UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/10

SUBJECT NAME	:	NEURAL NETWORK AND FUZZY LOGIC
SUBJECT CODE	:	BEM 4233
COURSE	:	4 BEE
EXAMINATION DATE	:	NOVEMBER 2009
DURATION	:	2 1/2 HOURS
INSTRUCTION	:	ANSWER FOUR (4) QUESTIONS ONLY

THIS PAPER CONSIST OF 9 PAGES

Q1 (a) Describe the function of relation and projection in fuzzy operation.

(2 marks)

(b) By referring to Figure Q1 (b):

(i) Determine membership functions for A, B, and C.

(8.5 marks)

(ii) If $G = A \cup B \cup C$, find the membership function of G.

(8.5 marks)

(c) Suppose we have following two fuzzy sets of Torque (T) and Speed (S):

$$T(x) = Torque = \left\{ \ {}^{0.3}/_{20} + {}^{0.5}/_{40} + {}^{1.0}/_{60} + {}^{0.8}/_{80} + {}^{0.2}/_{100} \ \right\}$$

$$S(y) = Speed = \left\{ \ {}^{0.1}/_{250} + {}^{0.3}/_{500} + {}^{0.5}/_{1000} + {}^{1.0}/_{2000} \ \right\}$$

(i) Construct the relation for the implication of **IF x is Torque THEN y is Speed** using Mamdani implication.

(4 marks)

(ii) Determine all projection values of the relation constructed in Q1 (c) (i).

(2 marks)

Q2 For a given fuzzy logic system, we have the following nine fuzzy rules:

Rule 1: IF X is *small*	AND Y is *small*	THEN Z is *small*
Rule 2: IF X is *small*	AND Y is *medium*	THEN Z is *small*
Rule 3: IF X is *small*	AND Y is *large*	THEN Z is *medium*
Rule 4: IF X is *medium*	AND Y is *small*	THEN Z is *small*
Rule 5: IF X is *medium*	AND Y is *medium*	THEN Z is *medium*
Rule 6: IF X is *medium*	AND Y is *large*	THEN Z is *medium*
Rule 7: IF X is *large*	AND Y is *small*	THEN Z is *medium*
Rule 8: IF X is *large*	AND Y is *medium*	THEN Z is *medium*
Rule 9: IF X is *large*	AND Y is *large*	THEN Z is *large*

Where *small, medium* and *large* are fuzzy sets define by:

$$S = small = \left\{ \frac{1}{0} + \frac{1}{1} + \frac{1}{2} + \frac{0.5}{3} + \frac{0}{4} \right\}$$

$$M = medium = \left\{ \frac{0}{2} + \frac{0.5}{3} + \frac{1.0}{4} + \frac{0.5}{5} + \frac{0}{6} \right\}$$

$$L = large = \left\{ \frac{0}{4} + \frac{0.5}{5} + \frac{1.0}{6} + \frac{1.0}{7} \right\}$$

(a) Sketch all the fuzzy sets in one universe of discourse axis.

(2 marks)

(b) If X = 3.5 and Y = 4.5, compute and sketch the model output before defuzzification using Mamdani implication relation and disjunctive aggregator.

(13 marks)

(c) Calculate crisp value of Y by using Bisector of Area (BOA) method and discrete Centroid of Area (COA) with sample only integer universe of discourse values for Q2 (b).

(10 marks)

Q3 A transient response of a fuzzy position control system with step input is shown in Figure Q3. The system consists of two antecedents (E which is error and ΔE which is change in error) and one consequent (ΔU which is change in control output) and each of these parameters only have 3 fuzzy sets which are Negative (*N*), Zero (*Z*) and Positive (*P*).

(a) By referring to Figure Q3, label the region that meet the following condition and give explanation why the region is choose.

(i) E = *P* and ΔE = *P*
(ii) E = *P* and ΔE = *N*
(iii) E = *N* and ΔE = *P*
(iv) E = *N* and ΔE = *N*

(6 marks)

(b) By using engineering common sense, design all the nine rules for controlling ΔU with respect to the E and ΔE. Use region labeled in Q3 (a) as a reference. Please give clear justification for each of the developed rule.

(13.5 marks)

(c) If the membership function for E consist of Trapezoid shape for N and P, and Triangle shape for Z. Determine suitable universe of discourse values for 100% membership of N, Z, and P. Explain why you choose that values.

(2.5 marks)

(d) Sketch the membership functions obtain in Q3(c) in the same universe of discourse axis. If membership functions of ΔE and ΔU have the same shape with E, sketch its membership function if universe discourse value of ΔE and ΔU is 10% and 30% from universe discourse of E respectively.

(3 marks)

Q4 The output equation for single layer two inputs, one bias and one output artificial neural networks is given below:

$$Y = \begin{cases} 1 & \text{if } W_1X_1 + W_2X_2 + B \geq \theta \\ 0 & elsewhere \end{cases}$$

Where W_1 and W_2 are weights, X_1 and X_2 are inputs, B is bias, Y is output and 0 is threshold value. This network will be use to train sample below:

X_1	X_2	Y
0	0	1
0	1	1
1	0	1
1	1	1
0	-1	0
-1	0	0
-1	-1	0

(a) Plot all the samples in a scatter plot of X_1 versus X_2.

(2.5 marks)

(b) Show the first epoch (means all the patterns are passed through once) what happens to the weights and bias when sample data above is to be trained by the Perceptron algorithm. Use learning rate, $\alpha = 0.5$ and threshold $0 = -1$. Write down your answers in the following form.

Iter	**X_1**	**X_2**	**S**	**T**	**Y**	**W_1**	**W_2**	**B**
0						1	1	-1
1	0	0		1				
2	0	1		1				
3	1	0		1				
4	1	1		1				
5	0	-1		0				
6	-1	0		0				
7	-1	-1		0				

(17.5 marks)

(c) Calculate the performance accuracy of Q4 (b) and determine the boundary decision function.

(2 marks)

(d) Three more sample consist of {X_1=2 X_2 = 1 T = 0 ; X_1=1 X_2 = 2 T = 0 ; X_1= -2 X_2 = -1 T = 1 } will be train together with the previous sample. Analyze either it is possible to train the new sample using Perceptron algorithm. Explain clearly your answer.

(3 marks)

Q5 Study the multilayer not fully connected neural network configuration which is to be trained using the backpropagation algorithm as shown in Figure Q5 and consider the following assumptions:

- All neurons in layers 1, 3, and 5 have linear activation functions and all neurons in layer 2 and 4 have log sigmoid logistic activation functions given by :

$$f(net) = \frac{1}{1+e^{-net}}$$

- Use learning parameter η, error $E = \frac{1}{2}(T - O_5)^2$ and ignore momentum term, α.

(a) Develop the equations of forward propagation for this neural network.
(5.5 marks)

(b) Derive the equation for the adaptation of the weights (ΔW_{25}, ΔW_{45}, ΔW_{15}, ΔW_{12}, ΔW_{32}, ΔW_{34}) and bias (ΔB_5, ΔB_2, ΔB_4)
(19.5 marks)

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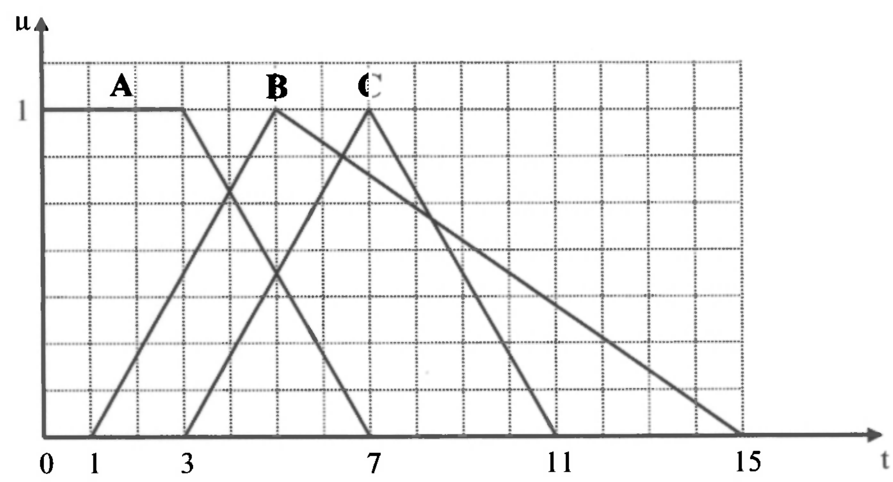

Figure Q1(b)

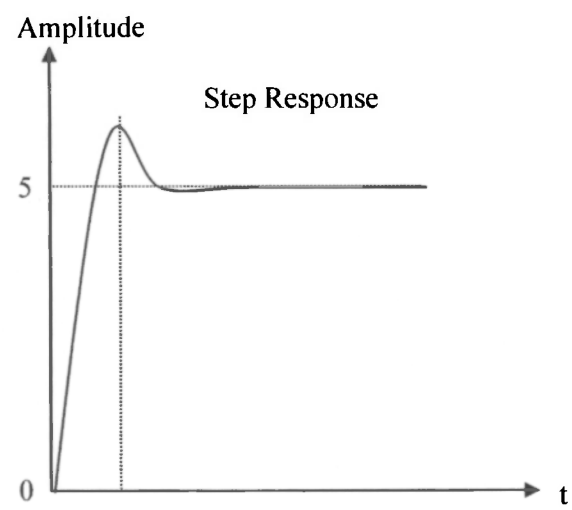

Figure Q3

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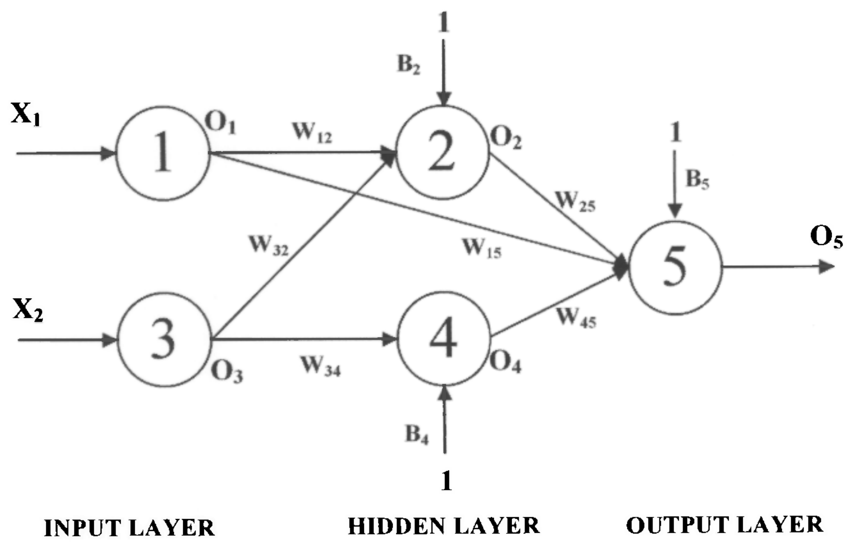

Figure Q5

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1) Cartesian product

$$\mu_{A_1 x A_2 x A_3 \ldots\ldots An}(x_1, x_2, x_n) = min[\mu_{A_1}(x_1), \mu_{A_2}(x_2), \ldots \mu_{A_n}(x_n)],$$

2) Mamdani Implication

$$(\mu_A(x) \Lambda \mu_B(x))$$

3) Disjunctive Aggregrator

$$\mu_y(y) = max\left[\mu_{y^1}(y), \mu_{y^2}(y), \cdots, \mu_{y^r}(y)\right]$$

4) Discrete Centroid of Area Method (COA)

$$z_{COA} = \frac{\sum_{j=1}^{n} \mu_A(z_j) z_j}{\sum_{j=1}^{n} \mu_A(z_j)}$$

5) Mamdani Implication Operator

$$\Phi_c[\mu_A(x), \mu_B(y)] \equiv \mu_A(x) \wedge \mu_B(y)$$