UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2009/2010

COURSE	:	NEURAL NETWORK AND FUZZY LOGIC
COURSE CODE	:	BEM 4233
PROGRAMME	:	4 BEE
EXAMINATION DATE	:	APRIL / MEI 2010
DURATION	:	2 ½ HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY.

THIS PAPER CONSISTS OF NINE (9) PAGES

Q1 (a) The output equation for single layer two inputs, one bias and one output artificial neural networks is given below:

$$a = x_1W_1 + x_2W_2 + b$$

Show the first epoch (means all the patterns are passed through once) plus the first iteration of the second epoch what happens to the weight when an XOR function as shown below is to be trained by the Hebbian algorithm. Write your answers in the following form (Learning rate, α=0.5).

Iter	**X_1**	**X_2**	**T**	**Y**	**W_1**	**W_2**	**b**
0					1	1	-1
1	1	1					
2	1	0					
3	0	1					
4	0	0					

(10 marks)

(b) By using KSOM neural networks, initiate the steps and computation of the following pattern provided at its input

#1 : 110 #2 : 010

Choose competitive layer nodes=3, initial learning rate α=0.4 and initial weights were randomized as follow:

$$W_{ij} = \begin{bmatrix} W_{11} & W_{12} & W_{13} \\ W_{21} & W_{22} & W_{23} \\ W_{31} & W_{32} & W_{33} \end{bmatrix} = \begin{bmatrix} 0.8 & 0.1 & 0.3 \\ 0.5 & 0.2 & 0.3 \\ 0.6 & 0.5 & 0.4 \end{bmatrix}$$

(15 marks)

Q2 Study the multilayer not fully connected neural network configuration which is to be trained using the back propagation algorithm as shown in Figure Q2 and consider the following assumptions:

- All of the even numbered neurons in layers 2, 4 and 6 have linear activation functions and all of the odd numbered neurons in layers 1, 3 and 5 use sigmoid activation function given by:

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

- All the weights are initialized to 0.5 and all the bias is initialized to be 0.2.

- Use learning rate, α and error, $E = \frac{1}{2}(T - Z_k)^2$

(a) Determine the equations of forward propagation for this neural network.

(8 marks)

(b) Derive the equation for the adaption of the weights (ΔW_{31}, ΔW_{54}, ΔW_{42}) and bias (Δb_2) based on the back propagation (BP) algorithm.

(17 marks)

Q3 Figure Q3 shows two layers Artificial Neural Network. Given ;

- Activation function for hidden layer (j), $\Phi_j = \frac{1}{1+e^{-\lambda Ij}}$, λ=1
- Activation function for output layer (k) , $\Phi_k = \frac{2}{1+e^{-\lambda Ik}}$ - 1, λ=1, η=1 .
- The desired output d= [-1 1]'

Determine the following using back propagation method that trained the network for two (2) iterations:

(i) The values of y_1 , y_2 and O_1, O_2 for each iteration.

(16 marks)

(ii) Updated weights for each iteration.

(9 marks)

Q4 (a) Given three (3) fuzzy sets :

$$A = \begin{cases} 0, t\langle 0 \\ 1, 0 < t < 3 \\ 7 - t/4, 3 \le t \le 7 \\ 0, t\rangle 7 \end{cases} \qquad B = \begin{cases} 0, t\langle 1 \\ t - 1/4, 1 \le t \le 5 \\ 15 - t/10, 5 \le t \le 15 \\ 0, t\rangle 15 \end{cases}$$

$$C = \begin{cases} 0, t\langle 3 \\ t - 3/4, 3 \le t \le 7 \\ 11 - t/4, 7 \le t \le 11 \\ 0, t\rangle 11 \end{cases}$$

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

(6 marks)

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

(10 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.

(3 marks)

(ii) Determine all projection values of the relationship in Q4 (b)

(6 marks)

Q5 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 defined:

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

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

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

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

(6 marks)

(b) If X = 2.5 and Y = 4.5, compute and sketch the model output before defuzzification using Mamdani implication relation and disjunctive aggregator.

(13 marks)

(b) Calculate crisp value of Y by using Bisector of Area (BOA) method for Q5 (b).

(6 marks)

Q6 (a) Given the α-cut fuzzy number A with supporting interval A=[1,9] and its α-cut segment $A_{\alpha=0.5}$=[2,8] $_{\alpha=0.5}$. Draw its graph for a α-cut set of a fuzzy set A.

(2 marks)

(b) Referring to Figure Q6 (b), determine membership functions for A, B, and C.

(9.5 marks)

(c) Given three (3) fuzzy sets which are represented by the following membership values:

$$A(x,\mu_A) = \{(0,0.0),(1,0.3),(2,0.5),(3,1.0),(4,0.7),(5,0.2)\}$$
$$B(y,\mu_B) = \{(0,0.1),(1,0.2),(2,1.0),(3,0.6),(4,0.2),(5,0.0)\}$$
$$C(z,\mu_C) = \{(0,0.0),(1,0.4),(2,0.6),(3,0.9),(4,1.0),(5,0.2)\}$$

By performing the fuzzy set operations, determine whether the following operations are true or false by showing the results of your operations.

(i) $A \cap A = \phi$

(ii) $(A \cup B) \cup C = A \cup (B \cup C)$

(iii) $(A \cup B) \cap C = A \cup (B \cap C)$

(iv) $\overline{B \cap C} = \overline{B} \cap \overline{C}$

(13.5 Marks)

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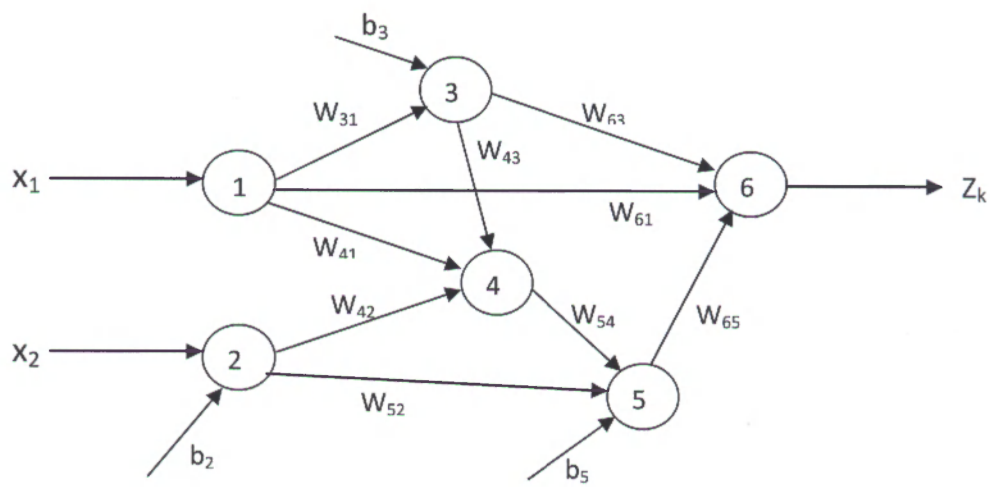

Figure Q2

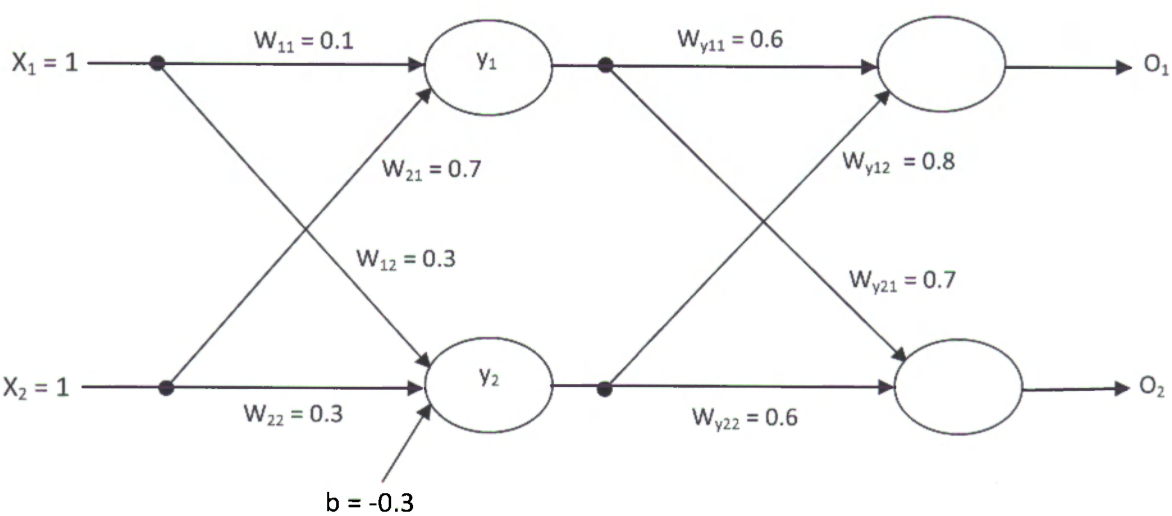

Figure Q3

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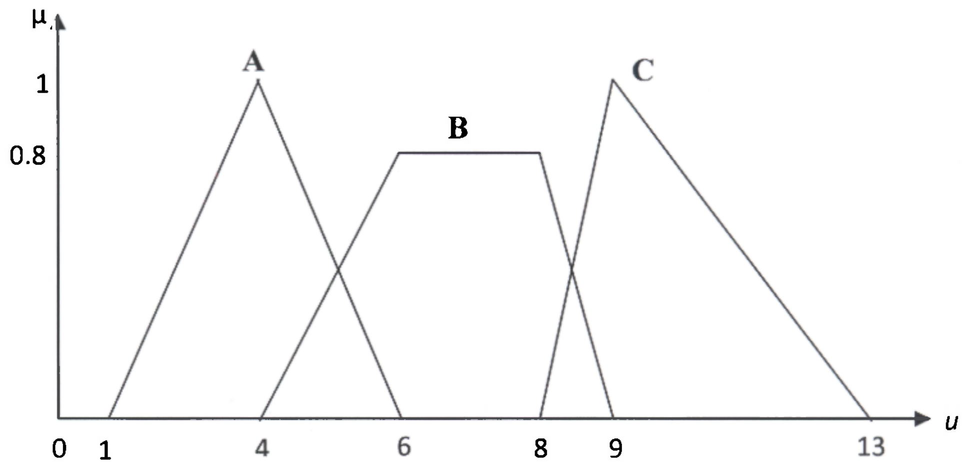

Figure Q6 (b)

Table 1

1.	**Cartesian product** $\mu_{A_1 x A_2 x A_3 \ldots\ldots A_n}(x_1, x_2, x_n) = \min[\mu_{A_1}(x_1), \mu_{A_2}(x_2), \ldots \mu_{A_n}(x_n)]$,
2.	**Mamdani Implication** $(\mu_A(x) \Lambda \mu_B(x))$
3.	**Disjunctive Aggregrator** $\mu_y(y) = max[\mu_{y^1}(y), \mu_{y^2}(y), \cdots, \mu_{y^r}(y)]$
4.	**Discrete Centroid of Area Method (COA)** $z_{COA} = \frac{\sum_{j=1}^{n} \mu_A(z_j) z_j}{\sum_{j=1}^{n} \mu_A(z_j)}$

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5.	**Mamdani Implication Operator** $$\Phi_c[\mu_A(x),\mu_B(y)] \equiv \mu_A(x) \wedge \mu_B(y)$$
6.	**The update weight of hidden layer w'$_j$:** $$\mathbf{w}^{new} = \mathbf{w}^{old} + \eta\boldsymbol{\delta}_y\mathbf{x}^T$$ $$\boldsymbol{\delta}_y = \left(\mathbf{w}_k^T \cdot \boldsymbol{\delta}_o\right) \cdot \boldsymbol{\Theta}_j'$$
7.	**The updated weight of output layer:** $$\mathbf{w}_k^{new} = \mathbf{w}_k^{old} + \eta\boldsymbol{\delta}_o\mathbf{y}^T$$
8.	δ **for hidden layer**
9.	δ **for output layer** $$\boldsymbol{\delta}_o = (\mathbf{d}-\mathbf{o})\boldsymbol{\Phi}_k'(\mathbf{I}_k) = (\mathbf{d}-\mathbf{o})\mathbf{o}(1-\mathbf{o})$$
10.	**The square error E** $$\mathbf{E} = \frac{1}{2}(\mathbf{d}-\mathbf{o})^2$$