

## Question 1

- 1(a) Define what is meant by the Quarter-Common Intermediate Format (QCIF) for uncompressed video. List two advantages of this format that make it suitable for video compression applications. Calculate the storage required (in kilobytes) for a 2 minute 30Hz QCIF video source. [7 Marks]
- 1(b) In information theory, describe what is meant by a *Binary Symmetric Source*. Draw a plot of the entropy of this kind of information source against symbol probability. Outline three properties of the entropy function that can be generalised from your plot. [9 Marks]
- 1(c) Describe what is meant by the term *run-length coding* and give an example of how it might be employed in an image or video compression scheme. [4 Marks]
- 1(d) "*In theory, a compression scheme can be made arbitrarily efficient, but only at the cost of coding delay.*" Briefly explain what is meant by this statement. Your answer should refer to Shannon's lossless coding theorem. [5 Marks]

[Total marks: 25]

## Question 2

- 2(a) State and explain the condition that must be fulfilled by binary variable length codewords in order to be of practical use in a compression scheme. Use a simple example to illustrate your answer. [4 Marks]
- 2(b) Consider the information source consisting of five symbols  $A, B, C, D, E$  with probabilities  $p_A = P\{A\} = 0.24, p_B = P\{B\} = 0.35, p_C = P\{C\} = 0.15, p_D = P\{D\} = 0.22, p_E = P\{E\} = 0.04$ . Calculate the Huffman codes for this information source, comment on their efficiency and postulate a reason for their efficiency/inefficiency. [8 Marks]
- 2(c) State and explain the algorithm for DECODING a message transmitted via arithmetic encoding. Your description should consist of a statement of the algorithm followed by a brief textual description of its operation. **Note:** You are **NOT** required to describe the arithmetic encoding algorithm. [8 Marks]
- 2(d) Briefly outline the two ways in which pixels are encoded in the ITU-T Group 3 Facsimile Compression Standard. [5 Marks]

[Total marks: 25]

## Question 3

You are required to design a proprietary image compression system for the efficient lossy coding of scanned printed black-type-on-white-paper documents. Assume that a transform coding approach is appropriate.

- 3(a)** Describe some key results from Fourier analysis of periodic functions that underpin the properties of orthogonal transforms in general, and in particular the design and characteristics of the Discrete Cosine Transform (DCT). [7 Marks]
- 3(b)** Outline the pros and cons of using a DCT-based compression scheme for the application described above. Describe at least two alternatives to the DCT that are better matched to the above application, clearly describing their main characteristics and why they are better matched to the application. [7 Marks]
- 3(c)** What is the relevance of the quantization stage to a transform coding process? Specify a scalar quantization process that you think is appropriate for the application at hand, including the key factors in the selection of this process and how it might be implemented in practice. (A thorough response to this question will include aspects such as bit allocation to transform coefficients and zonal or other ways of structuring/grouping transform coefficients). [7 Marks]
- 3(d)** Comment on the role, if any, of entropy coding in a transform-based scheme such as the one you have designed as required above. [4 Marks]

[Total marks: 25]

## Question 4

- 4(a) Explain the distinction between the system layer and the video layer in the MPEG-1 standard, including the different roles played by each. Comment on the relationship, if any, between system-layer packets and video or audio layer access units. How is the MPEG-1 system layer different from that used in MPEG-2. [8 Marks]
- 4(b) Explain the difference in roles played by *start codes* and *variable-length codes* in the MPEG-1 stream. Include in your response the purpose of *marker-bits* inserted at various points into the stream. Outline at least *two* different schemes for decoding variable length codes (VLCs). [8 Marks]
- 4(c) You are required to develop a video retrieval system that exclusively uses information contained in a compressed MPEG-1 video layer bitstream. The retrieval system is to be based on segmenting video into shots and characterising (i) the dominant colour in each shot and (ii) the dominant camera motion in each shot. Describe how you would use the information in the layered data structure used in the MPEG-1 standard to determine the information required for the application. [9 Marks]

[Total marks: 25]

## Question 5

- 5(a) Describe the operation of the three-step logarithm search strategy for calculating motion vectors in a motion estimation process. Illustrate your answer with a diagram of the pixel locations searched. Assuming a block size of  $16 \times 16$ , and an initial step size of 8, calculate the number of operations required assuming that: [8 Marks]
- the cost of accessing pixel data is negligible;
  - for each location accessed there are three computations - subtraction, addition and an absolute value calculation.
- 5(b) Describe the different coding modes possible for individual macroblocks in a H.261 bitstream. [7 Marks]
- 5(c) Describe how the presence/absence of quantized transform coefficients for particular  $8 \times 8$  blocks in a macroblock is signaled within a H.261 bitstream. Use a diagram and a simple example to illustrate your answer. [5 Marks]
- 5(d) What is meant by the term *non-normative* in the context of an image/video compression standard? Describe three typical non-normative aspects of H.261. [5 Marks]

[Total marks: 25]

## Question 6

- 6(a)** Sketch the structure of a typical hybrid transform/DPCM video codec [7 Marks] and briefly describe its operation.
- 6(b)** Assuming MPEG-4 object-based coding, indicate three components of the codec structure described in part (a) above that need to be modified in order to facilitate object-based compression. Describe the nature of these modifications in each case. [7 Marks]
- 6(c)** Sketch an alternative representation of a complete MPEG-4 encoding scheme to that provided for part (a) above that more clearly indicates the high level structure required when multiple objects in a scene are being encoded. Indicate where in this system user interaction could occur. [6 Marks]
- 6(d)** Describe the relationship between object segmentation from source video and MPEG-4 compression and briefly comment on whether the nature of this relationship is an advantage or a disadvantage of the standard. [5 Marks]

[Total marks: 25]