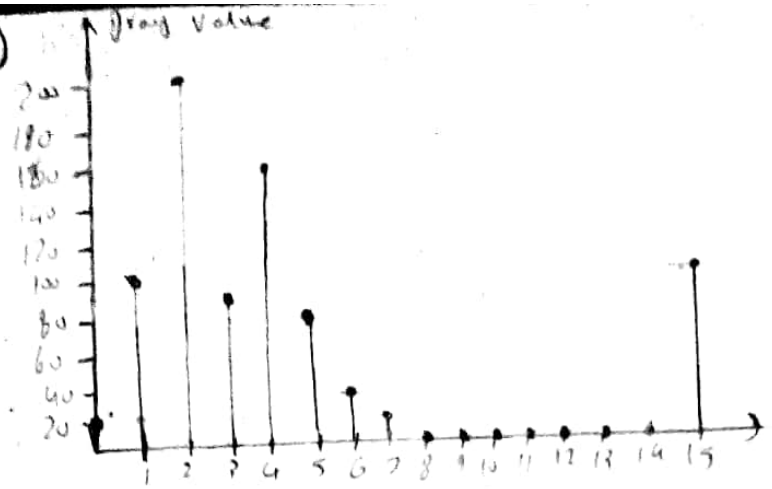
I choose threshold to be the average value $= \frac{111+109+129+110+130+150+131+151+149}{9}$

$T = 130$

binary image $= \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

(22.b)

(i)



→ the histogram is poorly contrasted

→ the image would be darkened

$n = 810$

$L = 16$

$\frac{L-1}{n} = \frac{15}{810} = \frac{1}{54}$

(ii)

i	n_i	$\sum n_i$	$\frac{1}{54}\sum n_i$	rounded value
0	20	20	.37	0
1	100	120	2.22	2
2	200	320	5.92	6
3	90	410	7.59	8
4	160	570	10.55	11
5	80	650	12.03	12
6	40	690	12.77	13
7	20	710	13.14	13
8	0	710	13.14	13
9	0	710	13.14	13
10	0	710	13.14	13
11	0	710	13.14	13
12	0	710	13.14	13
13	0	710	13.14	13
14	0	710	13.14	13
15	100	710	13.14	15
		810	15