

**NANYANG TECHNOLOGICAL UNIVERSITY****SEMESTER 1 EXAMINATION 2021-2022****EE6427 – VIDEO SIGNAL PROCESSING**

November / December 2021

Time Allowed: 3 hours

**INSTRUCTIONS**

1. This paper contains 5 questions and comprises 4 pages.
2. Answer all 5 questions.
3. All questions carry equal marks.
4. This is a closed book examination.
5. Unless specifically stated, all symbols have their usual meanings.

1. (a) Consider a one-dimensional transform 'A' whose basis function is shown in Figure 1.

$$A = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1/2 & -1/2 & -1 \\ 1 & -1 & -1 & 1 \\ 1/2 & -1 & 1 & -1/2 \end{bmatrix}$$

**Figure 1**

A grey level intensity matrix of a  $4 \times 4$  image block is shown in Figure 2.

$$\begin{bmatrix} 20 & 20 & 20 & 20 \\ 20 & 20 & 20 & 20 \\ 20 & 35 & 35 & 35 \\ 20 & 35 & 35 & 35 \end{bmatrix}$$

**Figure 2**

Note: Question No. 1 continues on page 2.

Compute the two-dimensional transform based on 'A' for the image block shown in Figure 2 (on page 1) by using the row-column decomposition method.

(10 Marks)

- (b) The MPEG-2 encoder has the option of sending motion vectors for macroblocks in I-frame when certain macroblocks in I-frame are damaged. Motion vectors can be used to retrieve the missing details if they are damaged during transmission. Draw a diagram with necessary functional blocks to explain how to obtain motion vectors in I-frame.

(10 Marks)

2. (a) Zero-order interpolation method is a simple technique that resamples the pixel values present in an input image. A grey level intensity matrix of a  $3 \times 3$  image block is shown in Figure 3. Assume a 3 to 5 zero-order interpolation is applied to the image block. Explain the Zero-order interpolation method and show the  $5 \times 5$  interpolated image block.

$$\begin{bmatrix} 8 & 1 & 7 \\ 1 & 1 & 1 \\ 6 & 1 & 5 \end{bmatrix}$$

**Figure 3**

(10 Marks)

- (b) Draw the block diagram of three-layer MPEG-2 Spatial Scalability encoding with the following functional blocks, where the input is a video and the outputs are base layer bitstream and enhancement layer bitstreams.

- Downsample by 4
- Downsample by 2
- Upsample by 2
- Base layer encoder
- Base layer decoder
- Enhancement layer 1 encoder
- Enhancement layer 1 decoder
- Enhancement layer 2 encoder

(10 Marks)

3. (a) A block of  $2 \times 2$  pixels in the current frame is shown in Figure 4 and its co-located block in the reference frame is shown by the shaded area in Figure 5. Given a search window of  $\pm 1$  pixels, find the best-matched motion vector and the corresponding block in Figure 5, if the distortion criterion is Mean Square Error (MSE).

70	85
60	75

**Figure 4**

80	70	50	60
60	55	70	80
60	60	70	60
70	85	70	60

**Figure 5**

(10 Marks)

- (b) In motion estimation, explain the main reason why half-pel accurate motion estimation could achieve better prediction performance than integer-pel accurate motion estimation. With the help of a simple diagram, explain the bilinear interpolation method used to obtain half-pel values in a  $2 \times 2$  image block.

(10 Marks)

4. (a) Consider an input sequence  $X$  with 2 elements  $\{X_0, X_1\} = \{10, 14\}$ . With the help of a simple diagram, describe the structure of basic lifting scheme for Haar Wavelet Transform. Show the output values of each functional block in the diagram.

(10 Marks)

- (b) Draw a diagram to explain the structure of 5/3 Lifting Discrete Wavelet Transform.

(10 Marks)

5. (a) A  $4 \times 4$  image block is given in Figure 6.

61	57	16	24
59	59	18	18
13	9	13	17
11	11	13	17

**Figure 6**

Calculate the one-level Haar Wavelet Transform decomposition of the  $4 \times 4$  image block.

(10 Marks)

- (b) With the help of a simple diagram, describe the steps of block-based gradient descent search algorithm in block motion estimation. What is the advantage of this search algorithm?

(10 Marks)

END OF PAPER







## EE6427 VIDEO SIGNAL PROCESSING

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.