
Question 1

(a) Consider the 8×8 block of pixel values shown in Figure 1. Calculate the Huffman codewords for the grey levels present in this block of pixels. You should use the frequency of occurrence of the grey levels in this block to derive probabilities of occurrence for the different grey levels

120	120	120	127	250	250	250	250
120	120	120	127	250	250	250	250
120	120	120	127	250	250	250	250
120	120	120	127	250	250	250	250
127	127	127	127	250	250	250	250
127	127	127	127	250	250	250	250
250	250	250	250	250	250	250	250
255	255	255	255	255	255	255	255

Figure 1: An 8×8 block of pixel values

[7 vidmarks]

(b) Define a metric for Huffman codewords which can be compared to the entropy of an information source in order to estimate the efficiency of Huffman coding. Calculate this measure for the codewords calculated in part (a) above.

Note: You are NOT required to calculate the entropy of the source, simply the defined metric.

[3 vidmarks]

(c) Describe *arithmetic encoding* as a source coding technique. Your description should consist of a brief overview, followed by a statement of the arithmetic encoding algorithm

Note: You are NOT required to present the arithmetic decoding algorithm.

[8 vidmarks]

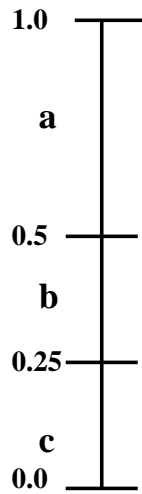


Figure 2: Intervals for information source of Question 2(d)

(d) Consider an information source consisting of three symbols a, b, c with probabilities $p_a = P\{a\} = 0.5, p_b = P\{b\} = 0.25, p_c = P\{c\} = 0.25$ and cumulative probability distribution as outlined in Figure 2. Present a diagram and the associated calculations in order to illustrate the operation of the algorithm outlined in section (c) above to encode the message 'baac'.

Note: you are NOT required to produce the final binary code, simply illustrate the evolution of the upper and lower bounds of the interval on the number line as each symbol is transmitted.

[7 vidmarks]

Question 2

(a) The set of a sine and cosine functions defined over a continuous interval which have an integer number of cycles in that interval form a complete orthogonal set. Explain what this means and how it is relevant to the Fourier Series representation of a periodic function.

[5 vidmarks]

(b) For a periodic function with period L , explain in some detail how the coefficients of a Fourier Series expansion of the function will depend on the function having:

1. even or odd symmetry
2. translational symmetry/anti-symmetry over a distance $L/2$
3. discontinuities of the function or its derivatives.

[10 vidmarks]

(c) Explain how the concept of the Fourier Series expansion of periodic functions can be used to develop the 1-D discrete cosine transform (DCT) of a 1-D block of data samples taken from a non-periodic sampled signal. Outline how the 1-D DCT can be extended to 2-D.

[10 vidmarks]

Question 3

(a) Distinguish between the design of a scalar quantization process using the Lloyd-Max approach, the companding approach and the optimum uniform quantizer approach.

[9 vidmarks]

(b) Give an overview of the main features of the ISO JPEG Standard lossy encoding scheme, explaining how the various component processes are justified. Outline how the JPEG2000 Standard encoding scheme improves on the earlier JPEG encoder.

[7 vidmarks]

(c) Outline the structure of the video compression layer of the ISO MPEG-1 digital audio/video coding standard, explaining the role played by each component process.

[9 vidmarks]

Question 4

(a) Describe a typical *logarithmic search strategy* for calculating motion vectors in a motion estimation process. Illustrate your answer with a diagram of the pixel positions searched.

[6 vidmarks]

(b) What is meant by *hierarchical motion estimation*? Illustrate your answer with a diagram.

[4 vidmarks]

(c) Describe the hierarchical structure of a H.261 bitstream and briefly outline the main bitstream elements of each level in the hierarchy. Illustrate your answer with a diagram which graphically relates this hierarchy to the different components of an individual video frame

[7 vidmarks]

(d) List and briefly describe the different types of macroblock possible (i.e. the different coding modes possible for any given macroblock) in H.261 video encoding

[8 vidmarks]

Question 5

(a) Sketch and describe the high-level structure of an MPEG-4 encoder for multiple video objects indicating at what points in the system user interaction could occur. Give two examples of possible user interaction.

[5 vidmarks]

(b) Explain how the processes of *block padding* and *polygon matching* are used in a motion estimation process for arbitrary shaped objects in an MPEG-4 encoder. Illustrate your answer with diagrams where appropriate.

[8 vidmarks]

(c) Explain what is meant by *spatial scalability* in MPEG-4 video encoding. Illustrate your answer with a diagram. In your diagram you should indicate the different types of Video Object Planes used (I-/P-/B-VOPs).

[8 vidmarks]

(d) “*Object segmentation in MPEG-4, like feature extraction in MPEG-7, is a non-normative aspect of the standard*”. Briefly explain what is meant by this statement for each standard.

[4 vidmarks]

Question 6

(a) Outline the meaning and benefit of Coded Orthogonal Frequency Division Multiplexing, as used in digital video broadcasting. Explain the significance and relationship within DVB-T receivers between the following terms: total symbol period, guard interval and active symbol period.

[12 vidmarks]

(b) Explain the main difference between the '2k' and '8k' Fast Fourier Transformation implementations of the DVB-T system.

[4 vidmarks]

(c) Explain briefly what is meant by hierarchical modulation and how it is achieved within DVB-T.

[4 vidmarks]

(d) Explain the main benefit of a Single Frequency Network (SFN) to a terrestrial broadcaster, and outline the main requirements that must be met in order to establish such a network.

[5 vidmarks]