



DUBLIN CITY UNIVERSITY

SEMESTER ONE EXAMINATIONS 2009-2010

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: 2009

EXAMINERS:
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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) [5 Marks]

What is meant by the term SOURCE CODING in a video encoding process? Is this a LOSSY or a LOSSLESS process? List two typical coding events that undergo source coding in a H.261 video encoder.

1(b) [2 Marks]

List TWO approaches to source coding used in recent video compression standards. (NOTE: you are NOT required to describe these approaches)

1(c) [9 Marks]

Give an example of an international standard for LOSSLESS image compression and briefly describe its operation. Indicate in your description a key component of the overall encoding process where compression is achieved (i.e. a specific process in the overall coding scheme where compression occurs).

1(d) [9 Marks]

Give an example of an international standard for LOSSY image compression and briefly describe its operation. Indicate in your description a key component of the overall encoding process where compression is achieved (i.e. a specific process in the overall coding scheme where compression occurs).

[End of Question 1]

QUESTION 2

[TOTAL MARKS: 25]

2(a) [3 Marks]

The Fourier Transform exhibits an ‘orthogonal’ set of basis functions. Explain the meaning and significance of ORTHOGONALITY in this context.

2(b) [6 Marks]

The Fourier Series expansion for a periodic function $f(x)$ is represented in the expression below. Explain what the symbols a_0 , a_n , and b_n represent, and how they may be interpreted.

$$f(x) = \frac{1}{2}a_0 + \sum_{n=1}^{\infty} a_n \cos(n\omega x) + \sum_{n=1}^{\infty} b_n \sin(n\omega x)$$

2(c) [3 Marks]

Towards compressing an image, you are required to transform the pixel data using a transform that exhibits a REAL and ORTHOGONAL basis. Recommend three commonly used transforms that would be suitable in this task.

2(d) [7 Marks]

The expression below represents the overall quantization error introduced quantizing a scalar variable x with an N -level quantizer. With the aid of a diagram, explain the formation of this expression, making reference to the symbols d_i and r_i and what they represent.

$$e_q = \sum_{i=0}^{N-1} \int_{d_i}^{d_{i+1}} (x - r_i)^2 P(x) dx$$

2(e) [6 Marks]

Transform-coding for the compression of image data can be summarized in four specific steps. Outline each of these steps in the order in which they occur in practice.

[End of Question 2]

QUESTION 3

[TOTAL MARKS: 25]

3(a)

[5 Marks]

Explain the process illustrated in Figure 1. What is the relevance of this process in transmitting the DCT coefficients of a transformed 8×8 block?

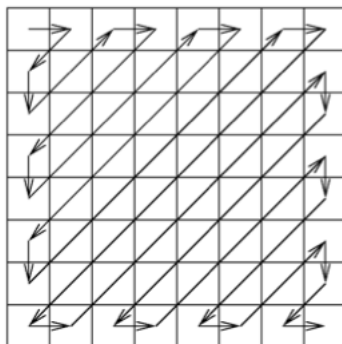


Figure 1: See above

3(b)

[4 Marks]

Outline the FOUR main modes of operation of the JPEG standard for still image compression.

3(c)

[3 Marks]

Mention TWO main ways in which perceptual redundancy is exploited in JPEG image compression.

3(d)

[3 Marks]

MPEG-1 video compression is based on four key elements. List these FOUR elements. Which of these elements are also found in JPEG image compression?

3(e)

[5 Marks]

Answer TRUE or FALSE to the following statements about the inter-frame relationships in an MPEG-1 video stream.

1. I-frames are used to predict other I-frames.
2. P-frames are used to predict other I-frames.
3. P-frames are used to predict B-frames.
4. B-frames are used to predict B-frames.
5. P-frames are used to predict P-frames.
6. B-frames can be predicted from both past and future frames.

7. B-frames can be predicted from past frames without reference to future frames.
8. B-frames can be predicted from future frames without reference to past frames.
9. P-frames are never used as reference frames for prediction.
10. The video stream must feature at least one I-frame.

3(f)

[5 Marks]

Below is a typical length-15 GOP structure of an MPEG-1 video stream. Shown is the display order of the frames (numbered 0-14) and their corresponding picture types (I, P, or B). Suggest a suitable stream order for these frames, which takes into account the issues surrounding inter-frame dependency and decoding efficiency. Your answer should take the form of a length-15 numbered list, corresponding to a reordering of the display-ordered frame numbers given.

Display Order	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Picture Type	B	B	I	B	B	P	B	B	P	B	B	P	B	B	P

[End of Question 3]

QUESTION 4

[TOTAL MARKS: 25]

4(a) [6 Marks]

Explain how TEMPORAL redundancy in a video sequence is exploited in an encoding process. Your answer should make reference to and describe the complementary processes of MOTION ESTIMATION and MOTION COMPENSATION.

4(b) [8 Marks]

Estimate the computational cost (i.e. the total NUMBER OF COMPUTATIONS required), for generating a motion vector for ALL 16×16 macro blocks in a QCIF video frame. You should assume:

- motion estimation is carried out on the luminance (Y) component only;
- a FULL SEARCH motion estimation algorithm is used with a search window size of ± 8 pixels;
- there are THREE computations required for each pixel location accessed, corresponding to a subtraction, absolute value and an accumulation.

What are the implications of your calculations for a video encoder?

4(c) [4 Marks]

In the above question we assume that only three computations are required for each pixel position accessed in the motion estimation search strategy. This implies a SPECIFIC APPROACH is being used to calculate the similarity between the 16×16 block in the current frame and the block being searched in the reference frame. What is this MATCHING CRITERION? Give a mathematical formulation for this criterion.

4(d) [7 Marks]

Explain how motion is modeled in the three step log search process for motion estimation. Does the motion model used reflect the real motion in a typical video sequence for natural scenes? Your answer should indicate the importance or otherwise in estimating and representing real scene motion in terms of the effect on the overall coding process from the following two perspectives:

- Computational complexity of the overall encoding process;
- Quality of the motion compensated prediction image generated as a result of using this model

[End of Question 4]

QUESTION 5

[TOTAL MARKS: 25]

5(a) [12 Marks]

Sketch the BITSTREAM DIAGRAMS as specified for a H.261 video codec. You should provide separate sketches for:

- Picture layer
- Group of Blocks (GOB) layer
- Macroblock layer
- Block layer

In each case, explain what each bitstream component/acronym refers to and specify whether it is encoded as a fixed length code or a variable length code. (NOTE: You DO NOT need to specify how many bits are used for each bitstream component.)

5(b) [9 Marks]

“MPEG-4 supports encoding of arbitrarily-shaped image regions that MAY or MAY NOT correspond to semantic objects present in the scene”

1. Is this statement TRUE or FALSE? [1 mark]
2. Give an explanation for your answer. [3 marks]
3. Explain why it could be desirable to encode arbitrarily-shaped image regions in the first place. [3 marks]
4. Give TWO examples of added value functionality in a video encoder that this facility supports. [2 marks]

5(c) [4 Marks]

Explain how a video encoding standard is formulated to:

1. provide for the existence of COMPETING PRODUCTS in the market place that implement the standard;
2. provide an opportunity of LEVERAGING FUTURE RESEARCH results in key aspects of video compression.

[End of Question 5]

[END OF EXAM]