DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY UNIVERSITY

UNIVERSITY EXAMINATION 2021/2022

FIRST YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN TELECOMMUNICATION ENGINEERING

EEE 6111: DIGITAL IMAGE PROCESSING

DATE: SEPTEMBER 2021 **TIME 3HRS**

INSTRUCTIONS: This examination paper contains five questions. Answer Question **ONE** and any other **TWO** questions. Question **ONE** is **COMPULSORY** and carries **30 Marks** and ALL the other questions carry **20 Marks** each.

Question 1:

a). Define the following terms as used in Digital Image processing

(i). Image **(2 Marks)**

(ii). Pixel **(2 Marks)**

(iii). Gray scale **(2 Marks)**

(iv). Segmentation **(2 Marks)**

(v). M-adjacency **(2 Marks)**

b). Prove that the two-dimensional Discrete Fourier Transform is:

(i). Separable **(3 Marks)**

(ii). Symmetric **(3 Marks)**

(iii). Unitary **(3 Marks)**

c). Give three applications of thresholding in image segmentation. **(3 Marks)**

d). Find the number of bits required to store a 256×256 image with 32 gray levels **(2 Marks)**

e). Explain the types of pixel connectivity. **(2 Marks)**

f). Using neat diagrams, briefly explain image acquisition using circular sensor strip. **(4 Marks)**

Question 2:

a). Generate a Haar basis of N = 2 **(3 Marks)**

b). Let p and q be two pixels at coordinates (5,5) and (10,15) respectively. Find out which distance measures gives the minimum distance between the two pixels. **(3 Marks)**

c). Compute the 2D DFT of the 4x4 gray scale given by

$$f(x,y) = \begin{matrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{matrix}$$

(10 Marks)

d). Define spatial and gray level resolution. Briefly discuss the effects resulting from a reduction in number of pixels and gray level. **(4 Marks)**

Question 3:

a). What is image thresholding? Obtain the threshold of the image I(x,y) if the threshold is 150 and the upper limit is 75.

$$I(x,y) = \begin{matrix} 205 & 164 & 99 & 67 & 45 \\ 156 & 120 & 55 & 43 & 123 \\ 234 & 14 & 12 & 89 & 78 \\ 23 & 231 & 34 & 129 & 65 \\ 100 & 91 & 200 & 157 & 57 \end{matrix}$$

(4 Marks)

b). Briefly discuss Histogram equalization technique **(2 Marks)**

c). Perform Histogram equalization of the image

$$I(x,y) = \begin{matrix} 4 & 4 & 4 & 4 & 4 \\ 3 & 4 & 5 & 4 & 3 \\ 3 & 5 & 5 & 5 & 3 \\ 3 & 4 & 5 & 4 & 3 \\ 4 & 4 & 4 & 4 & 4 \end{matrix}$$

(6 Marks)

d). The following small image has grey values in the range 0 to 19. Compute the grey level histogram and the mapping that will equalize this histogram. Produce an grid containing the grey values for the new histogram-equalized image.

$$I(x,y) = \begin{matrix} 12 & 6 & 5 & 13 & 14 & 14 & 16 & 15 \\ 11 & 10 & 8 & 5 & 8 & 11 & 14 & 14 \\ 9 & 8 & 3 & 4 & 7 & 12 & 18 & 19 \\ 10 & 7 & 4 & 2 & 10 & 12 & 13 & 17 \\ 16 & 9 & 13 & 13 & 16 & 19 & 19 & 17 \\ 12 & 10 & 14 & 15 & 18 & 18 & 16 & 14 \\ 11 & 8 & 10 & 12 & 14 & 13 & 14 & 15 \\ 8 & 6 & 3 & 7 & 9 & 11 & 12 & 12 \end{matrix}$$

(8 Marks)

Question 4:

a). What are the limitations of Discrete Fourier Transforms(DFT) in Image Processing and how is the limitation addressed by Discrete Wavelet Transforms(DWT)? **(4 Marks)**

b). Write brief notes about the following types of noises and how they are cleaned

(i). Salt and pepper noise

(ii). Gaussian noise

(iii). Speckle noise

(iv). Periodic noise

(4 Marks)

c). The array below represents a small gray scale image. Compute the images that result when the image is convolved with the masks shown without padding.

$$I(x,y) = \begin{matrix} 20 & 20 & 20 & 10 & 10 & 10 & 10 & 10 & 10 \\ 20 & 20 & 20 & 20 & 20 & 20 & 20 & 20 & 10 \\ 20 & 20 & 20 & 10 & 10 & 10 & 10 & 20 & 10 \\ 20 & 20 & 10 & 10 & 10 & 10 & 10 & 20 & 10 \\ 20 & 10 & 10 & 10 & 10 & 10 & 10 & 20 & 10 \\ 10 & 10 & 10 & 10 & 20 & 10 & 10 & 20 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 20 & 10 & 20 & 20 & 10 & 10 & 10 & 20 & 20 \\ 20 & 10 & 10 & 20 & 10 & 10 & 20 & 10 & 20 \end{matrix}$$

$$K = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

(6 Marks)

d). The arrays below represent small gray scale images. Compute the 4×4 image that would result in each case if the middle 16 pixels were transformed using a 3×3 median filter:

$$I(x,y) = \begin{matrix} 8 & 17 & 4 & 10 & 15 & 12 \\ 10 & 12 & 14 & 7 & 3 & 10 \\ 15 & 10 & 50 & 5 & 3 & 12 \\ 4 & 8 & 11 & 4 & 1 & 8 \\ 16 & 7 & 4 & 3 & 0 & 7 \\ 16 & 24 & 19 & 3 & 20 & 10 \end{matrix}$$

(6 Marks)

Question 5:

a). Define the tristimulus values. **(3 Marks)** b). Determine the saturation and intensity components of the following image, where the RGB values are as given:

$$I(x,y) = \begin{matrix} (0,1,1) & (1,2,3) & (7,7,7) & (5,1,2) & (1,1,7) \\ (2,1,2) & (1,7,7) & (2,0,2) & (3,,32) & (5,5,0) \\ (4,4,4) & (4,6,7) & (4,5,6) & (1,5,7) & (3,6,7) \\ (3,0,3) & (5,2,2) & (1,1,1) & (6,6,0) & (2,2,2) \\ (1,2,1) & (0,4,4 & (3,1,6) & (3,3,3) & (2,4,6) \end{matrix}$$

(5 Marks)

c). Perform the conversions between RGB and HSV or YIQ, for the values:

R	G	B	H	S	V
0.5	0.5	0			
0	0.7	0.7			
0.5	0	0.5			
			0.33	0.5	1
			0.67	0.7	0.7
			0	0.2	0.8

R	G	B	H	S	V
0.3	0.3	0.7			
0.7	0.9	0			
0.8	0.8	0.7			
			1	0.3	0.3
			0.5	0.5	0.5
			0	1	1

You may need to normalize the RGB values. **(6 Marks)**

d). Consider a 3-bit gray scale image with the following probabilities:

Grey value	0	1	2	3	4	5	6	7
Probability	0.19	0.25	0.21	0.16	0.08	0.06	0.03	0.02

(i). Entropy

(ii). Construct a Huffman code for each of the probability

(iii). For each case, determine the average bits/pixel

(iv). What do think are the conditions of the probability distribution which give rise to a high compression rate using Huffman coding?

(6 Marks)