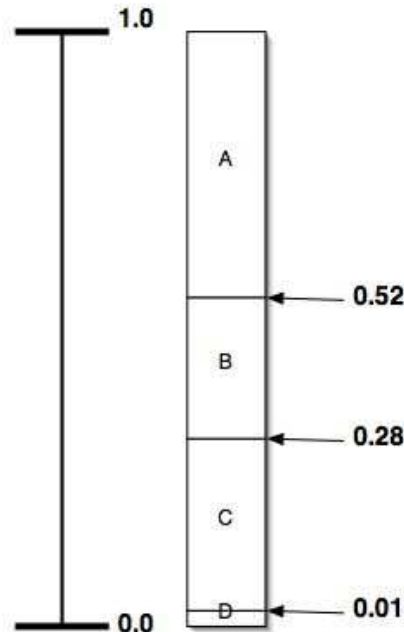


Question 1

- 1(a) State, and explain in your own words, two alternative definitions of Shannon's Lossless Coding Theorem. Explain an implication of this theorem on a practical coding scheme. [5 Marks]
- 1(b) Briefly outline the operation of the lossless mode of the ISO JPEG image coding standard indicating how individual pixels are encoded. You should use text, diagrams and sample pixel values to illustrate your answer.
Note: Your example should be for illustrative purposes only. You do **not** need to provide a real variable length codeword for your illustrative example, nor justify the efficiency or otherwise of the approach. [8 Marks]
- 1(c) What is meant by the term **non-normative** in the context of an image/video compression standard? Why are non-normative aspects of a standard desirable? Describe a non-normative aspect of H.261 and a (different) non-normative aspect of MPEG-4. In each case, explain why this particular aspect can be considered non-normative. [8 Marks]
- 1(d) Describe two aspects of the H.263 video coding standard that differ from the earlier H.261 standard, making overall encoding more efficient as a result. [4 Marks]

[Total marks: 25]

Question 2



- 2(a) Calculate the entropy of the information source consisting of four symbols A, B, C, D with probabilities $p_A = P\{A\} = 0.48, p_B = P\{B\} = 0.24, p_C = P\{C\} = 0.27, p_D = P\{D\} = 0.01$. Illustrate how the Huffman codewords for this source would be calculated. [8 Marks]
- 2(b) Assuming the same information source as defined in part (a) illustrate the operation of Arithmetic Encoding in order to encode the message $ABBC$. Calculate the binary fraction obtained as a result and comment which is more efficient coding of this message – Huffman or arithmetic? [8 Marks]
- Note 1:** you need not sketch the successive narrowing of the interval on the real number line, simply illustrate the evolution of *high* and *low* in the Arithmetic Encoding algorithm.
- Note 2:** you can assume that the interval $[0.0, 1.0)$ on the real number line is initially divided as illustrated in Figure .

Please turn over for parts (c) and (d)

Question 2 (Contd.)

- 2(d)** “*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 or not you agree with it. Explain your reasons in either case. **[5 Marks]**
- 2(d)** What is meant by “*run length encoding*”? Why is this a useful pre-processing step prior to entropy encoding of quantized DCT coefficients? **[4 Marks]**

[Total marks: 25]

Question 3



The image shown above is the result of saving a small piece of text as a JPEG file with a very low quality setting.

- 3(a)** Describe the steps involved in the JPEG compression process. Your answer should include reference to the transform stage (including the differing treatment of DC and AC coefficients), the quantization stage, the entropy coding stage and any “side” information included in the JPEG file in addition to the compressed image data. **[9 Marks]**
- 3(b)** Explain the source of the artifacts visible in the above image and why they are not normally visible in scanned images of text stored as JPEG files. **[8 Marks]**
- 3(c)** Outline the properties of a transform operation that would be better suited to the material digitized in the above image. Your response should refer to the role that the transform operation plays in transform-based coding. **[8 Marks]**

[Total marks: 25]

Question 4

- 4(a) Describe the layered data structure used in the MPEG-1 standard for an elementary video stream, including the role played by each layer in representing compressed video. Describe the time and picture-type structure of a typical GOP, explaining why the time-ordering that pictures acquire in the compressed data stream is different from the eventual display order. [9 Marks]
- 4(b) Consider the macroblocks in a reconstructed MPEG-1 B-picture. Describe the different ways in which data for this reconstruction can be derived from earlier elements in the compressed stream. Explain how and why DC coefficients are treated differently in *intra*-coded macroblocks than in *inter*-coded macroblocks. [8 Marks]
- 4(c) You are required to develop a system for detecting advertising inserts in broadcast TV content compressed as an MPEG-1 video layer bitstream. Describe how you would use the information in the layered data structure of the MPEG-1 standard to determine the information required for the application. You should assume that the advertising content is characterised by a significantly increased frequency of shot cuts, a greater amount of camera and scene motion, large areas of bold colour in the content, and more significant changes of colour over time. [8 Marks]

[Total marks: 25]

Question 5

- 5(a) Using diagrams and text, **QUANTITATIVELY** compare and contrast the *three-step logarithm* and the *parallel one-dimensional* motion estimation search strategies as they would typically be used in a video encoder. In formulating your answer you should consider the operations required per pixel in the search process assuming that: [8 Marks]
- the computational cost of accessing pixel data is negligible;
 - for each location accessed in the reference image/frame there are three computations - subtraction, addition and an absolute value calculation.
- 5(b) Explain the method of binary shape coding employed in the MPEG-4 video compression standard as it applies to a given Binary Alpha Block (BAB). Use appropriate diagrams in order to illustrate your explanation. [8 Marks]
- 5(c) “Every hybrid DPCM/transform-based video encoder implicitly includes a decoder.” [5 Marks]
Explain what is meant by this statement and why including decoding within an encoder is necessary. List two components of a typical video encoding scheme that correspond to decoding processes.
- 5(d) Explain the scene-representation adopted by the MPEG-4 video compression standard in order to support higher-levels of user interaction than was previously possible with other standards. [4 Marks]

[Total marks: 25]