	St. Francis Institute of Technology (Engg. College) **Internal Assessment Test-II** Academic Year: 2021-2022

Branch: **EXTC** Division: **A & B**	Year: **T.E** Semester: **VI**
Subject: **Artificial Neural Networks and Fuzzy Logic**	Time: **2:00 – 3:00 pm**
Date: **19/04/2022**	No. of Pages: **02**
Max. Marks: **20**	

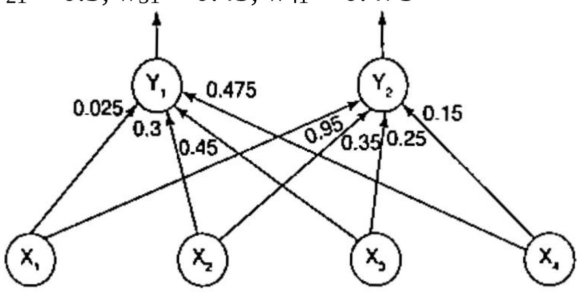
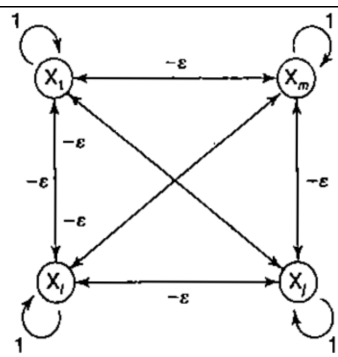
Instructions: Candidates should read carefully the instructions printed on the question paper and on the cover of the Answer Book provided for their use.

1. All questions are compulsory. Draw neat diagrams wherever necessary. Write everything in ink only (no pencil).
2. Assume data, if missing, with justification.

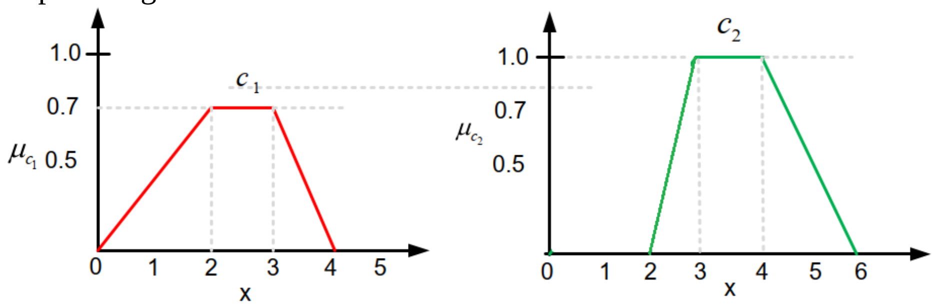
Solutions

Q.I.	Attempt all questions.	Marks	CO	BL	PI
1.	The support of a fuzzy set A is the set of all points x in X such that i. $\mu(x) > 0$, ii. $\mu(x) = 1$, iii. $\mu(x) = 0.5$, iv. $\mu(x)$ not equal to 1	1M	CO6	L2	1.3.1
Ans:	i. $\mu(x) > 0$				
2.	Consider a SOM neural network with five input neurons and three output neurons. How many parameters have to be learned in this network? i. 5, ii. 25, iii. 15, iv. 125	1M	CO3	L4	2.1.3
Ans:	iii. 15				
3.	Consider two fuzzy sets with their membership values as $A = \{(x_1, 0.5), (x_2, 0.1), (x_3, 0.4)\}$ and $B = \{(x_1, 0.2), (x_2, 0.3), (x_3, 0.5)\}$. Find the membership for the intersection of A and B. i. $\{(x_1, 0.2), (x_2, 0.1), (x_3, 0.4)\}$, ii. $\{(x_1, 0.5), (x_2, 0.3), (x_3, 0.5)\}$, iii. $\{(x_1, 0.5), (x_2, 0.1), (x_3, 0.5)\}$, iv. $\{(x_1, 0.2), (x_2, 0.3), (x_3, 0.4)\}$	1M	CO6	L3	2.4.1
Ans:	i. $\{(x_1, 0.2), (x_2, 0.1), (x_3, 0.4)\}$				
4.	In K-means clustering, the three centroids are $C_1 = (1, 2)$, $C_2 = (-3, 0)$, and $C_3 = (4, 2)$ and the input pattern is $x = (-1, 2)$. What will be the cluster assignment of x? i. 3, ii. 2, iii. 1, iv. cannot be assigned	1M	CO3	L3	4.1.4
Ans:	iii. 1				
5.	What is the maximum possible value of RBF (Gaussian) kernel used in SVM? i. 0, ii. 1, iii. $+\infty$, iv. undefined	1M	CO4	L2	2.1.3
Ans:	ii. 1				

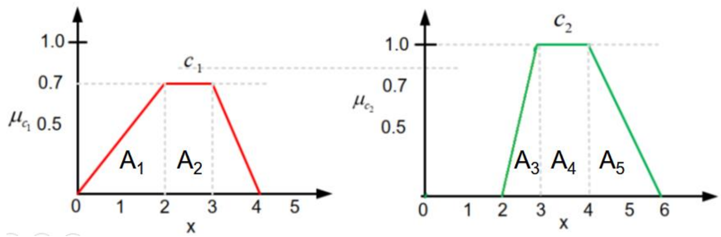
6.	In MaxNet neural network, the weights between any two different neurons are i. inhibitory, ii. excitatory, iii. -1, iv. +1	1M	CO3	L1	1.3.1
Ans:	i. inhibitory				
7.	The core of a fuzzy set is defined as the set of all points whose membership value is i. more than 1, ii. exactly 1, iii. less than 1, iv. exactly 0	1M	CO6	L1	1.3.1
Ans:	ii. exactly 1				
8.	What is the interpretation of slack variables ξ used in the optimization function of SVM? i. If $\xi_n > 1$, the n^{th} sample is on the correct side of boundary ii. If $\xi_n > 1$, the n^{th} sample is on the correct side of boundary but inside the margin iii. If $\xi_n > 1$, the n^{th} sample should be discarded from the training set iv. If $\xi_n > 1$, the n^{th} sample is on the wrong side of boundary	1M	CO4	L4	4.1.4
Ans:	iv. If $\xi_n > 1$, the n^{th} sample is on the wrong side of boundary				
9.	Consider two fuzzy sets *A* and *B* with membership functions $\mu(A)$ and $\mu(B)$. *A* is for HOT climate and *B* is for COLD climate. What will be the membership for PLEASANT climate? i. 1 - $\mu(B)$, ii. max($\mu(A)$, $\mu(B)$), iii. min($\mu(A)$, $\mu(B)$), iv. 1 - $\mu(A)$	1M	CO6	L4	2.4.1
Ans:	iii. min($\mu(A)$, $\mu(B)$)				
10.	For effective clustering, what should be the distance between any two clusters? i. as large as possible, ii. as small as possible, iii. -∞, iv. +∞	1M	CO3	L2	2.1.3
Ans:	i. as large as possible				
Q.II.	**Attempt any one.**				
1.	Construct a Kohonen self-organizing map to cluster the four vectors [0 0 1 1], [1 0 0 0], [0 1 1 0], and [0 0 0 1]. Form two clusters. Assume initial learning rate of 0.5.	5M	CO3	L3	2.4.1
Ans:	Initialize the weights randomly between 0 and 1. $w_{ij} = \begin{bmatrix} 0.2 & 0.9 \\ 0.4 & 0.7 \\ 0.6 & 0.5 \\ 0.8 & 0.3 \end{bmatrix}$, $D(j) = \sum_{i=1}^{n}(x_i - w_{ij})^2$, $w_{ij}(\text{new}) = (1-\alpha)w_{ij}(\text{old}) + \alpha x_i$ For x = [0 0 1 1], calculate the Euclidean distance D(1) = 0.4, D(2) = 2.04 Since D(1) < D(2), therefore D(1) is minimum. Hence the winning cluster unit is Y_1, i.e. J = 1. Update weight of winning cluster unit.				

	$w_{11} = 0.1$, $w_{21} = 0.2$, $w_{31} = 0.8$, $w_{41} = 0.9$ For x = [1 0 0 0], calculate the Euclidean distance D(1) = 2.3, D(2) = 0.84 Since D(2) < D(1), therefore D(2) is minimum. Hence the winning cluster unit is Y_2, i.e. $J = 2$. Update weight of winning cluster unit. $w_{12} = 0.95$, $w_{22} = 0.35$, $w_{32} = 0.25$, $w_{42} = 0.15$ For x = [0 1 1 0], calculate the Euclidean distance D(1) = 1.5, D(2) = 1.91 Since D(1) < D(2), therefore D(1) is minimum. Hence the winning cluster unit is Y_1, i.e. $J = 1$. Update weight of winning cluster unit. $w_{11} = 0.05$, $w_{21} = 0.6$, $w_{31} = 0.9$, $w_{41} = 0.45$ For x = [0 0 0 1], calculate the Euclidean distance D(1) = 1.48, D(2) = 1.8 Since D(1) < D(2), therefore D(1) is minimum. Hence the winning cluster unit is Y_1, i.e. $J = 1$. Update weight of winning cluster unit. $w_{11} = 0.025$, $w_{21} = 0.3$, $w_{31} = 0.45$, $w_{41} = 0.475$ 				
2.	Construct a MaxNet with four neurons and inhibitory weight ε = 0.2, given the initial activations (input signals) as follows: $a_1(0) = 0.3$, $a_2(0) = 0.5$, $a_3(0) = 0.7$, $a_4(0) = 0.9$.	5M	CO3	L3	2.4.1
Ans:	 Update the activations for each neuron $a_j(new) = f\left[a_j(old) - \epsilon \sum_{k \neq j} a_k(old)\right]$ Iteration 1: $a_1(1) = 0$, $a_2(1) = 0.12$, $a_3(1) = 0.36$, $a_4(1) = 0.6$ Iteration 2: $a_1(2) = 0$, $a_2(2) = 0$, $a_3(2) = 0.216$, $a_4(2) = 0.504$ Iteration 3: $a_1(3) = 0$, $a_2(3) = 0$, $a_3(3) = 0.1152$, $a_4(3) = 0.4608$ Iteration 4: $a_1(4) = 0$, $a_2(4) = 0$, $a_3(4) = 0.02304$, $a_4(4) = 0.4377$ Iteration 5: $a_1(5) = 0$, $a_2(5) = 0$, $a_3(5) = 0$, $a_4(5) = 0.4332$ Thus, the convergence has occurred.				

<table>
<tr><td>Q.III.</td><td>Attempt any one.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1.</td><td>For the given fuzzy membership functions C_1 and C_2, determine the crisp output using centroid and mean-max methods.

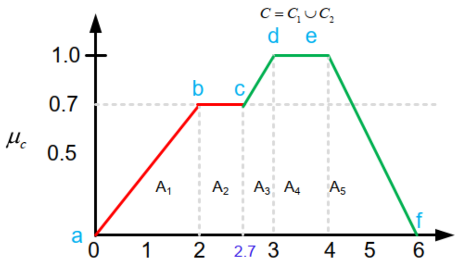


</td><td>5M</td><td>CO6</td><td>L3</td><td>2.4.1</td></tr>
<tr><td>Ans:</td><td>Find the union of C_1 and C_2:



For A_1 (0,0),(2,0.7): y − 0 = (0.7/2) (x − 0), so y = 0.35x
For A_2 (2,0.7),(3,0.7) : y = 0.7
For A_3 (2,0),(3,1): y − 0 = [(1 – 0)/(3 – 2)] (x − 2), so y = x − 2
From A_2 to A_3 : 0.7 = x – 2, so x = 2.7
For A_4 (3,1),(4,1): y = 1
For A_5 (4,1),(6,0): y − 1 = [(0 – 1)/(6 – 4)] (x − 4), so y = −0.5x + 3

$$\mu_c(x) = \begin{cases} 0.35x & 0 \le x < 2 \\ 0.7 & 2 \le x < 2.7 \\ x-2 & 2.7 \le x < 3 \\ 1 & 3 \le x < 4 \\ (-0.5x+3) & 4 \le x \le 6 \end{cases}$$



$$x^* = \frac{\int x.\mu_c(x)dx}{\int \mu_c(x)dx} = \frac{N}{D}$$

$$N = \int_0^2 0.35x^2 dx + \int_2^{2.7} 0.7x\,dx + \int_{2.7}^3 (x^2-2x)dx + \int_3^4 x dx + \int_4^6 (-0.5x^2+3x)dx$$

= 10.98

$$D = \int_0^2 0.35x dx + \int_2^{2.7} 0.7 dx + \int_{2.7}^3 (x-2)dx + \int_3^4 dx + \int_4^6 (-0.5x+3)dx$$

= 3.445

Thus, $x^* = \frac{10.98}{3.445} = 3.187$

Using Mean-max method, x* = (3+4)/2 = 3.5</td><td></td><td></td><td></td><td></td></tr>
</table>

2.	The discretized membership functions for two fuzzy sets are given as T = { 0/0 + 0.2/1 + 0.7/2 + 0.8/3 + 0.9/4 + 1/5 }, R = { 0/0 + 0.1/1 + 0.3/2 + 0.2/3 + 0.4/4 + 0.5/5 }. Find the algebraic sum, algebraic product, bounded sum and bounded difference of the given fuzzy sets.	5M	CO6	L3	2.4.1
Ans:	Algebraic sum = { 0/0 + 0.28/1 + 0.79/2 + 0.84/3 + 0.94/4 + 1/5 } $\mu_{A+B}(x) = \mu_A(x) + \mu_B(x) - \mu_A(x) \cdot \mu_B(x)$ Algebraic Product = { 0/0 + 0.02/1 + 0.21/2 + 0.16/3 + 0.36/4 + 0.5/5 } $\mu_{A \cdot B}(x) = \mu_A(x) \cdot \mu_B(x)$ Bounded Sum = { 0/0 + 0.3/1 + 1/2 + 1/3 + 1/4 + 1/5 } $\mu_{A \oplus B}(x) = \min[1, \mu_A(x) + \mu_B(x)]$ Bounded Difference = { 0/0 + 0.1/1 + 0.4/2 + 0.6/3 + 0.5/4 + 0.5/5 } $\mu_{A \odot B}(x) = \max[0, \mu_A(x) - \mu_B(x)]$				