UNIVERSITY OF TECHNOLOGY, SYDNEY
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

49275 NEURAL NETWORKS AND FUZZY LOGIC

ASSIGNMENT 1

QUESTION ONE [*Perceptron Dichotomiser Training*] [50 marks]

Two perceptron dichotomisers are trained to recognise the following classification of six patterns **x** with known class membership *d*.

$$\mathbf{x}_1 = \begin{bmatrix} 0.8 \\ 0.5 \\ 0.0 \\ 0.1 \end{bmatrix},\ \mathbf{x}_2 = \begin{bmatrix} 0.2 \\ 0.1 \\ 1.3 \\ 0.9 \end{bmatrix},\ \mathbf{x}_3 = \begin{bmatrix} 0.9 \\ 0.7 \\ 0.3 \\ 0.3 \end{bmatrix},\ \mathbf{x}_4 = \begin{bmatrix} 0.2 \\ 0.7 \\ 0.8 \\ 0.2 \end{bmatrix},\ \mathbf{x}_5 = \begin{bmatrix} 1.0 \\ 0.8 \\ 0.5 \\ 0.7 \end{bmatrix},\ \mathbf{x}_6 = \begin{bmatrix} 0.0 \\ 0.2 \\ 0.3 \\ 0.6 \end{bmatrix}$$

$$d_1 = [1],\ d_2 = [-1],\ d_3 = [1],\ d_4 = [-1],\ d_5 = [1],\ d_6 = [-1]$$

1.1 The first dichotomiser is a discrete perceptron as shown in Figure 1.1. Assign -1 to all augmented inputs. For the training task of this dichotomiser, the fixed correction rule is used, with an arbitrary selection of learning constant $\eta = 0.05$ and the initial weight vector

$$\mathbf{w}^1 = \begin{bmatrix} 0.0976 \\ 0.8632 \\ -0.3296 \\ 0.3111 \\ -0.2162 \end{bmatrix}$$

Assume that the above training set may need to be recycled if necessary, calculate the final weight vector. Show that this weight vector provides the correct classification of the entire training set. Plot the pattern error curve and the cycle error curve for 10 cycles (60 steps).

[25 marks]

1.2 The second dichotomiser is a continuous perceptron with a bipolar logistic activation function $z = f_2(v) = \dfrac{1 - e^{-v}}{1 + e^{-v}}$ as shown in Figure 1.2. Assign 1 to all augmented inputs. For the training task of this dichotomiser, the delta training rule is used with an arbitrary selection of learning constant $\eta = 0.5$ with the same initial weight vector $\mathbf{w}^1$ in Question 1.1.

Assuming that the above training set may need to be recycled if necessary, calculate the weight vector $\mathbf{w}^7$ after one cycle and the weight vector $\mathbf{w}^{301}$ after 50 cycles. Obtain the cycle error at the end of each cycle and plot the cycle error curve. How would the weight vectors $\mathbf{w}^7$ and $\mathbf{w}^{301}$ classify the entire training set? Discuss your results.

[25 marks]

Note: The following formulae may be used to calculate the pattern error curve and the cycle error curve. There are 6 patterns in this question, i.e. P=6.

Pattern error: $E_p = \frac{1}{2}(d_p - z_p)^2$

Cycle error: $E_c = \frac{1}{2}\sum_{p=1}^{P}(d_p - z_p)^2 = \sum_{p=1}^{P} E_p$

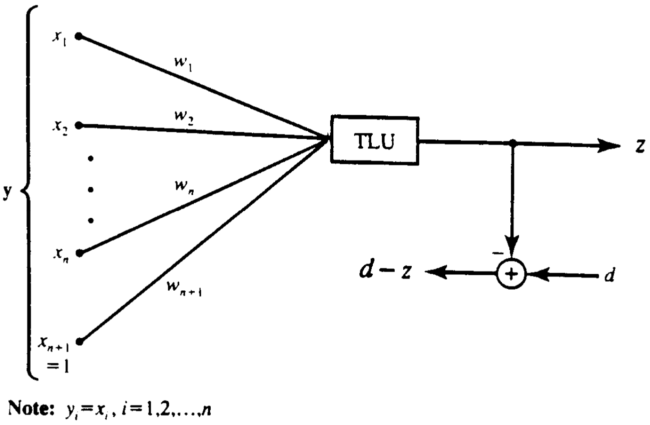

Figure 1.1 Discrete Perceptron Classifier Training

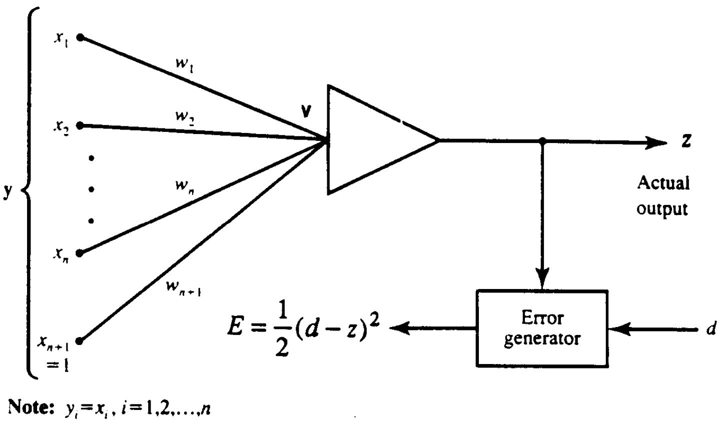

Figure 1.2 Continuous Perceptron Classifier Training

QUESTION TWO [50 marks]

2.1 [Engineering Management] [15 marks]

In engineering management it is often necessary to borrow money to finance projects of significant size. Engineering firms are therefore quite sensitive about their financing capacity, or their credit limits. Credit limits are often related to previous borrowing practices and to current credit account average balances. In turn, average balances are related to the profitability of the engineering venture. Suppose we have a fuzzy set **C** for credit limits, a fuzzy set **B** for average account balance, and a fuzzy set **P** for profits, all in units of thousands of dollars. Let the universes for these fuzzy sets be:

Credit limits = $\{500, \quad 1000, \quad 1500, \quad 2000\}$

Average account balance = $\{20, \quad 50, \quad 100, \quad 500, \quad 1000, \quad 1200\}$

Profits = $\{-50, \quad 0, \quad 50, \quad 100, \quad 500\}$

Suppose that the following relation has been established between the credit limits of the firm and its average account balance

$$A = \begin{bmatrix} 0.8 & 1.0 & 0.6 & 0.2 & 0 & 0 \\ 0.2 & 0.3 & 0.5 & 0.8 & 0.1 & 0 \\ 0.1 & 0.2 & 0.4 & 0.9 & 0.6 & 0.1 \\ 0.1 & 0.1 & 0.4 & 0.8 & 0.8 & 0.3 \end{bmatrix}$$

and that the following relation has been established between the average account balances of the firm and its profit margins.

$$E = \begin{bmatrix} 0.8 & 0.9 & 0.7 & 0.1 & 0 \\ 0.7 & 1.0 & 0.8 & 0.2 & 0 \\ 0.5 & 0.9 & 0.9 & 0.5 & 0.1 \\ 0.2 & 0.5 & 0.7 & 0.8 & 0.9 \\ 0.1 & 0.4 & 0.6 & 0.9 & 0.8 \\ 0 & 0.3 & 0.5 & 0.8 & 0.7 \end{bmatrix}$$

Find a relation between **C** and **P** by computing $R = A \circ E$

2.1.1 Using max-min composition [10 marks]

2.1.2 Using sum-product composition [5 marks]

2.2 [Laser Beam Alignment] [35 marks]

Fuzzy logic is used to control a two-axis mirror gimball for aligning a laser beam using a quadrant detector. Electronics sense the error in the position of the beam relative to the centre of the detector and produces two signals representing the x and y direction errors. The controller processes the error information using fuzzy logic and provides appropriate control voltages to run the motors which reposition the beam. The fuzzy logic controller for this system is shown in Figure 2.1.

To represent the error input to the controller, a set of linguistic variables is chosen to represent 5 degrees of error, 3 degrees of change of error, and 5 degrees of armature voltage. Membership functions are constructed to represent the input and output values' grades of membership as shown in Figure 2.2. The rule set in the form of "Fuzzy Associative Memories" is shown in Figure 2.3.

The controller gains are assumed to be $GE = 1, GCE = 1, GU = 1$.

2.2.1 If the Mean of Maximum (MOM) defuzzification strategy (sum-product inference) is used with the fire strength α_i of the i-th rule calculated from

$$\alpha_i = \mu_{E_i}(e).\mu_{CE_i}(ce)$$

calculate the defuzzified output voltages of this fuzzy controller at a particular instant. The error and the change of error at this instant are $e = 3.25$ and $ce = -0.2$.

[10 marks]

2.2.2 If the Centre of Area (COA) defuzzification strategy (max-min inference) is used with the fire strength α_i of the i-th rule calculated from

$$\alpha_i = \min(\mu_{E_i}(e), \mu_{CE_i}(ce))$$

calculate the corresponding defuzzified output voltage at a particular instant when the error and the change of error are $e = 3.25$ and $ce = -0.2$.

[25 marks]

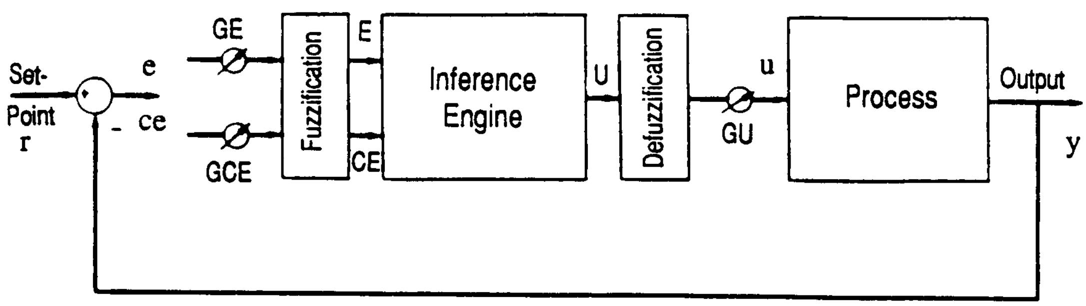

Figure 2.1 Fuzzy logic control system

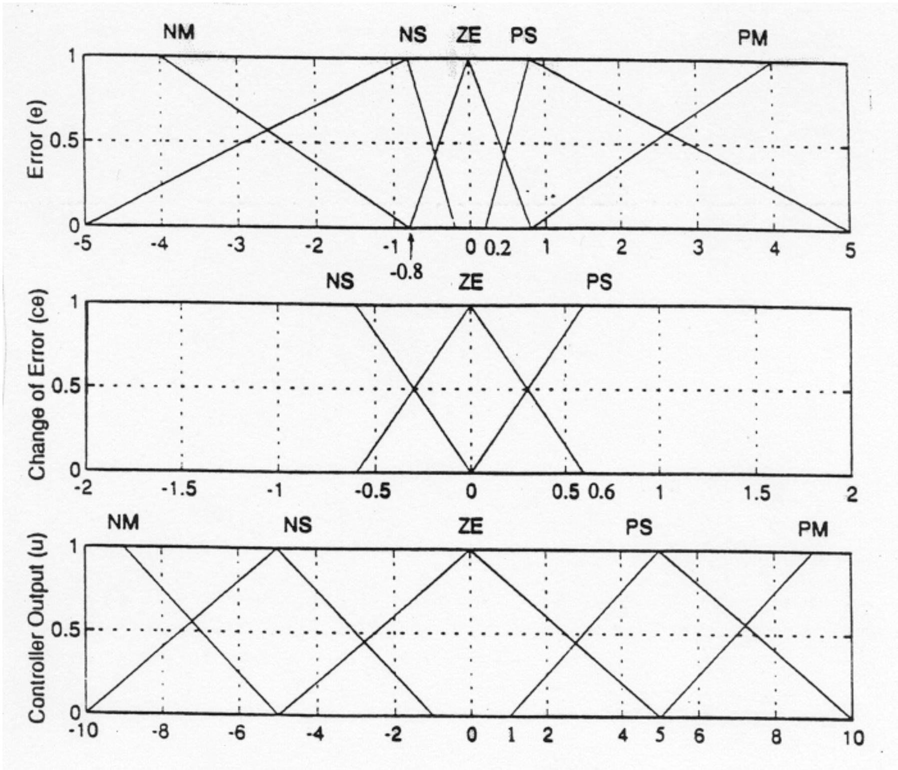

Figure 2.2 Membership functions of a laser beam alignment system

Change of Error \ Error	NM	NS	ZE	PS	PM
NS	PM	PM	PS	ZE	NS
ZE	PM	PS	ZE	NS	NM
PS	PS	ZE	NS	NM	NM

Figure 2.3 Fuzzy Associative Memories

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March 2016

MARKING SCHEME

Assignment 1: Neural Networks and Fuzzy Logic

Student Name: ____________________ **Mark:** ___________

Requirement	Criteria	Comment	
Standard “Declaration of Originality” cover page as provided by the Faculty	At front of report, completed and signed		Yes/no
Question 1 1.1 Discrete Perceptron	• Presentation • Final weight vector • Correct classification • Pattern error curve • Cycle error curve • Calculation/software code		/25
1.2 Continuous Perceptron	• Presentation • $W(7)$ • $W(301)$ • Cycle error curve • Classification after nc=1 • Classification after nc=50 • Software code		/25
Section 2 2.1 Engineering Management	• Presentation • Relation R=AoE (max-min) • Relation R=AoE (sum-product) • Calculation/software code		/15
2.2 Laser Beam Alignment	• Presentation (MOM) • Fuzzification E • Fuzzification CE • Defuzzified output voltage • Calculation/software code • Presentation (COA) • Fuzzification E & CE • Total Area • Total Moment • Defuzzified output voltage • Calculation/software code		/35