Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2013-14 (2.0 hours)

EEE6081 Visual Information Engineering

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. The poly-phase decomposition of a wavelet transform is shown in the following equation.

$$\begin{bmatrix} y_0 \\ y_1 \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \end{bmatrix}$$

[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. The non-zero values a, b, c and d represent the polyphase components of the length-2 wavelet filters.

a. Considering the orthogonality and regularity conditions, find the values of a, b, c and d. **(5)**

b. Using the above shown wavelet transform, write down the forward wavelet transform matrix corresponding to the first level of decomposition for an input signal that contains 4 elements. **(2)**

c. Derive the corresponding inverse transform matrix of the forward wavelet transform matrix in question 1.b? **(4)**

d. Explain the characteristics of the output poly-phase components, y_0 and y_1 and their use in the wavelet domain processing. **(4)**

e. Explain how you can use the above shown wavelet transform for removing the noise in an image. **(5)**

2. **a.** Explain, using diagrams, how motion is estimated for motion compensated temporal prediction in video coding. **(4)**

b. Derive an expression for estimating the complexity of the block matching algorithm for motion estimation. **(4)**

c. What is the effect of block size in estimating motion for video coding? Explain your answer with respect to the effect on compression efficiency, prediction accuracy, cost of motion vectors and error propagation. **(4)**

d. Explain how multi-resolution decomposition can be used for reducing the computational complexity of the motion estimation process. **(4)**

e. Explain how the motion vectors estimated in video coding can be used for obtaining the motion descriptors commonly used in video sequence analysis and indexing **(4)**

3. **a.** Explain how an 8-bit depth resolution image can be converted to a 4-bit depth resolution image. **(3)**

b. Explain the effect of bit depth reduction on the visual quality of an image containing both high spatial frequency regions and low spatial frequency regions. **(3)**

c. Compute the data rate for transmitting an uncompressed HD resolution video sequence (1080x1920) in 4:2:0 format containing 8 bits per pixel per colour component and 50 frames per second frame rate. **(4)**

d. Briefly explain

(i) What is meant by “quality scalable image coding”;

(ii) How the quality scalability is achieved in image coding; and

(iii) An application of quality scalable image coding. **(5)**

e. 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 integer input and corresponding output data, respectively. If a and b are non-integer constants, show the lifting steps for obtaining the reversible integer-to-integer realisation of this wavelet transform and its inverse transform. **(5)**

4. **a.**

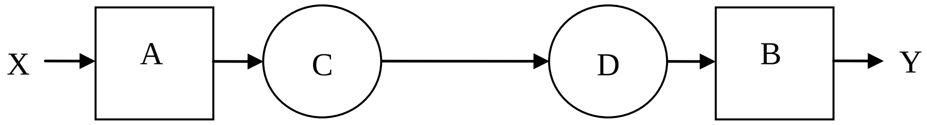

Figure 1

Figure 1 shows a block diagram of a system for creating an approximated version (Y) of an image X.

A and B represent two-dimensional (2-D) low pass filters. C and D represent 2-D down-sampling and interpolating (i.e., inserting zero –valued samples) by a factor of 4, 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. Derive an approximation for the sampling redundancy factor for decomposing an image into multi-resolution representation using the 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.

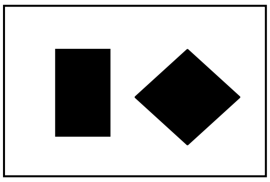

Figure 2

In the image in Figure 2, black and white represent the grey scale values 255 and 0, respectively. Sketch the sub bands of the 2-level multi-resolution representation using the 2-D pyramid transform. **(5)**

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