Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2014-15 (2.0 hours)

EEE6218 Visual Information Processing

Answer **THREE** questions. **No marks will be awarded for solutions to a forth 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.

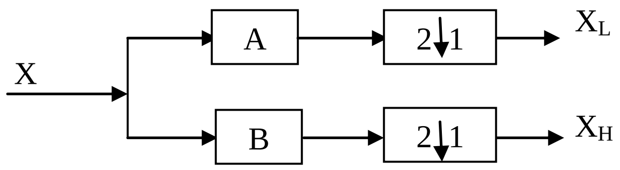

Figure 1

Figure 1 shows the analysis filterbank of the orthogonal one dimensional discrete wavelet transform. A is a low pass filter with coefficients {*a*, *b*, *c*, *d*} and B is the corresponding high pass filter with coefficients {*p*, *q*, *r*, *s*}. X is the input signal. X_L and X_H are the low pass and high pass channels

a. Explain the use of the low pass channel X_L. **(3)**

b. Draw how the filterbank in Figure 1 is extended to use for single-level two-dimensional (2-D) wavelet decomposition. **(3)**

c. Explain the difference between separable filtering and non-separable filtering. State two advantages of non-separable filtering. **(4)**

d. Derive the 2-D non-separable filters based on the one dimensional filters, A and B, in Figure 1 to perform single-level 2-D wavelet decomposition using the non-separable filtering approach. **(6)**

e. Explain how the filterbank in Figure 1 can be used for dyadic wavelet decomposition of a video sequence. What is the main drawback of this approach? **(4)**

2.

a. Explain why we use the luminance and two chrominance signals form (Y C_b C_r) rather than the additive primary colour form (Red-Green-Blue) for colour television broadcasting? **(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. You have been asked to assist in the development of a television broadcast system for an alien species, the *Clangers*, who have different visual abilities to our own.

Using the information given below, carry out these requirements – giving, where appropriate, brief explanations of your working.

i. Calculate the required resolution of the display in terms of number of pixels. **(3)**

ii. Calculate the practical memory requirements, in bytes, to store one frame. **(3)**

iii. Estimate the channel bandwidth required for uncompressed television transmissions. **(3)**

iv. If the *Clangers* are like us and possess inferior ability to perceive fine detail in the chrominance information, explain how this can be exploited to obtain a 50% reduction of the overall bandwidth need. **(3)**

v. Recommend a digital video compression standard that can be used for further reduction of the data rate. **(2)**

Information on Clangers' visual system and other requirements:

- Aspect ratio of television display (width:height) = 4:3.
- *Clangers'* spatial frequency cut-of (horizontal and vertical) = 150 cycles/degree subtended to their eye.
- *Clangers* have only two types of colour receptor on the retinas, can perceive approximately 38,000 different colours (hues) and can distinguish some 200 different intensity levels.
- *Clangers* can detect intensity flicker up to 80 Hz at the illumination levels typical in television displays. They, like us, are less prone to perceive flicker over small areas.
- *Clangers* sit, on average, 12 times the display height away from their televisions.
- Available transmission bandwidth is at a premium and every effort needs to be made to minimise it.

3. **a.**

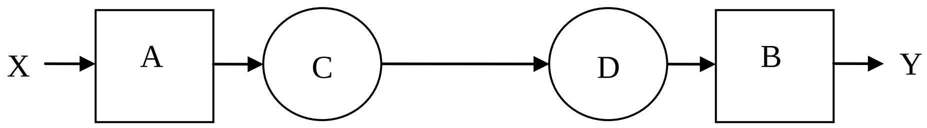

Figure 2

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 2. **(4)**

b. Derive an approximation for the sampling redundancy factor for decomposing an image into multi-resolution representation using the 2-D pyramid transform. **(4)**

c. Explain how the 2-D pyramid transform can be used for image coding with spatial resolution scalability functionality. **(4)**

d.

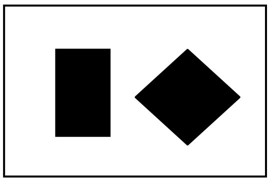

Figure 3

In the image in Figure 3, 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. **(4)**

e.

Image 1 Image 2 Image 3 (fused)

Figure 4: Image Fusion

Explain using a block diagram how pyramid transform-based multi-resolution image representation can be used for fusing image 1 (only the big clock is clear) and image 2 (only the small clock is clear) to obtain the fused image as in image 3 (both clocks are clear) in Figure 4. **(4)**

4. **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. **(4)**

b. Explain briefly the purpose of the discrete wavelet transform in scalable image coding. **(4)**

c. 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. **(4)**

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). Four 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 all I, P and B modes (I B P B P B)

Method 4: Group of pictures with I and hierarchical B modes (I B B B B B)

Consider these 4 scenarios to answer the questions 4.d– 4.g.

d. What are the advantages and disadvantages of Method 3 compared to Method 1? **(2)**

e. State why Method 2 is the least robust method and suggest a way to improve the robustness of method 2. **(2)**

f. Show graphically the coding/decoding path of frames shown in Method 4. **(2)**

g. Compare the decoding delay and the complexity of Method 3 and Method 4. **(2)**

GCKA/MH