Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

FACULTY OF ENGINEERING, MATHEMATICS & SCIENCE

SCHOOL OF ENGINEERING

Electronic & Electrical Engineering

Engineering **Hilary Term, 2016**

Senior Sophister

Annual Examinations

4C8 DIGITAL MEDIA PROCESSING

13th January 2016 **M17** **09.30 – 11.30**

Dr. David Corrigan

Instructions to Candidates:

Answer FOUR questions, including Question ONE and any THREE of the remaining four questions.

Materials Permitted for this Examination:

Calculator

Drawing Instruments

Mathematical Tables

Graph Paper

Non-programmable calculators are permitted for this examination. Please indicate the make and model of your calculator on each answer book used.

SECTION A – Compulsory Question

Q.1

(a) Consider the image of the tennis court Shown in the top left of Fig. Q.1. The graphs in the top right, bottom left and bottom right represent histograms of the red, green and blue channels respectively

(i) Explain how the tennis court manifests itself in the 3 histograms.

[4 marks]

(ii) Write a Matlab function that uses suitable threshold operations to define a segmentation of the tennis court. The function should have 1 input parameter representing an RGB image and one output containing the binary segmentation.

[5 marks]

(iii) Write a Matlab function that uses the segmentation of the tennis court to alter the colour of the tennis court to cyan. The function should have 2 inputs and 1 output. The first input is a 3-dimensional array of unsinged 8-bit integers representing the image and the second is a 2-dimensional binary array representing the segmentation of the image. The output is an array containing the modified image.

[6 marks]

(b) Histogram Equalisation of an 8-bit grayscale image can defined mathematically for each pixel (x, y) with some intensity k by the equation

$$f(k) = \text{round}\left(255 \times \sum_{n=0}^{k} p_n\right)$$

where $f(k)$ is the intensity of the pixel after histogram equalisation, p_n is the value of the n^{th} bin of normalised histogram and $\text{round}(y)$ rounds y to the nearest integer.

Q.1 (b) (cont'd.)

Write a Matlab function that performs histogram equalisation on an 8-bit greyscale image. The function should contain a single input and output. The output is a 2-D unsigned 8-bit array containing the input image and the output is an array of the same size and type containing the image after histogram equalisation.

[10 marks]

Note: For this question you can assume that you have access to the standard mathematical and matrix algebra functions in Matlab, including the function **hist()** that calculates the histogram of an array. However, you may not make use of advanced image processing functions that exist in the image processing toolbox.

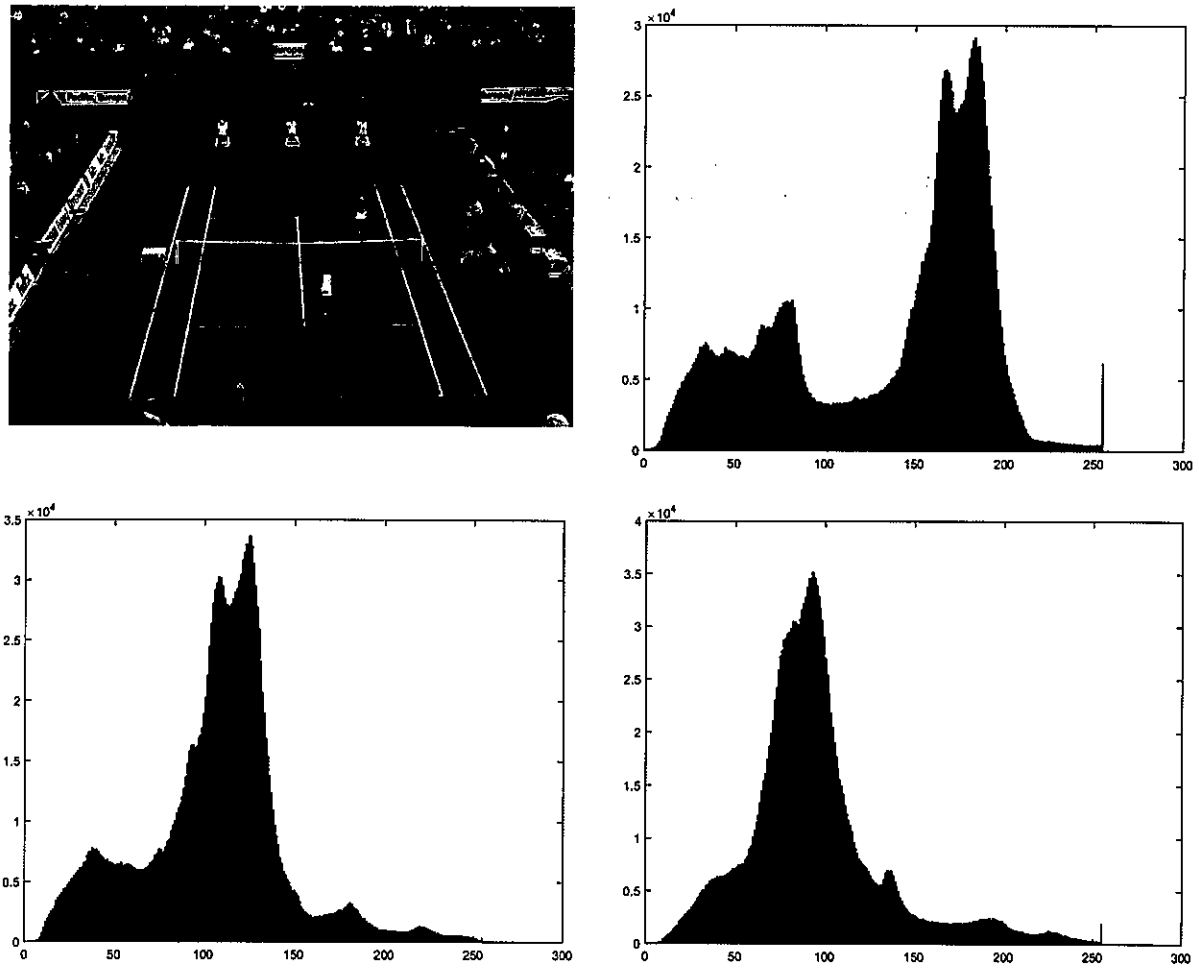

Fig. Q.1

SECTION B – Answer any THREE Questions

Q.2

(a) What is the key difference between lossless and lossy compression? Describe the considerations involved in the decision to use either lossy or lossless compression algorithms in medical imaging scenarios.

[6 marks]

(b) Explain what is meant by differential coding in the context of lossless image compression. Explain why differential coding is a useful technique for lossless compression.

[8 marks]

(c) Give an overview of how a CT scan is performed. In your answer, also describe how the data generated by the scan is processed and represented. What is each data element in a CT scan known as and what does its value represent?

[11 marks]

Q.3

(a) Why is the YCbCr colourspace used over RGB in the JPEG standard? Describe 2 ways in which JPEG exploits the choice of colourspace to achieve more efficient compression.

[6 marks]

(b) In the context of transform image coding, explain what is meant by Run Length Coding (RLC). Explain in detail the reason why RLC is necessary in JPEG for efficient compression of a transformed and quantised image.

[6 marks]

(c) Describe in detail how Run Length Coding is applied in practice in the JPEG standard. Explain the engineering choices involved in its application. Devise examples where necessary to help clarify your answer.

[13 marks]

Q.4

(a) Demonstrate how the 1D Haar Transform may be implemented using a Discrete Wavelet Transform. Write down the transfer functions of the filters involved. Use the following 1D signal to illustrate your answer.

n	0	1	2	3	4	5
$x[n]$	3	4	5	-7	- 6	1

[10 marks]

(b) Draw and correctly label a filter bank which shows how the above operations can be extended to calculate the 2-D Haar Transform of an image.

[5 marks]

(c) Fig. Q.4 shows a rate distortion curve comparing the performance of two image compression codecs.

(i) What does the graph in Fig. Q.4 say about the relative performance of the 2 codecs? Justify your answer.

[6 marks]

(ii) Describe a limitation of the analysis offered by the curve. Suggest a way this limitation could be overcome.

[4 marks]

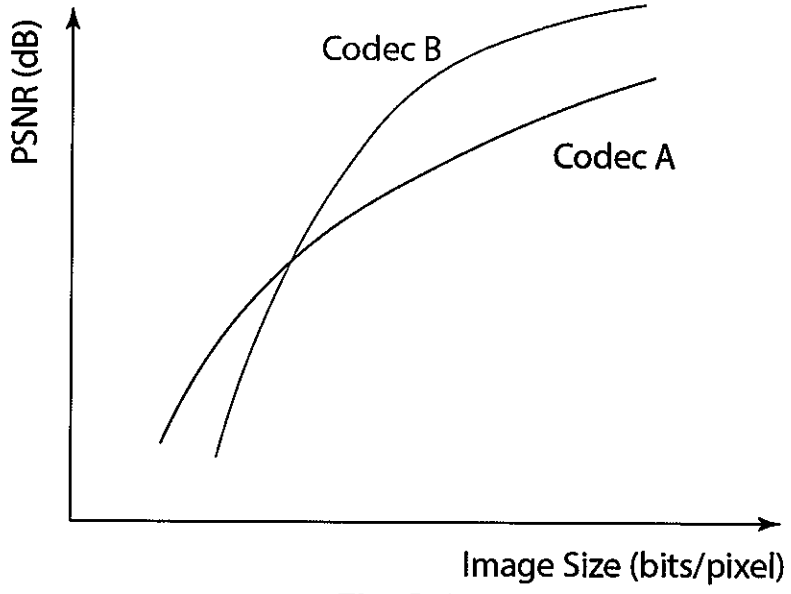

Fig. Q.4

Q.5

(a) Define what is meant be the parameters "block size" and "search radius" in the context of block matching. Describe how the choice of these parameters affects the performance of block matching.

[8 marks]

(b) State how the use of a multiresolution approach improves the computational efficiency of block matching compared with a conventional exhaustive search.

[4 marks]

(c) Fig. Q.5 shows a block diagram of a simple P-frame encoder in a Motion Compensated Predictive Coding (MCPC) scheme.

(i) Why is MCPC preferable for video compression compared with JPEG image compression of each frame?

[4 marks]

(ii) What data is represented on the block diagram at the positions represented by the labels A, B, C and D?

[3 marks]

(iii) Explain why this architecture is **not** suitable in practice for encoding P-frames in MCPC. How is this limitation overcome in practical MCPC encoders?

[8 marks]

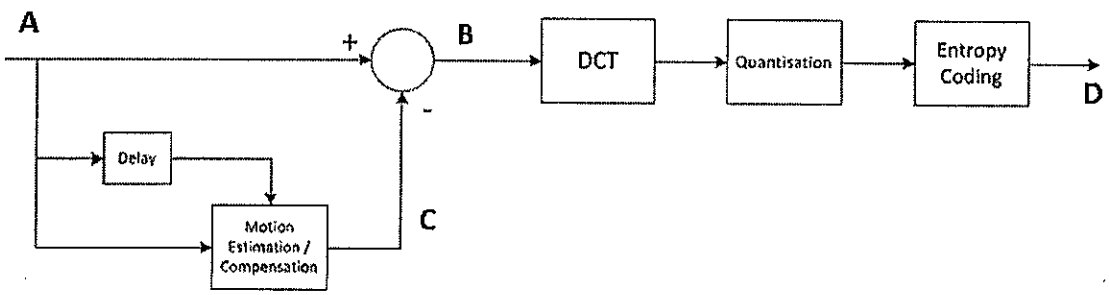

Fig. Q.5