UNIVERSITY OF SOUTHAMPTON ELEC6213W1

SEMESTER 2 EXAMINATIONS 2018-19

IMAGE PROCESSING

DURATION 90 MINS (1.5 Hours)

This paper contains 3 questions

Answer question Q1 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 translation 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) **Write** 2D continuous Forward and Inverse *Fourier Transforms.* **Describe** how Fourier Transform decomposes an image.

[6 marks]

b) **Show** that the *Discrete Cosine Transform* defined in the following equation is a linear transformation.

$$F(u,v) = \tfrac{2}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left(\frac{(2x+1)u\pi}{2N}\right)\cos\left(\frac{(2y+1)v\pi}{2N}\right)$$

[8 marks]

c) **Describe** what *Homomorphic* filtering is by drawing the filtering process in block diagrams and **explain** in what cases this filtering is useful.

[9 marks]

d) **Calculate** the (continuous) Fourier transform of the following filter.

$$f(x,y) = exp(-(a|x| + b|y|))$$

where *a,* and *b*>0.

[12 marks]

Section B

Q2)

a) In an image analysis context, **describe** what geometrical moments are used for.

[4 marks]

b) Geometrical moments for discrete images are defined as:

$$m_{p,q} = \sum_x \sum_y x^p y^q I(x,y)\,\Delta A$$

where $\Delta A = \Delta x \Delta y$.

Explain if these moments are invariant to the translation, scaling and rotation transformations.

If some of the geometrical moments are invariant to any of these transformations, **describe** for what values of *p* and *q* the Geometrical moments are invariant to any of translation, scaling and rotation transformations and why.

[8 marks]

c) Assume that a shape $I(x,y)$ is in its centre of mass (i.e. $\bar{x} = 0, \bar{y} = 0$). In this case,

$m_{pq} = \mu_{pq} = \sum_x \sum_y (x - \bar{x})^p\,(y - \bar{y})^q I(x,y)\Delta A$.

Show that the second order normalised centralised moment $\eta_{20} = \frac{\mu_{20}}{\mu_{00}^2}$ remains unchanged if the shape is scaled by a scaling parameter *s.*

(Hint: Show η_{20} for $I(x,y)$ and $I(sx,sy)$ is the same.)

[12 marks]

d) **Show** that $\eta_{20} + \eta_{02}$ is invariant with respect to rotation. We still assume that the shape $I(x,y)$ is in its centre of mass (i.e. $\bar{x} = 0, \bar{y} = 0$).

(Hint: A point with coordinates (x, y) in an image is rotated with angle θ to point $(x', y')$with the following transformation:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$)

[11 marks]

TURN OVER

Q3)

a) **Describe** what is meant by *Wiener filtering* by writing its transfer function in frequency domain.

[6 marks]

b) **Explain** how the transfer function of the corrupting process $H(u, v)$ may be guessed or deduced in a restoration problem.

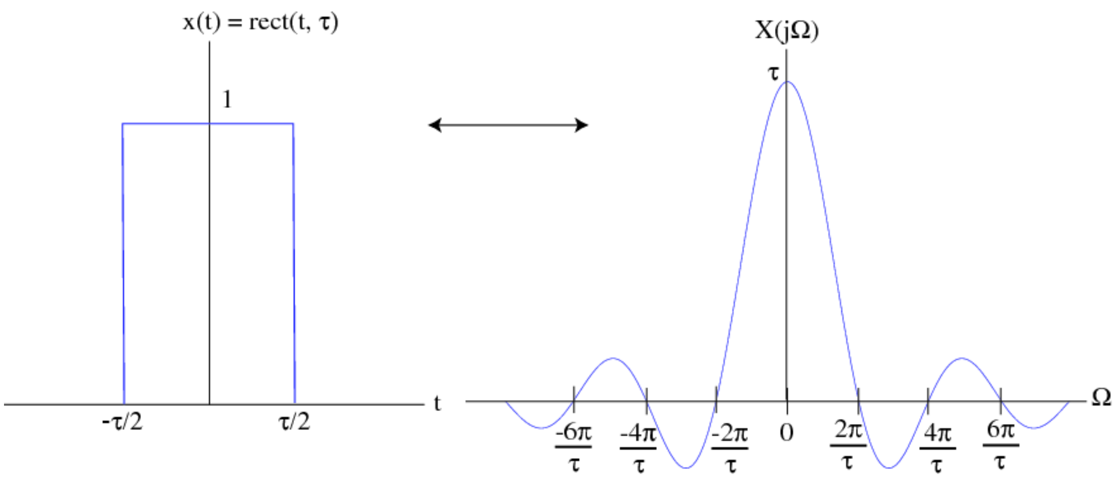
[6 marks]

c) **Explain** what advantage(s) the Wiener filtering technique has in comparison with inverse filtering.

[6 marks]

d) During acquisition, an image undergoes uniform linear motion in the vertical direction for a time T_1 with a constant speed V. The direction of motion then switches to the horizontal direction for a time T_2 with the same speed. Assuming that the time it takes the image to change directions is negligible and the shutter opening and closing times are also negligible, **give** an expression for the blurring function $H(u, v)$.

Hint: The Fourier transform of $rect(t, \tau)$ is $\tau Sinc\left(\frac{\omega\tau}{2}\right)$, i.e.:



[17 marks]

[End of Paper]

