NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2017-2018

EE7207 – NEURAL AND FUZZY SYSTEMS

November/December 2017 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. There are four vectors:

$$Q_1 = [1 \quad -1 \quad -1]^T$$
$$Q_2 = [-1 \quad 1 \quad 1]^T$$
$$Q_3 = [1 \quad 1 \quad 1]^T$$
$$Q_4 = [-1 \quad -1 \quad -1]^T$$

(a) Design a bi-directional associative memory (BAM) neural network to map Q_1 and Q_2 to Q_3 and Q_4, respectively. Sketch the architecture of the BAM neural network designed, compute the weights on the links between neurons, and test whether the designed BAM works.

(7 Marks)

(b) Design a Gaussian radial basis function (RBF) neural network to map Q_1 and Q_2 to Q_3 and Q_4, respectively. Sketch the RBF neural network architecture, determine centre vectors of hidden layer neurons and the weights on the links between neurons, and test whether the designed RBF neural network works.

(9 Marks)

(c) Through an example, discuss the fault tolerating capability of the BAM and RBF neural networks designed in parts 1(a) and 1(b), respectively.

(4 Marks)

2. Self-organizing map (SOM) neural network is a very popular tool in data analytics.

(a) List the 3 ingredients of SOM neural network, and describe the learning procedure of SOM neural network.

(7 Marks)

(b) List the two learning phases of SOM neural network, and discuss settings of learning rate and neighbourhood function in the two phases.

(7 Marks)

(c) Give two application examples of SOM neural network, and explain the rationale of adopting SOM neural network in these applications.

(6 Marks)

3. Support vector machine (SVM) is widely used in pattern classification.

(a) Give two kernel functions used in kernel support vector machines, and briefly describe the two functions.

(6 Marks)

(b) Based on linearly separable 2-class pattern classification problem, describe the optimal separating hyperplane of linear SVM and the primal optimization problem for finding this optimal hyperplane.

(8 Marks)

(c) Discuss how Kernel SVM fundamentally differs from RBF neural network, and discuss how to solve multi-class pattern classification problems using SVM.

(6 Marks)

4. (a) Assume that x represents the input of room temperature for a temperature feedback control system. The linguistic terms can be defined as:

Temperature x = {very-cold, cold, warm, very-warm, hot}.

Build a set of three fuzzy rules, based on three-control action variables: heat, cool and no-change, into the fuzzy knowledge database in the form of if-then fuzzy logic rules.

Create a simple fuzzy associative memory matrix (FAMM) of room temperature values versus target temperature values (measured by a feedback sensor), corresponding to the five given linguistic terms, that an air conditioner control system is expected to provide.

(5 Marks)

(b) For the two fuzzy membership functions defined in Figure 1, determine the range of interval and membership function of the combined system with an addition operation.

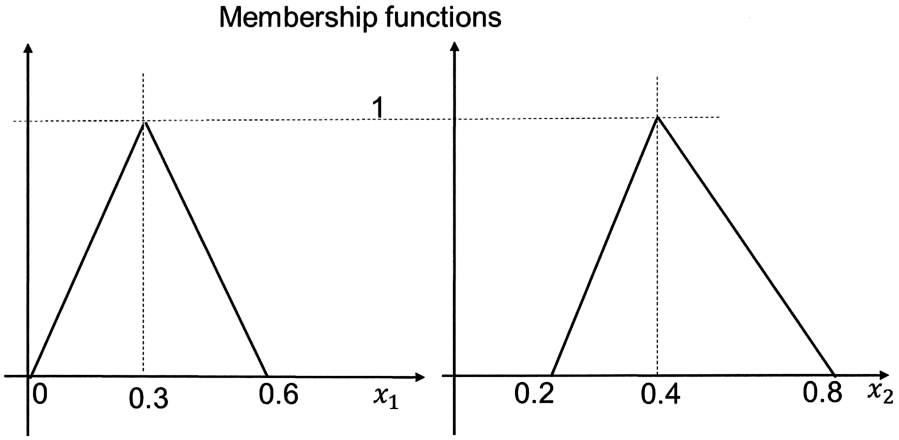

Figure 1

(10 Marks)

(c) List and discuss two main strong points and two weak points of fuzzy systems, respectively.

(5 Marks)

5. A fuzzy temperature control system has two inputs x and y and one output z. The membership functions of fuzzy sets for both x and y are given in Figure 2 and the fuzzy membership functions of output z are given in Figure 3.

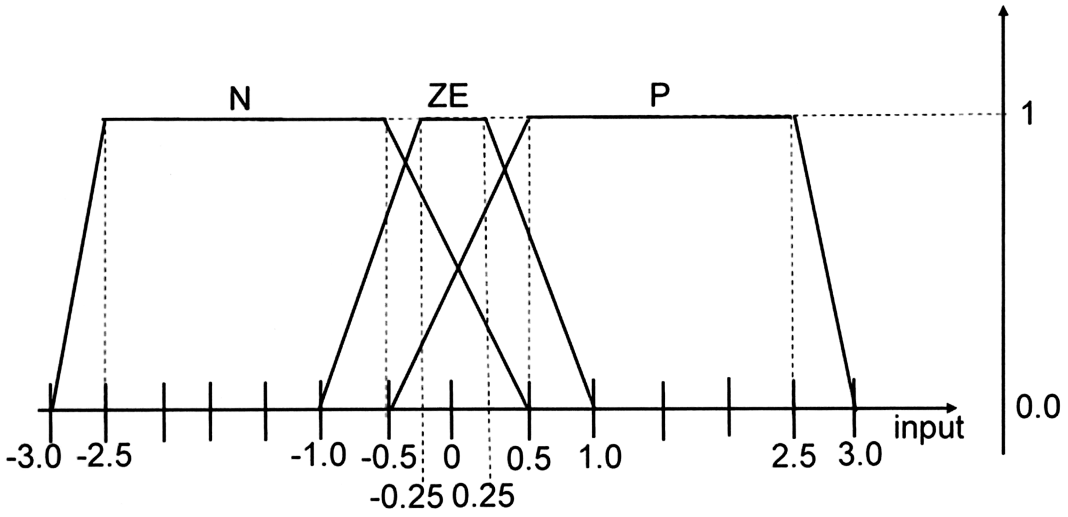

Figure 2

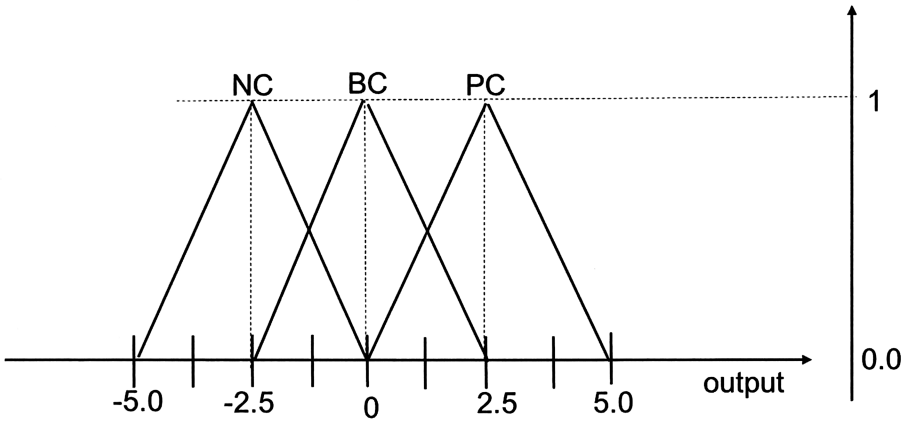

Figure 3

(a) Calculate given fuzzy trapezoidal membership functions for x and y and the triangular membership functions for z, respectively.

(5 Marks)

Note: Question No. 5 continues on page 5

(b) Given crisp inputs $x = 0.2$ and $y = -0.35$, if the inputs are applied to a set of if-then fuzzy logical rules, which are summarised in Table 1 (row corresponds to the fuzzy term set of x and column corresponds to the fuzzy term set of y). Assuming that we are using the conjunction operator (FUZZY AND) in the antecedents of the rules based on Mamdani's minimum, calculate the corresponding rule firing levels.

Table 1

	N	ZE	P
N	If x is N and y is N Then z is PC	If x is ZE and y is N Then z is PC	If x is P and y is N Then z is BC
ZE	If x is N and y is ZE Then z is PC	If x is ZE and y is ZE Then z is BC	If x is P and y is ZE Then z is NC
P	If x is N and y is P Then z is BC	If x is ZE and y is P Then z is NC	If x is P and y is P Then z is NC

(10 Marks)

(c) Assuming that we are using the center of gravity of defuzzification method, calculate the crisp output.

(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.