Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2012-13 (2.0 hours)

EEE6081 Visual Information Engineering 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** Explain the purpose of having an orthogonal transform in an image encoder. **(5)**

b. A transform matrix (H) for transforming a 4x1 input data vector is shown below.

$$H = \frac{1}{128}\begin{bmatrix} 64 & 64 & 64 & 64 \\ 84 & 35 & -35 & -84 \\ 64 & -64 & -64 & 64 \\ 35 & -84 & 84 & -35 \end{bmatrix}$$

Derive the inverse transform matrix showing all steps. **(5)**

c. How do you use the transform in **Question 1.b** to remove noise from an image corrupted with noise? **(5)**

d. An input data matrix of 4x4 size is transformed using the 2-dimensional Discrete Cosine transform (DCT) and the output is shown below.

$$\begin{bmatrix} 440 & -24 & -17 & -4 \\ 19 & 12 & 8 & -2 \\ 5 & 4 & 3 & -1 \\ -3 & -3 & 2 & -4 \end{bmatrix}$$

If the transform coefficients are quantised using a quantisation parameter of 10 in a compression algorithm, estimate the loss of energy in the decoded data matrix as a percentage of the total energy. **(5)**

2. **a.** The lifting factorisation of a wavelet transform is as follows:

$$\begin{bmatrix} y_0 \\ y_1 \end{bmatrix} = \begin{bmatrix} 1 & b \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ a & 1 \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \end{bmatrix}$$

[x_0, x_1] and [y_0, y_1] represent the poly-phase components of the input and output signals, x and y, respectively. Subscripts, 0 and 1, correspond to the even and odd indexed poly-phase components, respectively.

If a and b are any non-zero number, show the lifting steps for obtaining the reversible integer-to-integer realisation of this wavelet transform and the corresponding inverse transform. **(5)**

b. If the output poly-phase components, y_0 and y_1, in the wavelet transform in **Question 2.a** represent low pass and high pass components of the input data and the low pass filter used in the transform is even-symmetric, derive the value of a and b. **(5)**

c. What is the use of the low pass component y_0 in the wavelet transform in **Question 2.a**? **(5)**

d. Explain how you use the wavelet transform in **Question 2.a** to obtain the 2-level full tree wavelet packet decomposition of an image containing 128 x 128 pixels. **(5)**

3. **a.** State the four types of redundancies present in a video sequence and explain briefly how they are eliminated in video compression giving examples of such techniques for each of the four redundancy types. **(5)**

b. Explain, using diagrams, how motion is estimated for motion compensated temporal prediction in video coding. Also, state how the accuracy of the motion estimation has been improved in the latest video coding standards, such as, H.264 and MPEG-4. **(5)**

c. In video coding, a frame can be encoded either as an intra frame (I) or as a forward predicted frame (P) or as a bi-directionally predicted frame (B). Three methods of frame organisation depending on these encoding types are listed below.

Method 1: All frames are encoded as intra frames (I I I I I I I ....)

Method 2: Forward motion predicted differential coding (I P P P P P P ...)

Method 3: Group of pictures with I and hierarchical B modes (I B B B B B)

Consider these three scenarios to answer the following questions.

(i) What are the advantages and disadvantages of Method 2 compared to Method 1?

(ii) How do you improve method 2 to overcome the disadvantage over method 1?

(iii) What are the advantages and disadvantages of Method 3 compared to other two methods? **(5)**

d. Explain how the motion vectors estimated in motion compensated temporal prediction can be used for obtaining MPEG-7 motion descriptors used in video sequence analysis and indexing. **(5)**

4. a.

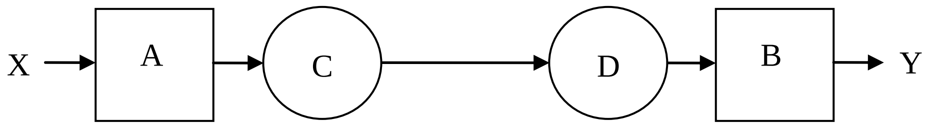

Figure 1

Figure 1 shows a block diagram of a system for creating an approximated version (Y) of a one-dimensional signal (X). A and B represent low pass filters. C and D represent down-sampling and interpolating (i.e., inserting zero –valued samples) by a factor of 2, respectively.

Explain briefly, using a diagram, how to design a pyramid-based multi-resolution representation scheme and its reconstruction process using the signal approximation scheme shown in Figure 1. **(5)**

b. Compute the sampling redundancy factor for a 3 level decomposition of a two-dimensional (2-D) pyramid transform. **(5)**

c. Explain how the 2-D pyramid transform can be used for image coding with spatial resolution scalability functionality. **(5)**

d. Consider the sub bands produced from a 3 level 2-D pyramid-based multi-resolution representation for embedding a watermark.

State, giving reasons, which sub bands and coefficients you would choose to embed the watermark ensuring both high imperceptibility and high robustness to compression at the same time. **(5)**

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