NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2016-2017

EE6427 – VIDEO SIGNAL PROCESSING

November/December 2016 Time Allowed: 3 hours

INSTRUCTIONS

1. This paper contains 5 questions and comprises 3 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) The source S = {a, b, c, d, e} has the following set of 36 characters in a message

Message = {ababcabcdabcdabcababaabcdeaabab cabcd}.

What are the Huffman code words appropriate for the source S?

Note: assign "0" to the higher probability side and "1" to the lower probability side of each combination operation.

Calculate the entropy and average number of bits for the Huffman code words.

Use the Huffman code words to encode the message "ace".

(10 Marks)

(b) The source S = {D, E, I, O, V} is assigned to the segments of the first interval in the following manner: D = [0, 0.1), E = [0.1, 0.4), I = [0.4, 0.7), O = [0.7, 0.9), and V = [0.9, 1). Show the divisions of the interval for arithmetic encoding of the message "VIDEO".

(10 Marks)

2. (a) Use the LZW compression algorithm to encode the following set of 12 characters in a message

Message = {myyummymummy}

Please use the ASCII code 256 for the starting of index during encoding, and show the encoding result.

(10 Marks)

(b) The hierarchical JPEG encodes an image in multiple resolutions. The decoder at the receiving end can choose the optimum resolution depending on the receiver capabilities. Thus, high-resolution images can be easily viewed in lower resolution devices. Use a block diagram to show a two-level hierarchical JPEG encoder.

(10 Marks)

3. (a) What is the difference between frame types in group of pictures (GOP) for H.261 and MPEG-1 video? Describe how each type of frame in GOP achieves video compression.

(10 Marks)

(b) A MPEG-1 bitstream consists of audio and video is stored at 1.5Mbits per second (Mbps). The audio has an average bitrate of 300Kbps. The video sequence with open GOP structure start with a B frame as in the following,

$B_1\ B_2\ B_3\ I_4\ B_5\ B_6\ B_7\ P_8\ B_9\ B_{10}\ B_{11}\ P_{12}$

The video is compressed using 4:2:0 chroma subsampling with a frame resolution of 352x288 and 8 bits per pixel. The video is compressed at the required quality with an average I-frame compression ratio of 10:1, an average P-frame compression ratio of 25:1, and an average B-frame compression ratio of 50:1.

Assume that the compression ratio includes all required headers and the size of system bitstream can be ignored.

(i) Determine the encoding order of the GOP.

(ii) Compute the frame rate per second for the video.

(iii) If a longer GOP structure is used, i.e. $B_1\ B_2\ B_3\ I_4\ B_5\ B_6\ B_7\ P_8\ B_9\ B_{10}\ B_{11}\ P_{12}$ $B_{13}\ B_{14}\ B_{15}\ P_{16}$, how does this affect the frame rate per second for the video? Please justify your result.

(10 Marks)

4. (a) With the help of a simple diagram, explain the structure of basic lifting scheme for Haar Wavelet Transform.

(10 Marks)

(b) A data sequence Y with 16 elements is defined in the following

Y = {29, 29, 37, 37, 33, 33, 33, 33, 17, 17, 17, 17, 18, 18, 17, 15}

With the help of a simple block diagram, show the four-level Haar Wavelet Transform decomposition of the data sequence Y using lifting scheme. Show the coefficients output from each stage of lifting scheme, and arrange the resulting coefficients from the lowest subband to the highest subband.

(10 Marks)

5. (a) A 4 x 4 image block is given in Figure 1.

Calculate the two-level Haar Wavelet Transform decomposition of the image block in figure 1. Show the coefficients output from each stage of decomposition.

(10 Marks)

32	24	24	24
32	24	24	24
36	37	23	11
36	24	11	11

Figure 1

20	13	4	-1
-5	0	0	0
0	-1	0	0
0	0	1	0

Figure 2

(b) A two-level Discrete Wavelet Transform decomposition result is shown in Figure 2. Apply the Embedded Zerotree Wavelet (EZW) coding scheme to the wavelet coefficients in Figure 2. Show the output for each pass. Note that four symbols in dominant pass for EZW are T (zerotree root), Z (isolated zero), P (positive) and N (negative), and the Huffman code words to represent the symbols are T: 0, Z: 10, N: 110, P: 1110. How many bits are required to represent the wavelet coefficients?

(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.