Reg No.:.................................... Name:....................................

College of Engineering Thalassery

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.TECH DEGREE Vth SEMESTER MODEL EXAMINATION, OCTOBER 2017

Course Code: CS 361

Course Name: SOFT COMPUTING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

1) Differentiate between biological neuron and artificial neuron on the basis of structure and function of a singe neuron. (3)
2) Given tha task of identifyig human gestures computationally. Which neural learning model will use? Why? (3)
3) Are there any relation between the number of neurons and the type of classification? Explain. (3)
4) Can a two input adaline compute the XOR function? Why? (3)

PART B

Answer any two questions, each carries 9 marks.

5) Determine the weights after one iteration for hebbian learning of a single neuron network starting with initial weights w=[1,-1], inputs as X_1=[1,-2] , X_2=[2,3], X_3=[1,-1] and C=1. Use bipolar activation function. (9)

6)
   a) Explain the significance of hidden layer. (3)
   b) Train a perceptron network for learning a binary inputs and bipolar output OR gate function. Work out two complete iterations. (6)

7)
   a) If the activation function of all hidden unit is linear, then show that MLP is equivalent to single layer perceptron. (4)
   b) Using Mc-Culloch Pitts neuron, implement a bipolar AND function. Assume initial weights to be [1,1]. (5)

PART C

Answer all questions, each carries 3 marks.

8) Distinguish between fuzzy and probability with example. (3)
9) Whether a power set can be formed for a fuzzy set? Justify. (3)
10) Why the excluded middle laws does not get satisfied in fuzzy logic? (3)
11) How a fuzzy relation is converted into a crisp relation using lambda-cut process? (3)

PART D

Answer any two questions, each carries 9 marks.

12) Consider two fuzzy sets A and B:

$$A = \left\{ \frac{0.8}{1} + \frac{0.4}{2} + \frac{0.6}{3} + \frac{0.1}{4} + \frac{0.3}{5} + \frac{1}{6} \right\}$$

$$B = \left\{ \frac{0.3}{1} + \frac{0.8}{2} + \frac{0.6}{3} + \frac{0.8}{4} + \frac{0.2}{5} + \frac{1}{6} \right\}$$

Find complement, union, intersection, difference, bounded sum and bounded difference over these fuzzy sets. (9)

13) Explain different types of defuzzification methods with suitable examples. (9)

14) The formation of algal solutions in surface water is strongly dependent on pH of water, temperature and oxygen content. T is a set of water temperatures from a lake given by, T = {50,55,60} and O is oxygen content values in water given by, O ={1,2,6}. The fuzzy sets are given by,

$$T = \left\{ \frac{0.7}{50} + \frac{0.8}{55} + \frac{0.9}{60} \right\}$$

$$O = \left\{ \frac{0.1}{1} + \frac{0.6}{2} + \frac{0.8}{6} \right\}$$

$$I = \left\{ \frac{0.5}{50} + \frac{1}{55} + \frac{0.7}{60} \right\}$$

Find,

a) R = T x O (4)

b) S = I o R, using max-product composition. (5)

PART E

Answer any four questions, each carries 10 marks.

15) Explain the two types of fuzzy inference systems with examples. (10)

16) Formulate a problem that can derive inference through fuzzy systems. (10)

17) Given digits 0 to 9 and operators +,-,* and /. Using Genetic Algorithm how will you represent the target positive integer. Design the whole optimization process and the type of optimization function used. (10)

18) Let the universe, X = {1,2,3,4} and 'small integers' be defined as,A = {(1,1),(2,0.5),(3,0.4),(4,0.2)}. Let the fussy relation 'almost equal' is represented as,R:

$$
\begin{array}{c c}
 & \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\
\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} & \begin{pmatrix} 1 & 0.8 & 0 & 0 \\ 0.8 & 1 & 0.8 & 0 \\ 0 & 0.8 & 1 & 0.8 \\ 0 & 0 & 0.8 & 1 \end{pmatrix}
\end{array}
$$

Find the membership function of the fuzzy set, B = 'rather small integers' , if it is interpreted as the composition A o R.

(10)

19) Develop an FIS Mamdani model for controlling temperature in an air conditioner. (10)

20) Explain the characteristics and properties of neuro-fuzzy hybrid systems. (10)

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PART A

(4x 3)

1)

Criteria	Artificial neuron	Biological neuron
Speed	The cycle time of execution in the ANN is of few nanoseconds	It is of few milliseconds.
Processing	Can perform several parallel operations simultaneously.	Can perform massive parallel operations simultaneously
Size and complexity	Size and complexity is based on chosen application and network designer.	Total number of neurons is about 10^{11} and the total number of interconnections is 10^{15}.

ANN is also known for computers.

Biological neuron is in brain. (3 marks)

2) ANN model can be used. Variant of ANN, MLP can also be used. (1 mark)

It is a neurally implemented mathematical model. The interconnections with their weighted linkages hold the informative knowledge. The processing elements of ANN have

the ability to learn, recall and generalize from the given data by suitable assignment.
Based on the idea of creating predictor for each gesture class (2 marks)

3) Yes. (½ mark)

Number of input neurons = Number of input data to be classified.

Number of hidden neurons = Number of processing elements which helps to increase accuracy.

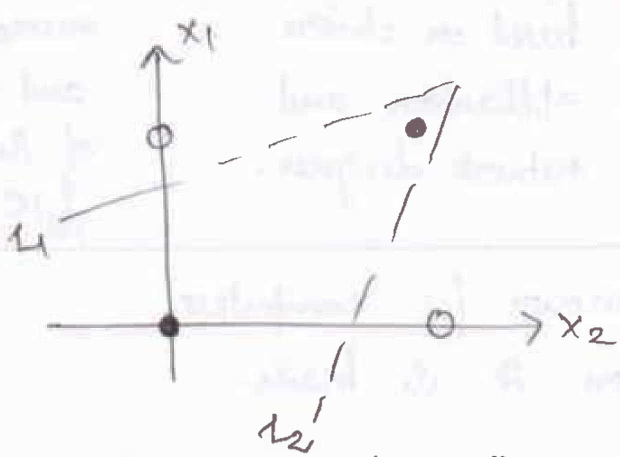
Number of output neurons = Number of output classes. (2½ marks)

4) No. (1 Mark)

Truth table of XOR function:

x_1	x_2	Y
0	0	0
0	1	1
1	0	1
1	1	0

$Y = x_1 \oplus x_2$



Cannot be seperated with a single line. Not linearly seperable. (2 marks)

PART B

(2 x 9)

5)

Inputs			Output
x_1	x_2	Cin	t
1	-2	1	$0.9 \cong 1$
2	3	1	0
1	-1	1	$0.9 \cong 1$

Output 't' is calculated using the equations,

Net input, $y_{in} = C_{in} + x_1 w_1 + x_2 w_2$

Apply activation function over the net input,

$$y = f(y_{in}) = \frac{2}{1 + e^{-y_{in}}} - 1$$ (3 marks)

Initially, $w_1 = 1, w_2 = -1, c_w = 1$

x_1	x_2	cin	t	Weight changes Δw_1	Δw_2	Δc_w	Weights w_1	w_2	c_w
							(1	-1	1)
1	-2	1	1	1	-2	1	2	-3	2
2	3	1	0	0	0	0	2	-3	2
1	-1	1	1	1	-1	1	3	-4	3

(4 marks)

After one iteration,

$$[w_1, w_2, c_w] = [+3, -4, +3]$$ (2 marks)

6) a) When the number of hidden layers increases, then the accuracy of target output or classification result also increases. (3 marks)

b) Truth table for OR function:

Inputs			Output
x_1	x_2	b_{in}	t
1	1	1	
1	0	1	
0	1	1	
0	0	1	

(1 marks)

Initially, $w_1 = w_2 = b_w = 0$

Net input, $y_{in} = b_{in} + x_1 w_1 + x_2 w_2$

$$y = f(y_{in}) = \begin{cases} 1 & \text{if } y_{in} > 0 \\ 0 & \text{if } y_{in} = 0 \\ -1 & \text{if } y_{in} < 0 \end{cases}$$

(1 marks)

Input			Target	Net input	Calculated output	Weight changes			Weights		
x_1	x_2	b_{in}	t	y_{in}	y	Δw_1	Δw_2	Δb_w	w_1	w_2	b_w
1	1	1	1	0	0	1	1	1	1	1	1
1	0	1	1	2	1	0	0	0	1	1	1
0	1	1	1	2	1	0	0	0	1	1	0
0	0	1	-1	1	1	0	0	-1	1	1	0
1	1	1	1	2	1	0	0	0	1	1	0
1	0	1	1	1	1	0	0	0	1	1	0
0	1	1	1	1	1	0	0	0	1	1	0
0	0	1	-1	0	0	0	0	0	1	1	-1

(4 marks)

7)

a) A linear function can be defined as,

$f(x) = x$ for all x.

The output here remains the same as input. (1 marks)

If a MLP has a linear activation function in all neurons, ie, a linear function that maps the weighted inputs to the output of each neuron, then linear algebra shows that any number of layers can be reduced to a two layer input-output model. (3 marks)

b) Truth table for AND function:

Inputs x_1	Inputs x_2	Output y
1	1	1
1	-1	-1
-1	1	-1
-1	-1	-1

(1 mark)

Both weights are excitatory, ie, $w_1 = w_2 = 1$

For inputs, $(1, 1)$ $y_{in} = 2 \Longrightarrow$ has output value 1.

$\therefore$ threshold, $\theta = 2$

$(1, -1)$ $y_{in} = 0$

$(-1, 1)$ $y_{in} = 0$

$(-1, -1)$ $y_{in} = -2$

$$y = f(y_{in}) = \begin{cases} 1 & \text{if } y_{in} \geq 2 \\ -1 & \text{if } y_{in} < 2 \end{cases}$$

(4 marks)

PART C (4 x 3)

8) In probability, complete membership is allowed.
In fuzzy logic, partial membership is allowed. (½ mark)
Probability is associated with events and not facts.
Fuzzy logic, basically try to capture the essential concept of vagueness. (½ mark)

9) Yes. (1 mark)
Power set can be formed for a fuzzy set, Set of all possible subset. The cardinality of fuzzy sets on any universe is infinity. This is mainly a result of occurrence of partial membership on any fuzzy sets. (3 marks)

10) Excluded middle laws; $A \cup \bar{A} = X$.
Fuzzy logic is a logic for border line cases. If you have universal set, A, then classify those individual or elements in 3 types: those who have property P, those who have property not P, -P, and those who are borderline.
$\therefore P \cup \overline{P} \neq \dot{A}$ (3 marks)

11) Consider fuzzy set, A. Lambda cut denoted by,
A_λ $(0 \leq \lambda \leq 1)$. A_λ is the crisp set.
$A_\lambda = \{ x \mid \mu_A(x) \geq \lambda \}$ (3 marks)

PART D (2x9)

12) **Union**

$$A \cup B = \left\{\frac{0.8}{1} + \frac{0.8}{2} + \frac{0.6}{3} + \frac{0.8}{4} + \frac{0.3}{5} + \frac{1}{6}\right\}$$ (1 mark)

Intersection

$$A \cap B = \left\{\frac{0.3}{1} + \frac{0.4}{2} + \frac{0.6}{3} + \frac{0.1}{4} + \frac{0.2}{5} + \frac{1}{6}\right\}$$ (1 mark)

Complement

$$\overline{A} = 1 - A = \left\{\frac{0.2}{1} + \frac{0.2}{2} + \frac{0.4}{3} + \frac{0.2}{4} + \frac{0.7}{5} + \frac{0}{6}\right\}$$

$$\overline{B} = 1 - B = \left\{\frac{0.7}{1} + \frac{0.6}{2} + \frac{0.4}{3} + \frac{0.9}{4} + \frac{0.8}{5} + \frac{0}{6}\right\}$$ (1 mark)

Difference

$$A | B = A \cap \overline{B} = \left\{\frac{0.7}{1} + \frac{0.4}{2} + \frac{0.4}{3} + \frac{0.1}{4} + \frac{0.2}{5} + \frac{0}{6}\right\}$$

$$B | A = \overline{A} \cap B = \left\{\frac{0.2}{1} + \frac{0.2}{2} + \frac{0.4}{3} + \frac{0.2}{4} + \frac{0.2}{5} + \frac{0}{6}\right\}$$ (2 marks)

Bounded sum

$$\mu_{A \oplus B}(x) = \min\left[1, \mu_A(x) + \mu_B(x)\right]$$

$$= \min\left[1, \left\{\frac{1.1}{1} + \frac{1.2}{2} + \frac{1.2}{3} + \frac{0.9}{4} + \frac{0.5}{5} + \frac{2}{6}\right\}\right]$$

$$= \left\{\frac{1}{1} + \frac{1}{1} + \frac{1}{1} + \frac{0.9}{4} + \frac{0.5}{5} + \frac{1}{6}\right\}$$ (2 marks)

Bounded difference

$$\mu_{A \ominus B}(x) = \max\left[0, \mu_A(x) - \mu_B(x)\right]$$

$$= \max\left[0, \left\{\frac{0.5}{1}, \frac{0.4}{2} + \frac{0}{3} + \frac{0.7}{4} + \frac{0.1}{5} + \frac{0}{6}\right\}\right]$$

$$= \left\{\frac{0.5}{1} + \frac{0.4}{2} + \frac{0}{3} + \frac{0.7}{4} + \frac{0.1}{5} + \frac{0}{6}\right\}$$ (2 marks)

13) Defuzzification methods:

1). Maxima method:

2) Centroid method

3) Weighted average method

4) Middle of maxima method

5) First of maxima or last of maxima. (1 marks)

Definition + example (8 marks)

14)

a) $R = T \times O =$
$$\begin{array}{c|c} & \begin{array}{ccc} 1 & 2 & 8 \end{array} \\ \begin{array}{c} 50 \\ 55 \\ 60 \end{array} & \begin{bmatrix} 0.1 & 0.6 & 0.7 \\ 0.1 & 0.6 & 0.8 \\ 0.1 & 0.6 & 0.8 \end{bmatrix} \end{array}$$
(4 marks)

b) $S = I \circ R =$
$$\begin{array}{c|c} & \begin{array}{ccc} 1 & 2 & 6 \end{array} \\ \begin{array}{c} 50 \\ 55 \\ 60 \end{array} & \begin{bmatrix} 0.5 & 1 & 0.7 \\ 0.5 & 1 & 0.8 \\ 0.5 & 1 & 0.8 \end{bmatrix} \end{array}$$
[4 marks]

Max-product composition:

$$\mu_T(x, z) = \mu_{R \circ S}(x, z) = \max_{y \in Y} \left[\min \left[\mu_R(x, y), \mu_S(y, z) \right] \right]$$

[1 mark]

PART C (4×10)

15)

Types of Fuzzy Inference System (FIS):

1) Mamdani Type

2) Sugeno Type

(1 mark)

A nonlinear mapping that derives its output based on fuzzy reasoning and a set of fuzzy if-then rules — FIS

The difference between these two FISs lie in the consequents of their fuzzy rules, and thus their aggregation and defuzzification procedures differ accordingly. (1 marks)

1) Mamdani Fuzzy Models

Built to control a steam engine and boiler combination. A set of fuzzy rules are supplied and experienced by human operators.

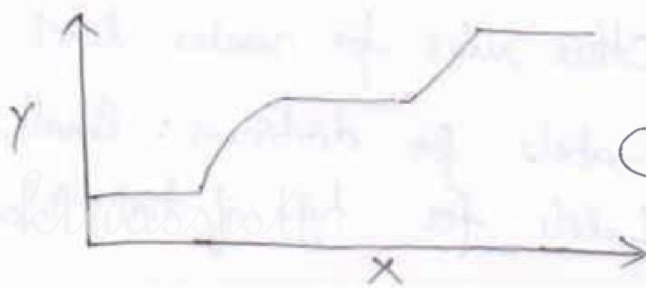
The Mamdani-style fuzzy inference process is performed in 4 steps:

i) Fuzzification of the input variables
ii) Rule evaluation (inference)
iii) Aggregation of the rule outputs (composition)
iv) Defuzzification

An example of a single-input single-output with three rules can be expressed as,

Rule 1: If X is small, then Y is small.
Rule 2: If X is medium, then Y is medium.
Rule 3: If X is large, then Y is large.

With max-min composition and centroid defuzzification, we can find the overall input-output curve as shown in figure:



(4 Marks)

2) Sugeno Fuzzy Model

For developing a systematic approach to generating fuzzy rules from a given input-output data set.

A typical fuzzy rule in a Sugeno fuzzy model:

If x is A then y is B then $z = f(x, y)$

A and B - Fuzzy sets

$z = f(x, y) \Rightarrow$ Crisp function

An example of a single-input Sugeno fuzzy model:

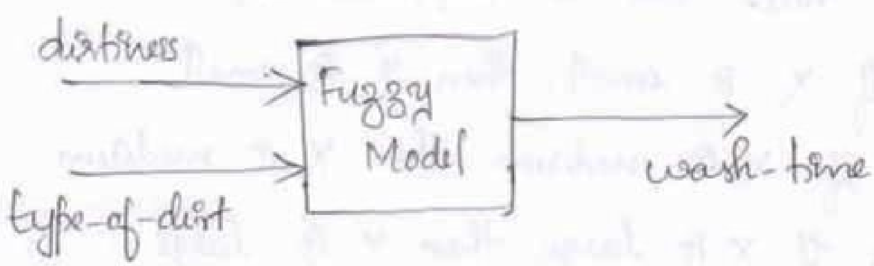
Rule 1: If X is small, then $Y = 0.1X + 6.4$

Rule 2: If X is medium, then $Y = -0.5X + 4$

Rule 3: If X is large, then $Y = X - 2$.

(4 Marks)

1b) Example: Washing Machine (or any) (1 mark)



If dirtiness is large and type-of-dirt is grease, then wash time should be very-long.

Other rules for water level and spin speed. (1 mark)

Labels for dirtiness: Small, Medium, Large

Labels for

Labels for output variable wash-time : Very Short, Short, Medium, Long, Very Long (1 Mark).

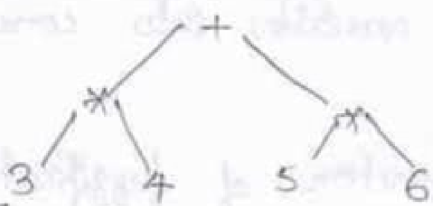
Construct a table showing combination of these rules and corresponding output (7 Mark)

17) The task is to find a mathematical expression whose values represent target positive integer using only given operators and predefined set of numbers.

All intermediate result and the final result must be positive integer numbers.

Number of combination is defined by, ${}^{n}C_{k}$ where n is the count of selected numbers and k is the count of numbers that can use in the expression.

Use a tree representation of the expression which will allow cross over and mutation operations to be implemented easily.



For eg:-

(3 Marks)

Actual fitness function $= \dfrac{1}{1+|t-n|}$, where t is the target number and n is the calculated value of the expression.

It is in the range [0,1]. The algorithm can stop when a chromosome number with fitness value of 1 is found.

(7 Marks)

18) Let us consider the possibility distribution induced by the proposition "X is a small integer",

$\cdot A = \{(1,1), (2,0.5), (3,0.4), (4,0.2)\}$

and crisp set $X = \{1,2,3,4\}$.

The possibility measure is then,

$\max\{1, 0.5, 0.4, 0.2\} = 1$ (1 Mark)

$\bar{A} = \{(1,0), (2,0.5), (3,0.6), (4,0.8)\}$

'rather small'

$B = \bar{A}OR = \{(1,0.8), (2,1), (3,0.8), (4,1)\}$

(9 Marks)

19) 1) The fuzzification interface involves the following functions:

a) Measure the value of input variables

b) Performs a scale mapping that transfers the range of values of input variables into corresponding universe of discourse.

c) Performs the function of fuzzification that converts input data into suitable linguistic variables.

2) The knowledge based comprises a knowledge about the application domain or a linguistic control rule base.

Rules	Temperature	Humidity	Compressed speed
1)	Very Low	Dry	off
2)	Very Low	Comforable	off
3)	Very Low	Humid	off
4)	Very Low	Stickey	Low

5)	Low	Dry	Off
6)	Low	Comfortable	Off
7)	Low	Humid	Low
8)	Low	Sticky	Medium
9)	High	Dry	Low
10)	High	Comfortable	Medium
11)	High	Humid	Fast
12)	High	Sticky	Fast
13)	Very High	Dry	Medium
14)	Very High	Comfortable	Fast
15)	Very High	Humid	Fast
16)	Very High	Sticky	Fast

(3 Marks)

Classification of Compressor speed as,

0-50 : Low

40-80 : Medium

70-1000 : Fast

3) <u>Inference</u> For each rule which represented in fuzzy level as set of restriction on the output based on certain conditions of the input. Output is a new fuzzy set which is the conclusion of rule since an implication operator is applied.

4) <u>Defuzzification</u>: Converting the result in fuzzy set form into crisp set. (2 Marks)

Fuzzification Results :

$$f_1 = \frac{\text{max. value} - \text{min. value}}{\text{max}}.$$

$f_0 = 1 - f_1$, Similarly for f_2, f_3, etc.

Inference engine:

$$R_0 = f_0 \wedge f_2 = \min(f_1, f_2)$$

Defuzzification:

$\sum S[i] * R[i] / \sum R[i]$, where $i = 1$ to 4 here.

S[i] from rule selector. (5 marks)

20) 1) A neuro fuzzy system is based on a fuzzy system which is trained by a learning algorithm derived from NN theory. The learning procedure operates on local information, and causes only local modifications in the underlying fuzzy system.

2) It can be viewed as a 3-layer feed forward neural network.

First layer : Input variables

Middle layer/Hidden layer : Fuzzy rules

Third layer : Output variables.

3) Created to solve the trade-off between :

The mapping precision and automation of NNs, and the interpretability of fuzzy systems.

4) Combines both such that either:

- Fuzzy system gives input to NN
- NN gives input to fuzzy systems.

5) NFS = NN + FS

(Each point carry 2 marks)

END