Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

VII SEMESTER B.TECH (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2015

SUBJECT: INTELLIGENT CONTROLLERS [ELE 461]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitably assumed.
- Use the table of fuzzy operations given at the end of the paper wherever required.

1A. Design an Auto-Associative Memory to store the patterns $[1\ \ 1\ \ 1]^t$ and $[-1\ \ 1\ \ -1]^t$. If the input pattern for this network is $[1\ \ -1\ \ -1]^t$, perform synchronous and asynchronous update to see the state transitions. Also find the energy in each case and comment on your results. **(5)**

1B. Design a multilayer perceptron classifier to perform the planar classification as shown in **Fig.1B** **(3)**

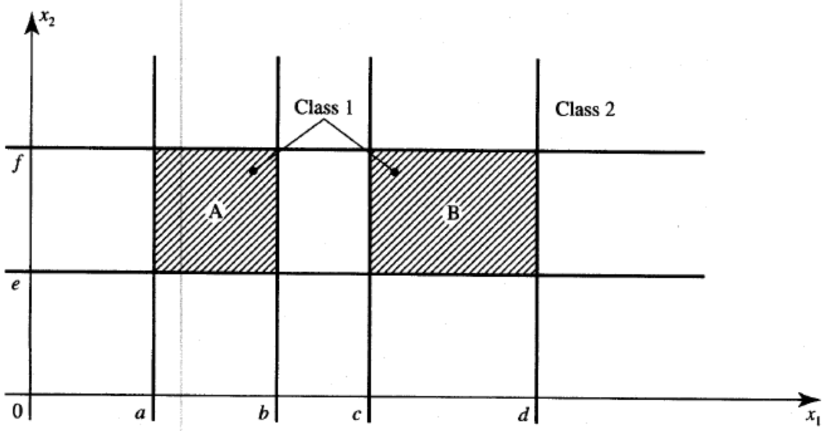

Fig. 1B

1C. List out the differences between artificial neural network and biological network **(2)**

2A. Let $U = \{x_1, x_2, x_3\}$, $V = \{y_1, y_2\}$ and assume the fuzzy rule:

If x is A then y is B

Where $\boldsymbol{A} = \frac{\mathbf{0.5}}{\boldsymbol{x_1}} + \frac{\mathbf{1}}{\boldsymbol{x_2}} + \frac{\mathbf{0.6}}{\boldsymbol{x_3}}$ and $\boldsymbol{B} = \frac{\mathbf{1}}{\boldsymbol{y_1}} + \frac{\mathbf{0.4}}{\boldsymbol{y_2}}$. Given that $x = A'$ where $A' = \frac{0.6}{x_1} + \frac{0.9}{x_2} + \frac{0.7}{x_3}$. Determine the membership function for B' using Generalized Modus Ponens rule. The fuzzy if then rule $A \rightarrow B$ is interpreted using Mamadani Product Implication. **(4)**

2B. Perform two training steps for the network using the Delta learning rule. Using λ = 1 and $c = 0.25$. Train the network using the following data pairs: **(4)**

$$\left\{X_1 = \begin{bmatrix} 2 \\ 0 \\ -1 \end{bmatrix}, d_1 = -1\right\}, \quad \left\{X_2 = \begin{bmatrix} 1 \\ -2 \\ -1 \end{bmatrix}, d_1 = 1\right\}$$

The initial weights are $W^1 = [1 \quad 0 \quad 1]^t$.

2C. Based on three sensor measurements (shape, texture and weight), the prototype vectors for orange and apple are given by P_1 and P_2 respectively. Design a perceptron to recognize these patterns. **(2)**

$$P_1 = \begin{bmatrix} 1 \\ -1 \\ -1 \end{bmatrix} \quad P_2 = \begin{bmatrix} 1 \\ 1 \\ -1 \end{bmatrix}$$

3A. The network shown in **Fig. 3A** using bipolar continuous neurons has been designed to assign input vectors X_1,X_2,X_3 to cluster 1 or 2. The cluster number is identical to the number of the neuron yielding the larger magnitude response. Determine the most likely cluster membership for each of the following three vectors. Assume λ = 2. The input vectors are. **(5)**

$$X_1 = \begin{bmatrix} 0.866 \\ 0.5 \end{bmatrix} \quad X_2 = \begin{bmatrix} -0.985 \\ -0.174 \end{bmatrix} \quad X_3 = \begin{bmatrix} 0.342 \\ -0.94 \end{bmatrix}$$

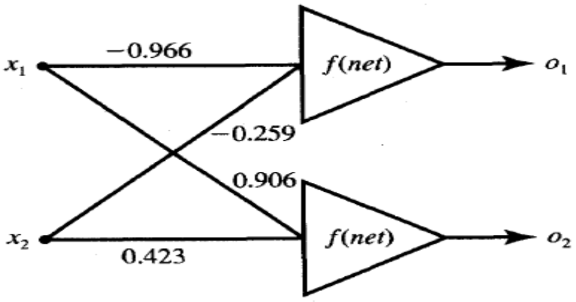

Fig. 3A

3B. A linear classifier is to be trained to assign X = 0 and X = 2 to class 1 & 2 respectively. Display the movement of weight vector on the weight plane starting from the initial weight of $[1 \quad 1]^t$ and follow intermediate steps until weights fall to the solution region. Use C = 1. Take bias input as 1. **(3)**

3C. Determine whether max operator, min operator and basic fuzzy complement form an associated class? Justify your answer with proof. **(2)**

4A. Perform single step Error Back Propagation for the data given below: The transposed weight matrices for the Ist layer is given by $V = \begin{bmatrix} -0.5 & -1 \\ 1 & -1 \end{bmatrix}$ and for the 2nd layer $W = [-0.5 \quad -1 \quad -1]$. The input to the network $p = 0.5$ and the bias input is -1. The desired output is $d = \sin(\pi p)$. Use unipolar continuous neurons in the 1st and linear neurons in the 2nd layer. Assume η = λ = 1. **(5)**

4B. Implement 3 input NAND gate using McCulloch Pitts Neuron Model. **(1)**

4C. Given two fuzzy sets

$$\mathbf{A} = \frac{1}{1} + \frac{0.8}{2} + \frac{0.6}{3} + \frac{0.5}{4} + \frac{0.2}{5} \qquad \mathbf{B} = \frac{0.2}{1} + \frac{0.5}{2} + \frac{1}{3} + \frac{0.9}{4} + \frac{0}{5}$$

(4)

Determine the following:
i) Center of fuzzy set B.
ii) Sugeno complement of fuzzy set B with λ = 0.5
iii) Fuzzy intersection of A & B by Einstein product

5A. In a single layer classifier the decision hyperplane contains the midpoint of the line segment connecting the centers of clusters and is normal to it. Identify and design the classifier for the following prototype vectors:

$$\mathrm{X}_1 = [10 \quad 2]^{\mathrm{t}}, \mathrm{X}_2 = [2 \quad -5]^{\mathrm{t}}, \mathrm{X}_3 = [-5 \quad 5]^{\mathrm{t}}$$ **(5)**

Also determine the number of decision hyperplanes if there are R pairwise separable classes.

5B. The detergent is evaluated on the following parameters: actual color of the material, consistency, base number (BN, measure of detergent capacity), and flash point (FP, ignition temperature of the material). After making several hundred batches of the detergent additive, the following relation matrix is obtained:

$$R = \begin{array}{cccc} & Excellent & Very\ Good & Fair \\ color & 0.3 & 0.4 & 0.3 \\ consistency & 0.1 & 0.5 & 0.4 \\ BN & 0.5 & 0.4 & 0.1 \\ FP & 0.4 & 0.3 & 0.3 \end{array}$$ **(3)**

The weight factor for the detergent is $a = \{0.1, 0.35, 0.4, 0.15\}$. Evaluate the quality of the detergent using max – min composition.

5C. In a newly drilled oil well, three sets of oil samples are taken and tested for their viscosity. The results are given in the form of the three fuzzy sets B_1, B_2, and B_3 as shown in **Fig. 5C.** Determine the most nearly representative viscosity value for all three oil samples using center average and mean of maxima defuzzifier.

(2)

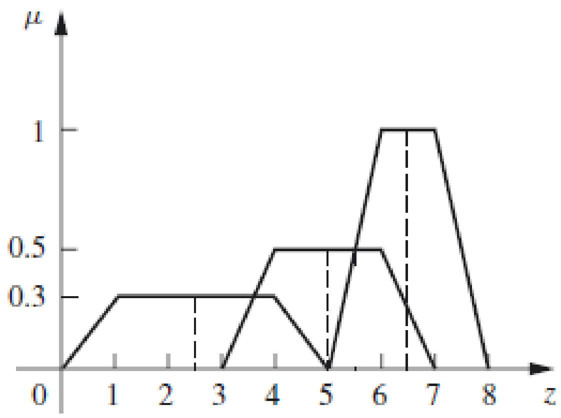

Fig. 5C

6A. Design a linear discriminant classifier for the data given below: P_1 to P_8 are the data points and d_1 to d_4 are the desired responses. **(3)**

$$P_1 = \begin{bmatrix} 2 \\ -1 \end{bmatrix} \; P_2 = \begin{bmatrix} 2 \\ 0 \end{bmatrix} \; d_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; \quad P_3 = \begin{bmatrix} -2 \\ 1 \end{bmatrix} \; P_4 = \begin{bmatrix} -2 \\ 2 \end{bmatrix} \; d_2 = \begin{bmatrix} -1 \\ 1 \end{bmatrix};$$

$$P_5 = \begin{bmatrix} -5 \\ -3 \end{bmatrix} \; P_6 = \begin{bmatrix} -1 \\ -1 \end{bmatrix} \; d_3 = \begin{bmatrix} -1 \\ -1 \end{bmatrix}; \quad P_7 = \begin{bmatrix} 2 \\ -2 \end{bmatrix} \; P_8 = \begin{bmatrix} 1 \\ -3 \end{bmatrix} \; d_4 = \begin{bmatrix} 1 \\ -1 \end{bmatrix};$$

6B. Design a fuzzy rule based traffic light control system for a 4 lane intersection. The inputs for the traffic light controller are the waiting time of vehicles in the range [0 100] seconds and queue length (i.e. number of vehicles waiting for green signal) in the range [0 75]. The output of the controller 'urgency' (in the range [0 200]) should decide the most appropriate phase to receive the green signal. If both queue length and waiting time for a lane is high then that particular lane should receive the green signal. If the waiting time is very high and queue length is very less then the vehicles in that lane should be given green signal. Use Mamadani min implication for rule interpretation, min for intersection operation and max for union operation. Also test the system for waiting time = 50 seconds and queue length = 40 using center average defuzzification. Use Zero (Z), Small (S), Medium (M) and Large (L) as membership values for each of the fuzzy proposition. **(7)**

Table of S-norm, T-norm & Fuzzy complement

S - norm	T -norm	Fuzzy Complement
$s_{ds}(a,b) = \begin{Bmatrix} a & if\ b = 0 \\ b & if\ a = 0 \\ 1 & otherwise \end{Bmatrix}$	$t_{dp}(a,b) = \begin{Bmatrix} a & if\ b = 1 \\ b & if\ a = 1 \\ 0 & otherwise \end{Bmatrix}$	$c_\lambda(a) = \dfrac{1-a}{1+\lambda a}$
$s_w(a,b) = min\left[1, (a^w + b^w)^{\frac{1}{w}}\right]$	$t_w(a,b) = 1 - min\left[1, ((1-a)^w + (1-b)^w)^{\frac{1}{w}}\right]$	$c_w(a) = (1 - a^w)^{\frac{1}{w}}$
$s_{as}(a,b) = a + b - ab$	$t_{ap}(a,b) = ab$	
$s_{es}(a,b) = \dfrac{a+b}{1+ab}$	$t_{ep}(a,b) = \dfrac{ab}{2-(a+b-ab)}$	

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