NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2019-2020

EE7207 – NEURAL AND FUZZY SYSTEMS

November / December 2019 Time Allowed: 3 hours

INSTRUCTIONS

1. This paper contains 5 questions and comprises 5 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) Design a Hopfield neural network to store the following three patterns represented by three vectors:

$$P_1 = [-1 \quad 1 \quad 1]$$

$$P_2 = [-1 \quad -1 \quad 1]$$

$$P_3 = [1 \quad 1 \quad -1]$$

Sketch the architecture of the Hopfield neural network designed, and compute the weight matrix.

(7 Marks)

(b) Bi-directional associate memory (BAM) neural network can be used to perform dimensionality reduction. Design a BAM neural network to transform the 3-dimensional vectors P_1, P_2 and P_3 in part 1(a) to the following 2-dimensional vectors respectively:

$$Q_1 = [1 \quad 1]$$

$$Q_2 = [1 \quad -1]$$

$$Q_3 = [-1 \quad 1]$$

Note: Question No. 1 continues on page 2.

Sketch the architecture of the BAM neural network designed, and compute the weight matrix.

(7 Marks)

(c) Check whether the Hopfield neural network designed could correctly retrieve all the three patterns in part 1(a). If not, discuss the cause of the problem, and suggest solutions to the problem.

(6 Marks)

2. (a) Describe a learning method of radial basis function (RBF) neural network, including hidden neuron centre determination and weight estimation.

(7 Marks)

(b) Describe the formulation of the primal problem of nonlinear support vector machine (SVM) for non-separable case, and discuss the rationale of this formulation.

(8 Marks)

(c) Discuss the difference in the learning methods of kernel SVM and RBF neural network.

(5 Marks)

3. There are N training samples

$$\{\mathbf{x}(1), d(1)\}, \{\mathbf{x}(2), d(2)\}, \ldots, \{\mathbf{x}(N), d(N)\}$$

where $\mathbf{x}(i)$ and $d(i)$ denote the input vector and target value of i^{th} sample, respectively.

$$\mathbf{x}(i) = [x_1(i) \quad x_2(i)]^T$$

(a) If the N training samples are used to train a multilayer perceptron (MLP) neural network, describe the sequential backpropagation (BP) training algorithm.

(6 Marks)

Note: Question No. 3 continues on page 3.

(b) Assume that the MLP neural network has the architecture as shown in Figure 1.

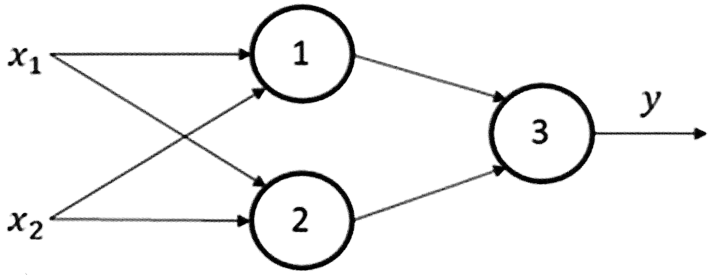

Figure 1

The hidden layer neurons employ sigmoid activation function, and the output layer neuron simply performs linear weighted summation on the outputs of hidden layer neurons. Derive the weight updating rule for the hidden layer neurons and output layer neuron if the following error function is to be minimised:

$$E(k) = \frac{1}{2}[d(k) - y(k)]^2$$

(10 Marks)

(c) Discuss why the number of hidden layers in the MLP neural network is usually not more than 2.

(4 Marks)

4. There are total of 60 students in a class with 20 students in grade A, 15 students in grade B, 7 students in grade C, 10 students in grade D and 8 students in grade F in the academic year 2010.

(a) Form the discrete membership function vector μ_P which represents the percentage between the number of students with grades A, B, C, D and F with respect to the total number of students.

(5 Marks)

(b) Given a five-year study performance statistic transfer matrix

$$\mu_R = \begin{bmatrix} 0.7 & 0.5 & 0.3 & 0 \\ 0.4 & 0.6 & 0.3 & 0.1 \\ 0.2 & 0.7 & 0.6 & 0.2 \\ 0.1 & 0.5 & 0.7 & 0.5 \\ 0 & 0.1 & 0.5 & 0.8 \end{bmatrix},$$

Note: Question No. 4 continues on page 4.

calculate

$$\mu_Q = \mu_P \circ \mu_R$$

(7 Marks)

(c) Based on the derived solution μ_Q in part 4(b), derive an alternative discrete time membership function vector μ_P which is different from part 4(a). Explain how you can compute it.

(8 Marks)

5. A distance control system has two inputs with membership functions as shown in Figure 2.

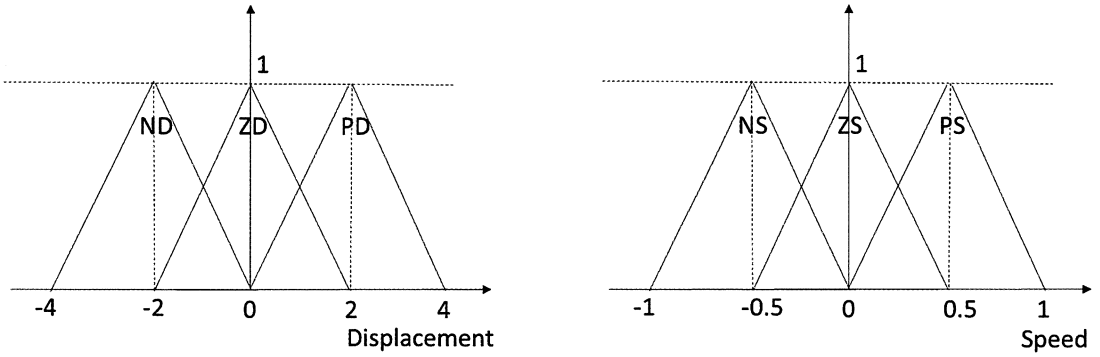

Figure 2

The distance displacement and speed are the two input variables with negative displacement (ND), zero displacement (ZD), positive displacement (PD), negative speed (NS), zero speed (ZS) and positive speed (PS), respectively. The output membership function is shown in Figure 3 with the output of power control, where DP, NC and IP represent decrease power, no change of power and increase power, respectively.

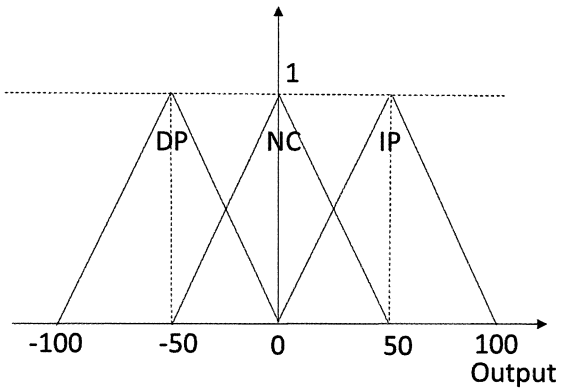

Figure 3

Note: Question No. 5 continues on page 5.

The relationship among all of inputs and outputs is presented in the form of a fuzzy logical map in Table 1. The left column represents the speed and the top row represents the distance displacement. The control outputs are presented by the remaining 9 entries in the table.

Table 1

	ND	ZD	PD
NS	DP	IP	IP
ZS	DP	NC	IP
PS	DP	DP	IP

(a) Write a set of linguistic rules based on Table 1.

(5 Marks)

(b) Assume that we are using the conjunction operator (FUZZY AND) in the antecedents of the rules based on Mamdani's minimum and giving the crisp inputs of displacement 0.5 and speed 0.4, calculate the corresponding rule firing levels.

(10 Marks)

(c) Use the center of gravity defuzzification method to calculate the output of power control according to part 5(b).

(5 Marks)

END OF PAPER

EE7207 NEURAL & FUZZY SYSTEMS

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.