

EE7403

**NANYANG TECHNOLOGICAL UNIVERSITY**

**SEMESTER 2 EXAMINATION 2018-2019**

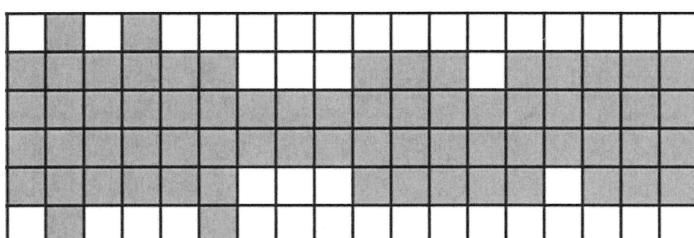
**EE7403 – IMAGE ANALYSIS AND PATTERN RECOGNITION**

April / May 2019

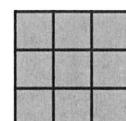
Time Allowed: 3 hours

**INSTRUCTIONS**

1. This paper contains 5 questions and comprises 3 pages.
  2. Answer ALL questions.
  3. All questions carry equal marks.
  4. This is a closed book examination.
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1. During image acquisition, the duration of the camera exposure is 0.3 second and the camera undergoes uniform planar motion of velocity 30 ( $x_o(t) = 30t$ ) in the horizontal direction ( $x$ -direction) for a time 0.1 second and then switches to the vertical direction ( $y$ -direction) with velocity 20 ( $y_o(t) = 20t$ ) for a time 0.2 second.
    - (a) Express the acquired image  $g(x, y)$  blurred by motion as a function of the image  $f(x, y)$  that has no motion blurring. (10 Marks)
    - (b) Derive an expression for the blurring function  $H(u, v)$ . (10 Marks)
  2. The object of a binary image is shown by the shaded squares (pixels) in Figure 1. Let the object be represented by a set  $A$ . A structure element  $B$  is shown by the shaded squares in Figure 2, where the origin  $(0, 0)$  of  $B$  is at its center.



**Figure 1**

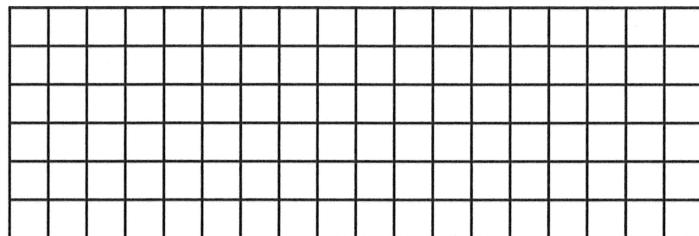


**Figure 2**

Note: Question No. 2 continues on page 2.

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- (a) Let,  $C = A \circ B$ ,  $A$  opened by  $B$ . Copy Figure 3 to the answer booklet and shade the elements of set  $C$ .



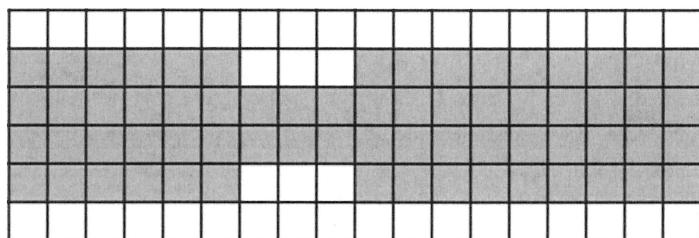
**Figure 3**

(6 Marks)

- (b) Let,  $D = A \bullet B$ ,  $A$  closed by  $B$ . Copy Figure 3 to the answer booklet and shade the elements of set  $D$ .

(6 Marks)

- (c) Design your structure elements and morphological operations that process the input image  $A$  in Figure 2.1 to output the image  $E$  as shown in Figure 4.



**Figure 4**

(8 Marks)

3. Suppose you are the principal of a secondary school. You know the statistics of your school students: Your school has 140 students in grade 1, 150 student in grade 2 and 160 students in grade 3. The ratios of the number of male students to the number of female students are 1:1.1, 1:1.2 and 1:1.4, for grades 1, 2 and 3, respectively. Somebody passed you a message just now that a male student will approach you to seek your help tomorrow. To prepare it, you need to judge what grade this student is in.

- (a) Derive a rule to judge the student's grade  $\omega_i$ ,  $i = 1, 2, 3$  based on the information of the students' gender  $x$ , (for example,  $x = 0$  for male,  $x = 1$  for female), which minimizes the probability of the wrong judgement.

(10 Marks)

- (b) Use the school statistics to judge the grade of this student so that the probability of the wrong judgement is minimal.

(10 Marks)

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4. A data set is collected for a two-dimensional random vector  $\mathbf{x} = [x_1 \ x_2]^T$ . The mean vector and the covariance matrix of the random vector  $\mathbf{x} = [x_1 \ x_2]^T$  are estimated from the data set. Suppose the mean vector is  $[1 \ 2]^T$  and the eigenvalues and their corresponding eigenvectors of the covariance matrix are  $\lambda_1 = 4, \lambda_2 = 1$ ,  $\phi_1 = [\frac{1}{\sqrt{5}} \ \frac{-2}{\sqrt{5}}]^T, \phi_2 = [\frac{2}{\sqrt{5}} \ \frac{1}{\sqrt{5}}]^T$ , respectively.
- (a) What is the covariance matrix of the data set? (10 Marks)
- (b) Plot an ellipse in the plane  $[x_1 \ x_2]^T$  to represent the Gaussian PDF of the random vector  $\mathbf{x}$ . Clearly show the position, the long axis, and the short axis of the ellipse. (10 Marks)
5. (a) Draw the diagram of a typical two-layer feed-forward neural network that has two inputs, two hidden neurons and one output neuron. Show all network weights in the diagram. (6 Marks)
- (b) The hidden neurons have the nonlinear activation function of  $f(s) = \frac{1}{1 + \exp(-s)}$  and the output neuron has the linear activation function of  $g(s) = s$ . Express the output  $y$  of the network as a function of the input vector  $[x_1 \ x_2]$ . (6 Marks)
- (c) Supposing the desired output for the input  $[x_1 \ x_2]$  is  $t$ , derive a learning rule that adjusts the weights of the output neuron to make the network output come closer to the desired output in a step-by-step manner. (8 Marks)

END OF PAPER

## **EE7403 IMAGE ANALYSIS & PATTERN RECOGNITION**

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.