NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2018-2019

EE6427 – VIDEO SIGNAL PROCESSING

November/December 2018 Time Allowed: 3 hours

INSTRUCTIONS

1. This paper contains 5 questions and comprises 7 pages.
2. Answer all 5 questions.
3. All questions carry equal marks.
4. This is a closed-book examination.

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1. (a) Consider a one-dimensional transform 'T' whose basis function is shown in Figure 1.

$$\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix}$$

Figure 1

Note: Question No. 1 continues on page 2

A grey level intensity matrix of 8x8 block of an image is shown in Figure 2.

$$\begin{bmatrix} 20 & 20 & 20 & 20 & 10 & 10 & 10 & 10 \\ 20 & 20 & 20 & 20 & 10 & 10 & 10 & 10 \\ 20 & 20 & 20 & 20 & 10 & 10 & 10 & 10 \\ 20 & 20 & 20 & 20 & 10 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \\ 10 & 10 & 10 & 10 & 10 & 10 & 10 & 10 \end{bmatrix}$$

Figure 2

Compute the two-dimensional transform 'T' of the block shown in Figure 2 by using row column decomposition method.

(12 Marks)

(b) Apply a quantizer of 30 to DC coefficient and apply a quantizer of 90 to all AC coefficients. Calculate the quantized transform coefficients, and show the quantized transform coefficients after zigzag scanning.

(3 Marks)

(c) Huffman codes for DC coefficient and AC coefficients are defined in Table 1 and Table 2 respectively where EOB stands for End Of Block. (Note: If the required codewords are not shown in the tables, please answer "codeword not found")

(i) Apply the Huffman codes in Table 1 to encode the quantized DC coefficient obtained in part (b).

(ii) Apply run length code to encode the quantized AC coefficients obtained in part (b), and follow by using the Huffman codes in Table 2 to encode the results obtained.

(5 Marks)

Note: Question No. 1 continues on page 3

Table 1

DC Coefficients	Size	Huffman codes for Size
0	0	00
-1,1	1	010
-3,-2,2,3	2	011
-7,…,-4,4,…,7	3	100
-15,…-8,8,…,15	4	101
-31,…,-16,16,…,31	5	110
⋮	⋮	⋮

Table 2

(Skip,Size)	Huffman Codes	(Skip,Size)	Huffman Codes
(0,1)	00	(0,6)	1111000
(0,2)	01	(1,3)	1111001
(0,3)	100	(5,1)	1111010
(EOB)	1010	(6,1)	1111011
(0,4)	1011	(0,7)	11111000
(1,1)	1100	(2,2)	11111001
(0,5)	11010	(7,1)	11111010
(1,2)	11011	(8,1)	111111000
(2,1)	11100	(3,2)	111110111
(3,1)	111010	(4,2)	1111111000
(4,1)	111011	⋮	⋮

2. (a) A series of coded frames is received by an MPEG-2 decoder with the frame types shown in the following. In what order should these frames be displayed?

$$I_1\ I_2\ B_3\ B_4\ I_5\ P_6\ B_7\ I_8\ B_9\ P_{10}$$

(7 Marks)

(b) In MPEG-2 video coding, the macroblock to be predicted is split into top field pixels and bottom field pixels. A simplified example is shown in Figure 3, each frame is split into top field and bottom field respectively (i.e. Frame 1 is split into Field T1 and Field B1). Use Figure 3 to show which fields are used as reference fields for encoding of T2, B2, T4 and B4 respectively.

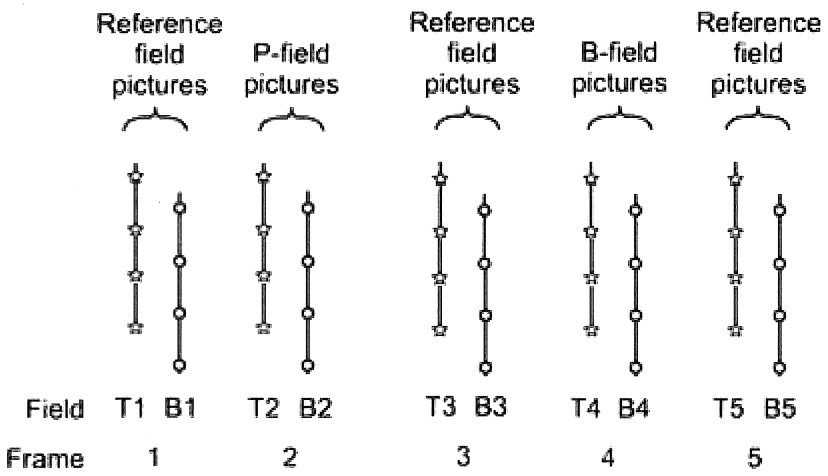

Figure 3

(7 Marks)

(c) Briefly explain how the JPEG progressive mode can be achieved.

(6 Marks)

3. (a) Draw a block diagram of H.261 video encoder and decoder with the following functional blocks.

- Coding Control (CC)
- Variable length coding (VLC)
- Variable length decoding (VLD)
- Decoder Buffer (BF)
- Frame Memory (FM)
- Discrete Cosine Transform (DCT)
- Inverse Discrete Cosine Transform (IDCT)
- Quantization (Q)
- Inverse Quantization (IQ)
- Motion Estimation (ME)
- Motion Compensation (MC)

(12 Marks)

(b) In block based video motion estimation, the new three-step search (NTSS) with a search area of ±7 pixels is considered to form the prediction of the current frame from the reference frame. With the help of a simple diagram, describe the search steps of new three-step search. How many search point in the each step of the search?

(8 Marks)

4. (a) Motion marker is an error resilience tool for MPEG-4 video. Explain how motion marker can help to maintain the video quality in case of transmission error occurs in a MPEG-4 video bitstream. Please indicate the position of motion marker in a MPEG-4 error resilient video packet.

(6 Marks)

(b) Error concealment tool can help to maintain the video quality in case of transmission errors in the compressed video bitstream. With the help of a simple diagram, describe Projection Onto Convex Sets (POCS).

(8 Marks)

(c) Given the YUV image values in Figure 4, what are the corresponding chroma subsampled values for a (i) 4:2:2 subsampling, and (ii) 4:1:1 subsampling.

200	198	195	199
204	201	198	199
208	203	199	199
210	207	201	202

Y

40	52	52	64
48	50	52	64
48	58	52	66
46	56	52	66

U

30	32	22	12
32	32	24	16
34	32	24	18
36	34	24	10

V

Figure 4

(6 Marks)

5. (a) A 4 x 4 image block is given in Figure 5.

39	45	32	32
39	45	32	32
40	40	18	18
38	42	18	18

Figure 5

Show the two-level Haar Wavelet Transform decomposition of the 4x4 image block. Show the coefficients output from each level of decomposition.

(10 Marks)

(b) A two-level discrete wavelet transform decomposition result is shown in Figure 6. Applying the EZW coding scheme to the wavelet coefficients in Figure 6 and show the encoding result. Note that four symbols in dominant pass for EZW are T (zerotree root), Z (isolated zero), P (positive) and N (negative) respectively.

22	-8	0	0
0	2	0	0
0	0	0	-1
0	1	0	2

Figure 6

(10 Marks)

END OF PAPER

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Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.