ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION **WINTER SEMESTER, 2018-2019**

DURATION: 3 Hours **FULL MARKS: 150**

CSE 4733: Digital Image Processing

Programmable calculators are not allowed. Do not write anything on the question paper.

There are **8 (eight)** questions. Answer any **6 (six)** of them.

Figures in the right margin indicate marks.

---

1. a) Describe the following morphological techniques:
   i. Extraction of Connected Component 3
   ii. Boundary Extraction 4
   iii. Hole Filling 4

   b) Consider the grayscale image in Figure 1, which shows a region of small circles enclosed by a region of larger circles. How can you detect the boundary that separates those two regions? Assume any necessary parameter values. 9

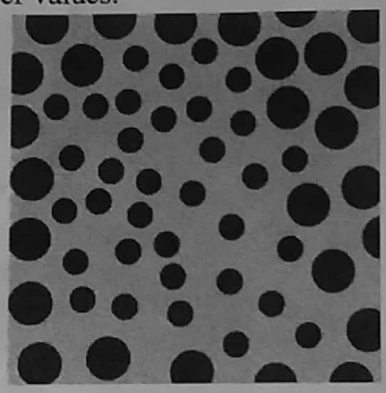

Figure 1.

   c) The top-hat transformation of a grayscale image f is defined as f minus its opening with a structuring element of b: 5

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

What kind of effects do you expect after top-hat transform?

2. a) Suppose you have applied a Sobel mask which produces strong responses for horizontal edges but no responses for vertical edges. Why does this mask also produce weak responses for +45° and -45° oriented edges? 5
   b) Describe the Hough Transform for detecting circles of any radius. 10
   c) Graph Theoretic approach can be used for detecting edges. How can you build a graph from an input image and find prominent edges in a particular orientation? 10

3. a) Is it possible to get 2D Fourier Transform by first taking 1D Fourier transform in the first dimension and then performing another 1D Fourier transform in the other dimension? Explain why. 7
   b) When do ringing effects appear in an image when Butterworth Filter has been applied in its Fourier Domain? Justify with necessary figures. 5
   c) Suppose you are provided with a 3×3 spatial mask which enhance the edge structures more when applied directly on the image. Explain how an equivalent effect can be obtained with its frequency domain representation. Justify your choice. 8
   d) Why does Gaussian smoothing filter in the space domain have a different size than its equivalent representation in the frequency domain? 5

4. a) Given an image of size M×N, you are asked to perform an experiment that consists of repeatedly lowpass filtering the image using a Gaussian lowpass filter with a given cutoff frequency D_0. You may ignore computational round-off errors. Let K denote the number of applications of the filter. Can you predict (without doing the experiment) the result (image) for a sufficiently large value of K? Justify your result. 10

b) The two Fourier spectra shown in Figure 2 are of the same image. The spectrum on the left corresponds to the original image, and the spectrum on the right was obtained after the image was padded with zeros. Explain the significant increase or decrease in signal strength along the vertical and horizontal axes of the spectrum shown on the right. 10

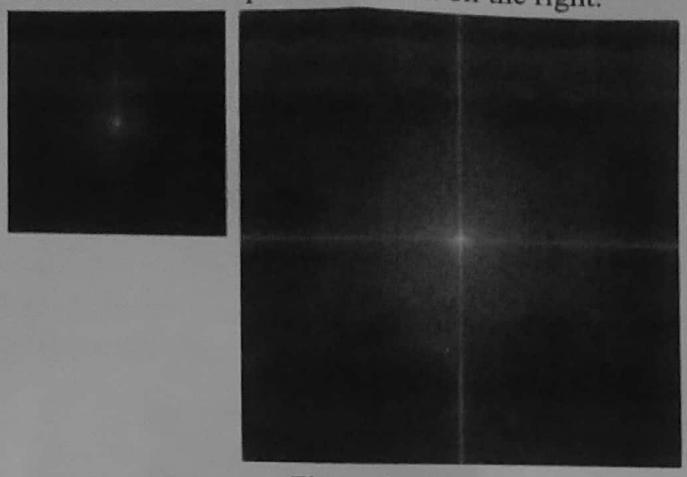

Figure 2.

c) Which filter is more preferable: Gaussian filter or Butterworth filter? Justify your choice. 5

5. a) What is a histogram of an image? 5

i. What effect would setting to zero the lower-order bit planes have on the histogram of an image in general?

ii. What would be the effect on the histogram if we set to zero the higher-order bit planes instead?

b) Explain why the discrete histogram equalization technique does not, in general, yield a flat histogram. Draw necessary illustrations. 10

c) Image subtraction is used often in industrial applications for detecting missing components in product assembly. The approach is to store a "golden" image that corresponds to a correct assembly; this image is then subtracted from incoming images of the same product. Ideally, the differences would be zero if the new products are assembled correctly. Different images for products with missing components would be nonzero in the area where they differ from the golden image. What conditions do you think have to be met in practice for this method to work? 10

6. a) Differentiate between correlation and convolution. 5

b) Why does smoothing effect increases with the size of a square averaging filter? 5

c) What is isotropic filter? Prove that a Laplacian mask is isotropic. 1+5

d) Suppose that you filter an image, $f(x,y)$, with a spatial filter mask, $w(x,y)$, using convolution, where the mask is smaller than the image in both spatial directions. Show the important property that, if the coefficients of the mask sum to zero, then the sum of all the elements in the resulting convolution array (filtered image) will be zero also (you may ignore computational inaccuracies). Also, you may assume that the border of the image has been padded with the appropriate number of zeros. 9

7. a) High-definition television (HDTV) generates images with 1125 horizontal TV lines interlaced (where every other line is painted on the tube face in each of two fields, each field being of a second in duration). The width-to-height aspect ratio of the images is 16:9. The 5

fact that the number of horizontal lines is fixed determines the vertical resolution of the images. A company has designed an image capture system that generates digital images from HDTV images. The resolution of each TV (horizontal) line in their system is in proportion to vertical resolution, with the proportion being the width-to-height ratio of the images. Each pixel in the color image has 24 bits of intensity resolution, 8 bits each for a red, a green, and a blue plane. These three "primary" images form a color image. How many bits would it take to store a 2-hour HDTV movie? 7

b) Develop an algorithm for converting a one-pixel-thick *m*-path to a *4*-path. 8

c) How would you implement the color equivalent of gray scale histogram specification (HS)? 5

d) In a simple RGB image, the R, G, and B component images have the horizontal intensity profiles shown in the following diagram in Figure 3. What color would a person see in the middle column of this image?

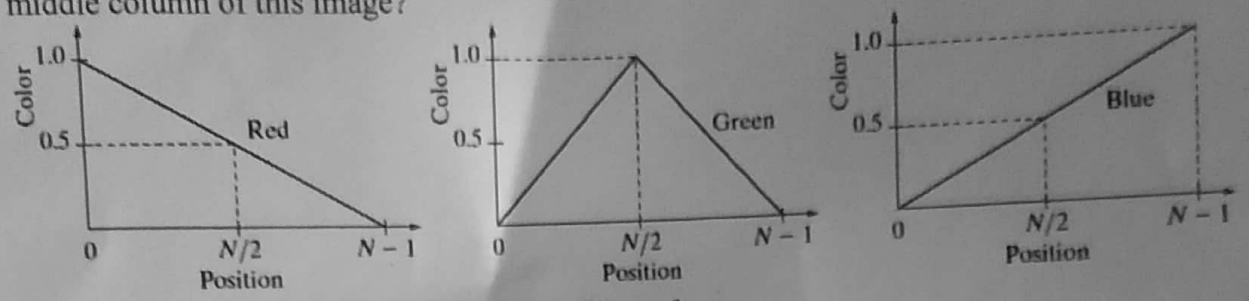

Figure 3.

8. Having heard about your success in getting highest grade in the *Digital Image Processing* course, you are contacted by a fluids company that wishes to automate bubble-counting in certain processes for quality control. The company has solved the imaging problem and can obtain 8-bit images of size 700×700 pixels, such as the one shown in Figure 4. Each image represents an area of 7 cm^2. The company wishes to do two things with each image: (i) Determine the ratio of the area occupied by bubbles to the total area of the image, and (ii) count the number of distinct bubbles. Based on the material you have learned up to this point, propose a solution to this problem. In your solution, make sure to state the physical dimensions of the smallest bubble your solution can detect. State clearly all assumptions that you make and that are likely to impact the solution you propose. 25

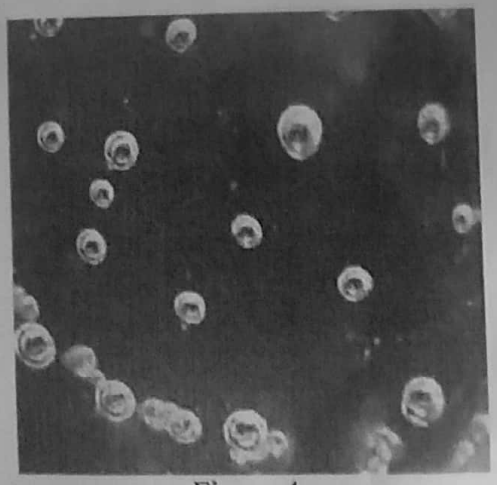

Figure 4.