UNIVERSITI TUN HUSSEIN ONN MALAYSIA

PEPERIKSAAN AKHIR
SEMESTER II
SESI 2008/09

NAMA MATAPELAJARAN	:	RANGKAIAN NEURAL DAN LOGIK FUZZY
KOD MATAPELAJARAN	:	BEM 4233
KURSUS	:	4 BEE
TARIKH PEPERIKSAAN	:	APRIL/MEI 2009
JANGKA MASA	:	2 JAM 1/2
ARAHAN	:	JAWAB EMPAT (4) SOALAN SAHAJA DARIPADA ENAM (6) SOALAN.

KERTAS SOALAN INI MENGANDUNGI SEPULUH(10) MUKA SURAT

Q1 (a) List down four components of fuzzy logic system and describe briefly function for each of the components.

(3 marks)

(b) In fuzzy sets, define the function of α – cut.

(1 mark)

(c) Given the triangular membership function A(x) with supporting interval x = [0, 8] and its peak at x = 4. Draw the graph for $A(x)_{\alpha=0.3}$ where 0.3 is the α– cut value and write down the mathematical expression of its membership function.

(6 marks)

(d) Suppose we have following two fuzzy sets of input voltage (I_V) and speed (S) :

$$Input\ Voltage = \left\{ \frac{0.25}{2} + \frac{0.5}{4} + \frac{1.0}{6} \right\}$$

$$Speed = \left\{ \frac{0.125}{250} + \frac{0.250}{500} + \frac{0.500}{1000} + \frac{1.000}{2000} \right\}$$

(i) Determine the efficient relation between input voltage and the speed if cartesian product might represent this relation.

(2 marks)

(ii) Table 1 shows the relationship between output voltage (O_V) and speed (S). Determine relationship between input voltage (I_V) and output voltage (O_V) by using Min-Max compositional operator.

Table 1: output voltage versus speed

$O_V \times S =$

O_V \ S	150	500	1000	2000
2	0.125	0.25	0.25	0.25
4	0.125	0.25	0.5	0.5
6	0.125	0.25	0.5	0.75
8	0.125	0.25	0.5	1

(6.5 marks)

(iii) Determine all projection values of $P = I_V \times O_V$

(1.5 marks)

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

Rule 1: IF X is *small* THEN Y is *medium*

Rule 2: IF X is *medium* THEN Y *large*

Rule 3: IF X is *large* THEN Z is *small*

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

$$S = small = \left\{ \tfrac{1}{1} + \tfrac{0.5}{2} + \tfrac{0}{3} \right\} \quad M = medium = \left\{ \tfrac{0}{1} + \tfrac{0.5}{2} + \tfrac{1.0}{3} \tfrac{0.5}{4} + \tfrac{0}{5} \right\}$$

$$L = large = \left\{ \tfrac{0}{3} + \tfrac{0.5}{4} + \tfrac{1.0}{5} + \tfrac{0.5}{6} + \tfrac{0}{7} \right\}$$

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

(2 marks)

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

(6 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)

(d) Construct the relation for the implication of Rule 2 using Mamdani implication operator.

(2 marks)

Q3 An engineer needs to design a fuzzy position control system using the following specifications:

- Each antecedent (for E which is error and ΔE which is change in error) and consequent (ΔU which is change in control output) must have only 3 fuzzy sets: Negative (N), Zero (Z) and Positive (P).
- The membership functions for the two antecedents and one consequent are already given in Figure Q3.
- Use the Mamdani rule base, disjunctive aggregator and discrete centroid of area defuzzyfication procedure.

(a) Using engineering common sense, write down the most appropriate fuzzy control rules in matrix form for this system.

(4 marks)

(b) Based on your rules in Q3(a) above, write down all the rules that would fire and also compute the consequent firing angle using triangulation for the following cases:

(i). $E = 30.0$ and $\Delta E = 40.0$

(2.5 marks)

(ii). $E = 10.0$ and $\Delta E = 20.0$

(4 marks)

(iii). $E = -5.0$ and $\Delta E = -10.0$

(6 marks)

Note: Your answer should be in triple form as follows [for example (*N, N; Z*), $\mu_{\Delta U} = 0.3$]. Also approximate your answer to the nearest 0.1 accuracy for the membership values.

(c) For the case of Q3 (b) (iii), sketch the resultant waveform of the consequents and calculate the actual output of the fuzzy controller using a discrete sample of 1 for the universe of discourse.

(3.5 marks)

Q4 (a) Write down four main components of a biological neural networks and explain clearly function for each of the components.

(4 marks)

(b) The output equation for single layer two inputs and one output artificial neural networks is given below:

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

Where W_1 and W_2 are weights, X_1 and X_2 are inputs, Y is output and θ is threshold value. This network will be use to train the AND-NOT sample below:

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

(i) By using analytical method, predict the values of W_1, W_2 and θ that able to give 100% of accuracy. Justify your answer.

(6 marks)

(ii) Write down the learning algorithm (steps) of the Perceptron neural networks.

(2 marks)

(iii) Show the first epoch (means all the patterns are passed through once) what happens to the weights when an AND NOT sample data above is to be trained by the Perceptron algorithm. Use learning rate, $\alpha = 0.1$ and threshold $\theta = -1$. Write down your answers in the following form.

Iter	X_1	X_2	S	T	Y	W_1	W_2
0						0.2	0.5
1	-1	-1		0			
2	-1	0		1			
3	0	-1		1			
4	0	0		1			

(6.5 marks)

(iv) Calculate the performance accuracy of Q4 (b) (iii).

(1.5 marks)

Q5 Study the multilayer fully connected neural network configuration which is to be trained using the backpropagation algorithm as shown in Figure Q5 and consider the following assumptions/initial parameters:

- All neurons in layers *i* and *k* have linear activation functions and all neurons in layer *j* (hidden neurons) have tan sigmoid logistic activation functions given by :

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

- All the weights between layer i and j are initialized to 0.1 and all the weights between layer j and k and initialized to 0.5, the bias is initialized to be 0.2.

- Learning parameter, $\eta = 0.1$ and ignore momentum term, α.

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

(2.5 marks)

b) Derive the equation for the adaptation of the weights and bias between the layer *k* to *j* and layer *j* to *i*.

(11.5 marks)

c) Calculate the output O_X of the neural network, when the inputs are as follows :

$$X_0 = 0.5,\ X_1 = 0.7,\ \text{and}\ X_2 = 0.1$$

(3 marks)

d) With the above inputs, calculate the new ΔW_{30}, ΔW_{31}, ΔB_0 and ΔB_1 when the target is equal to 1.

(3 marks)

Q6 (a) With your own words and appropriate sketching, describe the structure of Kohonen Self Organizing Map (KSOM) network and explain briefly the algorithm for unsupervised training KSOM.

(7 marks)

(b) By referring to the following table, design an appropriate Kohonen Self Organizing Map (KSOM) to cluster the given input data. In your answer, state the appropriate number of neurons and weights to use and sketch your KSOM. Justify all your decision.

X1	X2	Y
1	1	2
2	2	5
3	9	2
4	8	4
5	2	5
6	1	2

(4 marks)

(c) Using the KSOM neural networks, show the steps and computation of the following pattern provided at its input.

#1: 010 #2: 100

Choose competitive layer nodes = 3, initial learning rate $\alpha = 0.3$ and initial weights were randomized as follow:

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

(9 marks)

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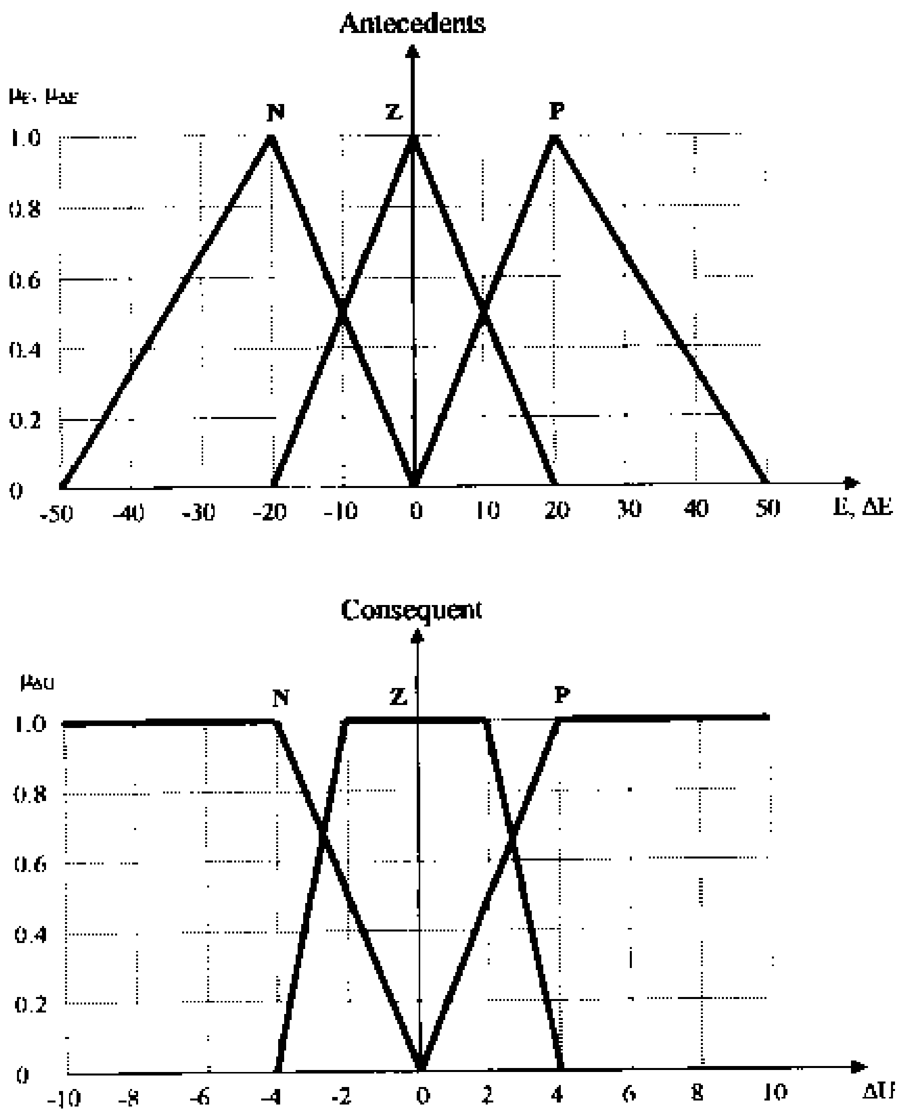

FIGURE Q3

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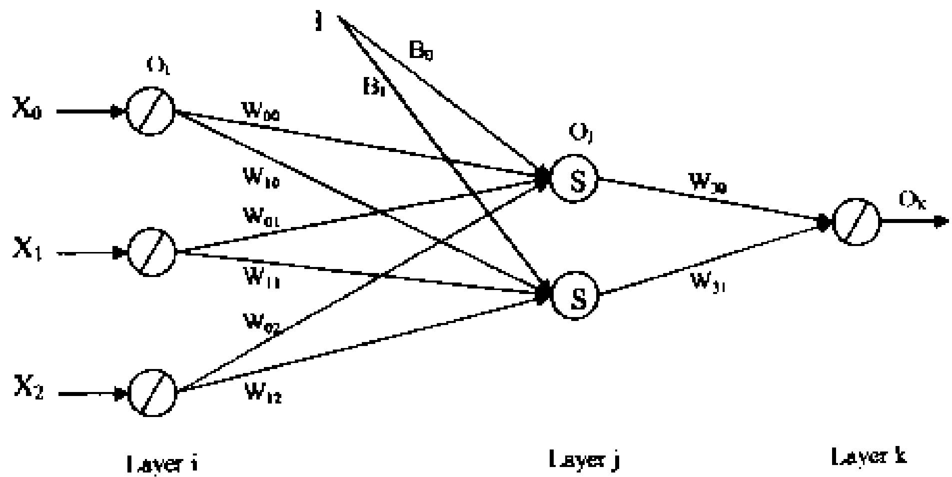

FIGURE Q5

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1) Cartesian product

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

2) Mamdani Implication

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

3) Disjunctive Aggregrator

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

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

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

6) Backpropogation Derivation Chain Rule

$$\Delta W_{KJ} = -n \frac{\partial E}{\partial W_{KJ}} \qquad \Delta B_K = -n \frac{\partial E}{\partial B_K}$$

$$\frac{\partial E}{\partial W_{KJ}} = \frac{\partial E}{\partial O_K} \frac{\partial O_K}{\partial NET_K} \frac{\partial NET_K}{\partial W_{KJ}} \text{ Where } \delta_K = \frac{\partial E}{\partial NET_K} \qquad \frac{\partial E}{\partial B_K} = \frac{\partial E}{\partial NET_K} \frac{\partial NET_K}{\partial B_K}$$

$$\Delta W_{JI} = -n \frac{\partial E}{\partial W_{JI}} \qquad \Delta BJ = -n \frac{\partial E}{\partial B_J}$$

$$\frac{\partial E}{\partial W_{JI}} = \frac{\partial E}{\partial NET_K} \frac{\partial NET_K}{\partial O_J} \frac{\partial O_J}{\partial NET_J} \frac{\partial NET_J}{\partial W_{JI}} \text{ Where } \delta_J = \frac{\partial E}{\partial NET_J} \qquad \frac{\partial E}{\partial B_J} = \frac{\partial E}{\partial NET_J} \frac{\partial NET_J}{\partial B_J}$$