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MANIPAL INSTITUTE OF TECHNOLOGY
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SECOND SEMESTER M.TECH. (OPEN ELECTIVE) DEGREE END SEMESTER EXAMINATION APRIL/MAY 2019

SUBJECT: NEURAL NETWORKS AND FUZZY LOGIC (ECE - 5248)

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to candidates
- Answer **ALL** questions.
- Missing data may be suitably assumed.

1A. Design an autoassociative memory to store the pattern $S^1 = [1 \quad -1 \quad 1]^t$. Perform memory recall in synchronous and asynchronous mode (if necessary) , with $X^0 = [-1 \quad 1 \quad -1]^t$ as the initializing pattern. Comment on the performance of the memory by finding the energy for the last iteration only.Assume sgn(0) = 1.

1B. In some neural network applications, it is desirable to use a stochastic (statistical) neuron model. The model is defined as follows: The output of the statistical neuron X is
$X = +1 \;\; , with\ a\ Probability\ of\ firing\ , \quad P(net)$
$X = -1, with\ a\ Probability\ of\ firing\ , 1 - P(net) where\ \ P(net) = \frac{1}{1+e^{-\frac{net}{T}}}$ and T is a noise term. Using the above neuron with T=0.5, find the output for each of the following input patterns:
$x_1 = [0.5 \quad 1]^t \;\; ; \;\; x_2 = [-0.95 \quad 2]^t$ **;** The weight matrix is $W^t = \begin{bmatrix} -1 & 1 \\ 1 & -1 \end{bmatrix}$

1C. Consider the following pairs of input and target output pairs:
$x_1 = [4 \quad 2]^t,\ d_1 = (1 \quad 1)^t \qquad x_2 = [-2 \quad 1]^t,\ d_2 = (-1 \quad 1)^t$;
$x_3 = [-1 \quad -2]^t,\ d_3 = (-1 \quad -1)^t$; $x_4 = [2 \quad 0]^t,\ d_4 = (1 \quad -1)^t$;
(i). Find the optimal weights and write the expressions for the linear discriminant functions that separate these classes?
(ii). Draw the diagram of the linear discriminant classifier

(5+3+2)

2A. It is required to simulate the non-linear function $y = 10|x|$ using back propagation algorithm. Perform one step back propagation by considering 2 linear neurons in the first layer and one linear neuron in the second layer with an input of x=0.5. Assume the initial weights to be one in both layers. Take η, λ =1 and augmented input to be equal to -1.

2B. The final weights obtained during perceptron training are $W^3 = [1 \quad 0 \quad 1]^t$. Perform two steps of perceptron learning rule on the following dataset to find the initial weights:

$$\left(\mathbf{x}_1 = \begin{bmatrix} 2 \\ 0 \\ -1 \end{bmatrix},\quad d_1 = -1\right),\quad \left(\mathbf{x}_2 = \begin{bmatrix} 1 \\ -2 \\ -1 \end{bmatrix},\quad d_2 = 1\right)$$

Assume c=0.5 and updation is performed in each step.

2C. (i). Show whether the Sugeno fuzzy complement is involutive
(Hint: if c[c (a)] = a for all a ϵ [0, 1]
(ii). Determine the equilibrium of Yager fuzzy complement
(Hint: Equilibrium is defined as c (a) = a for all a ϵ [0, 1]

(5+3+2)

3A. The initial weight matrix of a Kohenen's feature map is given by:

$$W^t = \begin{bmatrix} 0.5 & 0.1 & 0.5 \\ 0.1 & 0.8 & 0.7 \\ 0.9 & 0.3 & 0.2 \\ 0.2 & 0.1 & 0.7 \\ 0.6 & 0.5 & 1 \end{bmatrix}$$

Perform one step training for the input x1 = $[0.5\ 1\ 0.5]^t$. Assume α=0.25, R=1. Use correlation metric for winner selection**.**

3B. Find whether the following form an associated class or not
(i). algebraic sum, algebraic product and Sugeno complement
(ii). Einstein sum, algebraic product and basic complement.

3C. Specify all missing weights for the multilayer network shown in **Fig. 3C**, that implements XNOR classification using unipolar discrete neurons.

(5+3+2)

4A. (i). Consider the following fuzzy relation defined on U1×U2×U3 where U1 = {a, b, c} U2={s, t} U3={x, y}:

$$Q = 0.3/b,t,x + 0.01/a,s,x + 1/b,s,y + 0.9/b,t,y + 0.4/a,t,y + 0.6/c,s,y$$

Compute the projections of Q on U2×U3. Also Compute the cylindrical extension of the Projections to U1×U2×U3 and prove that $Q \subseteq Q_E$

(ii). Given two fuzzy sets

$$A = \left(\frac{1}{0} + \frac{0.5}{1} + \frac{0.1}{2} + \frac{0.5}{3} + \frac{0.1}{4}\right) \quad B = \left(\frac{0.2}{0} + \frac{0.4}{1} + \frac{1}{2} + \frac{0.6}{3} + \frac{0.2}{4}\right)$$

Given (i) B' =very very B. Use modus tollens to determine A' by considering Godel implication for A→B and interpret your result in each case

4B. With the help of flowchart, briefly explain the various steps involved in implementing Genetic Algorithm.

4C. Consider the following fuzzy relations:

$$Q1 = \begin{pmatrix} 0.2 & 1 & 1 \\ 0.8 & 0.5 & 0.6 \\ 0.7 & 1 & 0.3 \end{pmatrix} \qquad Q2 = \begin{pmatrix} 1 & 1 & 0.8 \\ 0.5 & 0.1 & 0.7 \\ 0.9 & 0.04 & 0.2 \end{pmatrix}$$

Perform Q1 o Q2 by max-product composition

(5+3+2)

5A. Design a simple fuzzy rule based system to simulate a non-linear function Y = cos X, where X is defined in the universe [-90 90] and Y is defined in the universe [-1 1]. Use Mamadani minimum implication with min for t-norm operator and max for s-norm operator. Use weighted average defuzzifier and test by applying the following fuzzy singletons: X = 0, -45 and 90.

5B. The confusion matrix for a classifier is shown in **Fig. 5B**. Determine sensitivity, specificity Precision, Recall, F-measure and accuracy for the classifier.

5C. Determine Fuzzy OR with γ = 0.5, given that the fuzzy set $A = \frac{1}{1} + \frac{0.3}{2} + \frac{0.6}{3} + \frac{0.8}{4} + \frac{0.1}{5}$ and $B = \frac{0.2}{1} + \frac{0.5}{2} + \frac{0.7}{3} + \frac{0.9}{4} + \frac{1}{5}$

(5+3+2)

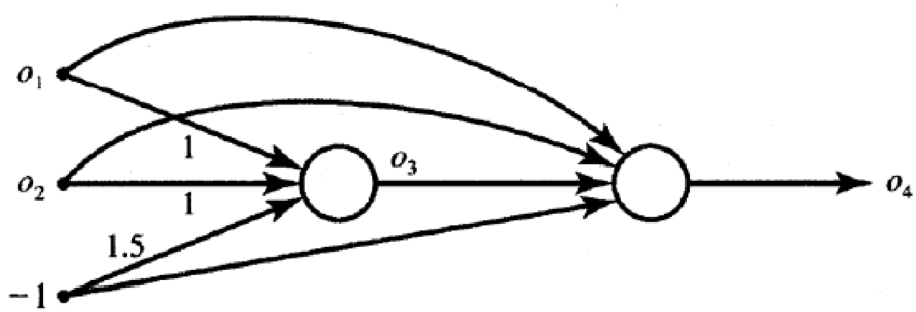

Fig. 3C

	Predicted class		
		POSITIVE	NEGATIVE
Actual class	TRUE	180 (a)	30 (b)
	FALSE	20 (c)	170 (d)

Fig. 5B