DUBLIN CITY UNIVERSITY

AUTUMN RESIT EXAMINATIONS 2010-2011

MODULE: (Title & Code)	EE554 Image and Video Compression
COURSE:	MEng in Electronic Systems (MEN) MEng in Telecommunications Engineering (MTC) Masters Engineering Qualifier Course (MEQ) Grad Cert. in Electronic Systems (GCES) Grad Cert. in Telecommunications Eng. (GCTC) Graduate Diploma in Electronic Systems (GDE) Grad Dip in Telecommunications Eng (GTC)
YEAR:	2010
EXAMINERS: (Including Telephone Nos.)	Prof Peter Ashburn Prof. Noel O'Connor, Ext no. 5078 Dr. David Sadlier, Ext no. 6830
TIME ALLOWED:	3 hours
INSTRUCTIONS:	Answer any FOUR questions

Please do not turn over this page until instructed to do so

The use of programmable or text storing calculators is expressly forbidden. Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones

QUESTION 1 [TOTAL MARKS: 25]

1(a) [6 Marks]

1. Describe the key characteristics of the Quarter-Common Intermediate Format (QCIF) for uncompressed video. [3 marks]
2. List a key ADVANTAGE of this format that makes it suitable for video compression applications. [1 mark]
3. Calculate the STORAGE REQUIRED (in megabytes) for a 10 minute QCIF video source assuming 4:2:0 format i.e. assume that the colour components are sub-sampled by a factor of 2 in each of the X (horizontal) and Y (vertical) directions. [2 marks]

1(b) [5 Marks]

> "Arithmetic coding is significantly more efficient than Huffman coding in general but suffers from significant coding delay as a consequence."

Discuss this statement indicating whether you AGREE or DISAGREE. Explain your reasons in either case.

1(c) [10 Marks]

1. Briefly outline the TWO ways in which pixels are encoded in the Group 3 and Group 4 Fax coding standard. [5 marks]
2. Comment on the ERROR ROBUSTNESS of the two approaches relative to each other. [2 marks]
3. Explain why EITHER approach to encoding is particularly suited to the kind of image data either standard could expect as typical input. [3 marks]

1(d) [4 Marks]

Using a diagram, describe the ORDER in which DCT coefficients are processed prior to entropy encoding in the JPEG standard and explain WHY the data is processed in this manner

[End of Question 1]

QUESTION 2 [TOTAL MARKS: 25]

2(a) [2 Marks]

The removal of inter-component REDUNDANCY by transforming RGB based images to YUV colour-space is a source of LOSSY compression. Explain what is meant by this statement.

2(b) [15 Marks]

Shown below are the Discrete Cosine Transform (DCT) coefficient values of an 8×8 pixel block that, during the process of MPEG-1 encoding, was transformed by the forward DCT. Also shown is the corresponding QUANTIZATION TABLE that is to be used to quantize these coefficients.

1. Use the quantization table provided to demonstrate QUANTIZATION AND RECONSTRUCTION of the DCT coefficients, according to MPEG-1 video encoding rules.

   Note, your answer should take the form of an 8×8 set of QUANTIZED COEFFICIENTS, followed by an 8×8 set of RECONSTRUCTED COEFFICIENT VALUES].

2. Indicate which two of the NON-ZERO reconstructed coefficient values have been altered ('distorted') the most from their original values?

DCT Coefficients:

$$\begin{bmatrix} -415 & -33 & -58 & 35 & 58 & -51 & -15 & 12 \\ 5 & -34 & 49 & 18 & 27 & 1 & -5 & 3 \\ -46 & 14 & 80 & -35 & -50 & 19 & 7 & -18 \\ -53 & 21 & 34 & -20 & 2 & 34 & 36 & 12 \\ 9 & -2 & 9 & -5 & -32 & -15 & 45 & 37 \\ -8 & 15 & -16 & 7 & -8 & 11 & 4 & 7 \\ 19 & -28 & -2 & -26 & -2 & 7 & -44 & -21 \\ 18 & 25 & -12 & -44 & 35 & 48 & -37 & -3 \end{bmatrix}$$

Quantization Table:

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

2(c) [8 Marks]

Outline the process of the ENTROPY CODING of DC Discrete Cosine Transform (DCT) coefficients in JPEG image compression. What additional data saving technique(s) are used in the entropy coding of AC DCT coefficients?

[End of Question 2]

QUESTION 3 [TOTAL MARKS: 25]

3(a) [4 Marks]

Below is the Hadamard Transform basis vector matrix for $N = 4$. Given that the Hadamard Transform is a non-sinusoidal based transform, explain how we can obtain a FREQUENCY INTERPRETATION from its basis vectors.

$$H_4 = \frac{1}{2}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

3(b) [2 Marks]

Following on from question (a) above, SPECIFY the $N = 4$ Walsh-Hadamard Transform basis vector matrix.

3(c) [2 Marks]

The Hadamard Transform may be described as IMPLEMENTATION FRIENDLY. Briefly discuss this point.

3(d) [4 Marks]

QUANTIZATION relates to the process of constraining a scalar measurement originally exhibiting a continuous domain to a discrete set of values. Briefly discuss the CHALLENGE OF QUANTIZER DESIGN with respect to general OBJECTIVES, making reference to the FEATURES of a scalar quantizer.

3(e) [3 Marks]

What aspects of the quantization process does a quantizer's RATE-DISTORTION FUNCTION model? How is the TREND of a Rate-Distortion Function generally characterised with respect to its parameter(s)?

3(f) [10 Marks]

Below is an expression for the optimum allocation of an average bitrate n_{av} across a group of transform coefficients, where n_i is the number of bits allocated to coefficient X_i.

$$n_i = n_{av} + \frac{1}{b}\log_2 \frac{\sigma_i^2}{\left[\Pi_{j=0}^{N-1}\sigma_j^2\right]^{\frac{1}{N}}}$$

1. What does the symbol σ_i^2 represent in this expression?
2. Explain the SIGNIFICANCE of this parameter with respect to how this expression represents the OPTIMAL division of n_{av} bits across the coefficients.

3. Briefly mention some of the PRACTICAL ISSUES surrounding the variety of values provided by this formula when it comes to implementing a real-world bit-allocation system?

[End of Question 3]

QUESTION 4 [TOTAL MARKS: 25]

4(a) [13 Marks]

1. Sketch the high level structure of a H.261 VIDEO ENCODER and briefly describe its operation. [5 marks]
2. In your diagram, indicate the DECODING components that are implicit components of the encoder. [3 marks]
3. Explain why decoding is necessary in the encoder. [5 marks]

4(b) [8 Marks]

Describe the EIGHT DIFFERENT CODING MODES possible for an individual macroblock in a H.261 video encoder.

4(c) [4 Marks]

A specific MACROBLOCK ADDRESSING mechanism is necessary within the H.261 video bitstream syntax because for some blocks zero bits are sent to the decoder. Describe how this addressing mechanism is IMPLEMENTED in practice.

[End of Question 4]

QUESTION 5 [TOTAL MARKS: 25]

5(a) [6 Marks]

Explain what is meant by OBJECT-BASED coding in MPEG-4. Describe THREE ADVANTAGES of object-based coding.

5(b) [5 Marks]

Explain how the DCT process should be MODIFIED in order to cope with coding the image data associated with a Binary Alpha Block (BAB) on the border of an object.

5(c) [9 Marks]

What is meant by TEMPORAL SCALABILITY in the context of an MPEG-4 video encoding process? Explain the relationship between the different kinds of VOPS present in the BASE LAYER and ENHANCEMENT LAYER. Provide a diagram to illustrate your answer.

5(d) [5 Marks]

> "Object-based coding is commercially and technically unattractive because of the associated difficulty and inherent ambiguity of the object segmentation step"

Discuss this statement by explaining the difficulties and ambiguity associated with object segmentation referred to above.

[End of Question 5]

[END OF EXAM]