UNIVERSITY OF SOUTHAMPTON ELEC6213W1

SEMESTER 2 EXAMINATIONS 2016-17

IMAGE PROCESSING

DURATION 120 MINS (2 Hours)

This paper contains 4 questions

Answer **BOTH** questions from section **A.**

Answer **ONE** question from section **B.**

An outline marking scheme is shown in brackets to the right of each question.

Only University approved calculators may be used.

A foreign language dictionary is permitted ONLY IF it is a paper version of a direct 'Word to Word' translation dictionary AND it contains no notes, additions or annotations.

Section A

Q1)

a) Explain what the *Fourier Transform* actually does

[6 marks]

b) Describe what the advantages and disadvantages of *Discrete Cosine Transform (DCT)* with respect to Discrete Fourier Transform *(DFT)* are.

[6 marks]

c) You have been given a linear filter to apply to a set of images. How would you implement the filtering process, with convolution or Fourier Transform? **Explain** your reasons.

[6 marks]

d) Show that the Fourier transform of the box (or rectangular) function is a *sinc* function by calculating the Fourier transform of the following (box) function.

$$B(x) = \begin{cases} 1 & -L \le x \le L \\ 0 & elsewhere \end{cases}$$

[7 marks]

e) As the figure below shows, the Fourier transform of a "tent" (or triangular) function (on the left) is a squared *sinc* function (on the right). **Advance** an argument that shows that the Fourier transform of a tent function can be obtained from the Fourier transform of a box function.

Hint:

-The tent itself can be generated by convolving two equal boxes.

[8 marks]

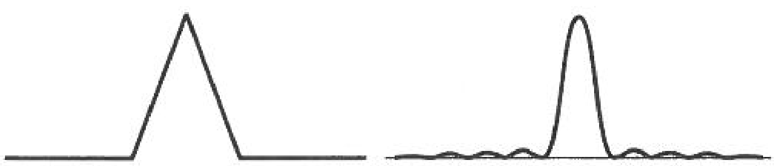


Figure (1)

Q2)

a) **Describe** what the heat equation $\frac{\partial u}{\partial t} = K\nabla^2 u$ with a constant *K* accomplishes when applied to a noisy image. **Explain** what problem(s) would arise in the noisy image filtered by a heat equation when *K* is considered as constant.

[9 marks]

b) **Explain** how anisotropic diffusion resolves the problem(s) stated in (Q2-a) and **describe** how different the noisy image filtered by an anisotropic diffusion appears in comparison with the same image filtered by a heat equation with a constant *K*.

[9 marks]

c) **Describe** what the *averaging* and *median* filters are and **explain** how the *median* filter can be used in a background subtraction process to separate the background from the walking person (foreground) in the sequence of images shown in figure (2). **State** what happens if the *averaging* filter is used for background subtraction instead of the *median* filter.

[15 marks]

Figure (2)

Section B

Q3)

a) **Explain** what are meant by the *histogram* of an image and the process of *histogram equalisation*?

[4 marks]

b) The objects and background in the image shown in figure (3) have a mean intensity of 170 and 60 respectively on a [0, 255] scale. The image is corrupted by Gaussian noise with 0 mean and a standard deviation of 18 intensity levels. **Plot** an approximate histogram of the noisy image shown in figure (3). To segment the objects inside the image shown in this figure, **propose** a thresholding method capable of yielding a correct segmentation rate of 90% or higher.

[10 marks]

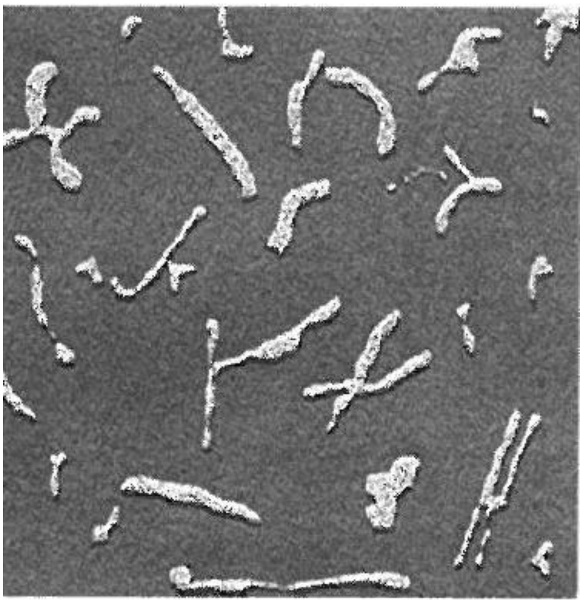


Figure (3)

c) An image with intensities in the range [0, 1] has the *probability distribution function* (PDF) $p_r(r) = -2r^2 + 2$ obtained from the image histogram. It is desired to transform the intensity levels of this image so that the new image will have a histogram given by $p_z(z) = 2z$. Assume continuous quantities and **find** the transformation (in terms of *r* and *z)* that will accomplish this.

[19 marks]

Q4)

a) A binary image contains straight lines oriented horizontally, vertically at 45 and -45 degrees. **Propose** four 3x3 masks that can be used to detect 1-pixel breaks in these lines. Assume that the intensities of the lines and background are 1 and 0 respectively.

[9 marks]

b) The Sobel operators (masks) for edge detection are shown in figure (4):

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Sobel

Figure(4)

TURN OVER

Show that the response of the Sobel masks can be implemented similarly by one pass of the *differencing* mask [-1 0 1] (or its vertical counterpart) followed by the *smoothing* mask [1 2 1] (or its vertical counterpart).

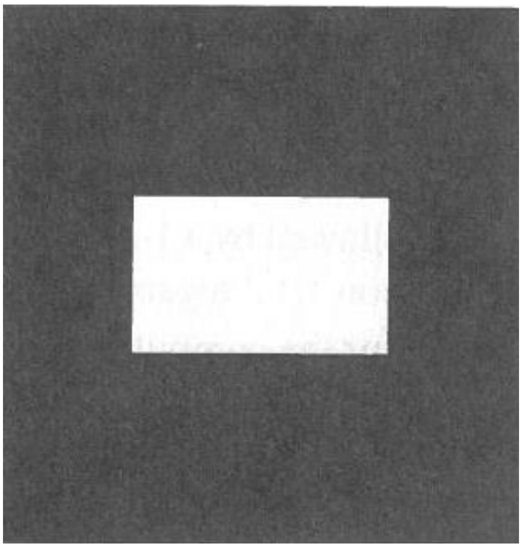
[8 marks]

c) The rectangle in the binary image in figure (5) is of size *m x n* pixels. **Determine** what the magnitude of gradient of this image would be if the gradient of the image is approximated as $|\nabla g| = \left|\frac{\partial g}{\partial x}\right| + \left|\frac{\partial g}{\partial y}\right|$ by showing all relevant different pixel values in the gradient image. The sobel masks are used to calculate derivatives.

[8 marks]

d) **Sketch** the histogram of edge *directions* computed by using $\theta(x,y) = Arc\tan\left(\frac{g_y}{g_x}\right)$ to label the magnitude of each element of the histogram.

[8 marks]



Figure(5)

END OF PAPER