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MANIPAL INSTITUTE OF TECHNOLOGY, MANIPAL 576104
(Constituent College of Manipal University)

SEVENTH SEMESTER B.TECH(IT) DEGREE END SEMESTER EXAMINATION-NOV/DEC 2015
SUBJECT:PROGRAM ELECTIVE III-NEURAL NETWORKS & FUZZY LOGIC (ICT 421)
(REVISED CREDIT SYSTEM)

TIME:3 HOURS **01/12/2015** **MAX.MARKS:50**

Instructions to Candidates

- Answer any **FIVE FULL** questions. All questions carry equal marks.
- Missing data if any, may be suitably assumed.

1A. Show that a Bayes classifier reduces to a linear classifier, when the environment is Gaussian.

1B. A fully connected feedforward network has four source nodes, three hidden neurons and two output neuron. Construct an architectural graph of this network. Apply back-propagation algorithm to this network and write the relation for each synaptic weight after one iteration of back-propagation algorithm.

1C. The back-propagation formula for the local gradient is given by

$$\delta_j(n) = \varphi_j'(v_j(n)) \sum_k \delta_k(n) w_{kj}(n) \qquad \text{neuron } j \text{ is hidden.}$$

Obtain, the expression for synaptic weight updation, when a hyperbolic tangent function is used as an activation function.

[5+3+2]

2A. Solve XOR problem using radial basis function network. Assume that

$$G(||\mathrm{x} - t_i||) = \exp(-||\mathrm{x} - t_i||^2) \qquad i = 1, 2.$$

2B. Support Vector Machines (SVM) avoids the need for heuristics, which is often used in the design of conventional radial basis function network and multi-layer perceptron. How does SVM address heuristic issues in radial basis function network and multi-layer perceptron?

2C. The correlation matrix R_X of the input vector $\mathrm{X}(n)$ in the LMS algorithm is defined by

$$R_\mathrm{X} = \begin{bmatrix} 1 & 0.5 \\ 0.5 & 1 \end{bmatrix}$$

i) Define the range of values for the learning-rate parameter η of LMS algorithm for it to be convergent in the mean square.

ii) Compute the condition number, $\chi(R_\mathrm{X})$.

[5+3+2]

3A. Assume that $\widehat{M}$ is the correlation matrix memory, derive suitable relation for recall and perfect recall of key patterns.

3B. Figure 1 shows the signal-flow graph of a 2-2-2-1 feedforward network. The function $\varphi(.)$ denotes a logistic function.

i) Write the input-output mapping defined by this network.

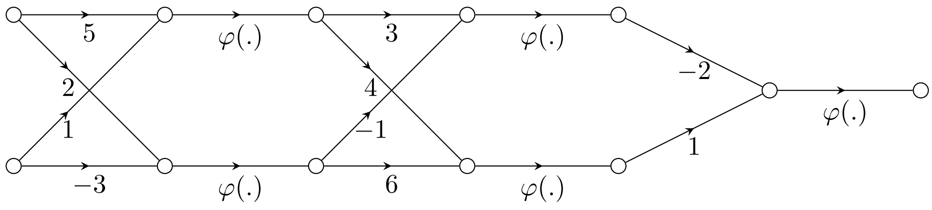

Figure 1: Q.3B

ii) Suppose that the output neuron in the signal-flow graph of Figure 1 operates in its linear region. Write the input-output mapping defined by this new network.

3C. With a neat diagram, illustrate classical approach to pattern classification.

[5+3+2]

4A. For the data shown in the accompanying table, show the first iteration in trying to compute the membership values for the input variables x_1, x_2 and x_3 in the output region R_1 and R_2. Use a $3 \times 3 \times 2$ neural networks. Assume a random set of weights for your neural networks.

x_1	x_2	x_3	R_1	R_2
1.0	0.5	2.3	1.0	0.0

4B. Samples of a new microprocessor IC chip are to be sent to several customers for beta testing. The chips are sorted to meet certain maximum electrical characteristics, say frequency and temperature rating, so that the "best"' chips are distributed to preferred customer 1. Suppose that each sample chip is screened and all chips are found to have a maximum operating frequency in the range 7-15 MHz at 20^0C. Also, the maximum operating temperature range $(20^0C \pm \Delta T)$ at 8 MHz is determined. Suppose there are eight sample chips with the following electrical characteristics: The following fuzzy sets are defined:

	Chip Number							
	1	2	3	4	5	6	7	8
f_{max}, MHz	6	7	8	9	10	11	12	13
$\Delta T_{max}, ^0C$	0	0	20	40	30	50	40	60

$$A = \text{set of "fast" chips} = \text{chips with } f_{max} \geq 12\ MHz = \left\{\frac{0}{1} + \frac{0}{2} + \frac{0}{3} + \frac{0}{4} + \frac{0.2}{5} + \frac{0.6}{6} + \frac{1}{7} + \frac{1}{8}\right\}$$

$$B = \text{set of "slow" chips} = \text{chips with } f_{max} \geq 8\ MHz = \left\{\frac{0.1}{1} + \frac{0.5}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} + \frac{1}{7} + \frac{1}{8}\right\}$$

$$C = \text{set of "cold" chips} = \text{chips with } \Delta T_{max} \geq 10^0C = \left\{\frac{0}{1} + \frac{0}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} + \frac{1}{7} + \frac{1}{8}\right\}$$

$$D = \text{set of "hot" chips} = \text{chips with } \Delta T_{max} \geq 50^0C = \left\{\frac{0}{1} + \frac{0}{2} + \frac{0}{3} + \frac{0.5}{4} + \frac{0.1}{5} + \frac{1}{6} + \frac{0.5}{7} + \frac{1}{8}\right\}$$

Compute the following sets of "fast" and "hot" chips

i) $A \cup D$

ii) $A \cap D$

iii) $A|D$

iv) $\overline{A \cup D}$

v) $\overline{A \cap D}$

4C. Use the fuzzy sets A, B, C and D from Q.4B to compute the following

i) $R1 = A \times D$, and

ii) $R2 = B \times C$.

[5+3+2]

5A. In public transportation systems there often is significant need for speed control. For example, for Namma Metro, the train speed cannot go too far beyond a certain target speed or the train will have trouble stopping at a desired location in the metro station. Set up a fuzzy set

$$A = \text{"speed over target"} = \left\{ \frac{0}{T_0} + \frac{0.8}{T_0+5} + \frac{1}{T_0+10} + \frac{0.8}{T_0+15} \right\}$$

on a universe of target speeds, sat $T = [T_0, T_0 + 15]$, where T_0 is a lower bound on speed. Define another fuzzy set,

$$B = \text{"apply brakes with high force"} = \left\{ \frac{0.3}{10} + \frac{0.8}{20} + \frac{0.9}{30} + \frac{1}{40} \right\}$$

on a universe of braking pressures, say $S = [10, 40]$.

i) For the compound proposition, IF speed is "way over target," THEN "apply brakes with high force," find a fuzzy relation using classical implication.

ii) For a new antecedent,

$$A' = \text{"speed moderately over target"} = \left\{ \frac{0.2}{T_0} + \frac{0.6}{T_0+5} + \frac{0.8}{T_0+10} + \frac{0.3}{T_0+15} \right\}$$

find the fuzzy brake pressure using max-min composition.

5B. Two fuzzy sets A and B both defined on X, are as follows: Express the following λ-cut sets

$\mu(x_i)$	x_1	x_2	x_3	x_4	x_5	x_6
A	0.1	0.6	0.8	0.9	0.7	0.1
B	0.9	0.7	0.5	0.2	0.1	0

using Zadeh's notation:

(i) $(\overline{A})_{0.7}$

(ii) $(B)_{0.4}$

(iii) $(A \cup \overline{A})_{0.7}$

(iv) $(B \cap \overline{B})_{0.5}$

(v) $(\overline{A \cap B})_{0.7}$

(vi) $(\overline{A} \cup \overline{B})_{0.7}$

5C. Consider the given fuzzy relation

$$R_1 = \begin{bmatrix} 1 & 0.8 & 0 & 0.1 & 0.2 \\ 0.8 & 1 & 0.4 & 0 & 0.9 \\ 0 & 0.4 & 1 & 0 & 0 \\ 0.1 & 0 & 0 & 1 & 0.5 \\ 0.2 & 0.9 & 0 & 0.5 & 1 \end{bmatrix}$$

Check whether R_1 is a tolerance relation. If it is a tolerance relation then how many compositions are required to transform it into an equivalence relation?

[5+3+2]

6A. Two companies bid for a contract. A committee has to review the estimates of those companies and give reports to its chairperson. The reviewed reports are evaluated on a non dimensional scale and assigned a weighted score that is represented by a fuzzy membership function, as illustrated by the two fuzzy sets B_1 and B_2, in Figure 2. The chairperson is interested in the lowest bid, as well as a metric to measure the combined "best" score. For the logical union of the membership function shown we want to find the defuzzified quantity. Calculate the defuzzified value, z^* using following methods:

(i) Centroid method

(ii) Weighted average method

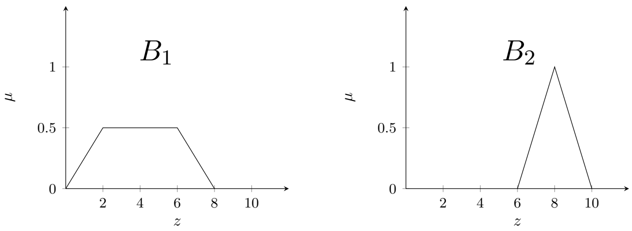

Figure 2: Q.6A

6B. A factory process control operation involves two linguistic parameters consisting of pressure and temperature in a fluid delivery system. We characterize each parameters in fuzzy linguistic terms as follows:

$$\text{“Low temperature”} = \left\{ \frac{1}{131} + \frac{0.8}{132} + \frac{0.6}{133} + \frac{0.4}{134} + \frac{0.2}{135} + \frac{0}{136} \right\}$$

$$\text{“High temperature”} = \left\{ \frac{0}{134} + \frac{0.2}{135} + \frac{0.4}{136} + \frac{0.6}{137} + \frac{0.8}{138} + \frac{1}{139} \right\}$$

$$\text{“High pressure”} = \left\{ \frac{0}{400} + \frac{0.2}{600} + \frac{0.4}{700} + \frac{0.6}{800} + \frac{0.8}{900} + \frac{1}{100} \right\}$$

$$\text{“Low pressure”} = \left\{ \frac{1}{400} + \frac{0.8}{600} + \frac{0.6}{700} + \frac{0.4}{800} + \frac{0.2}{900} + \frac{0}{1000} \right\}$$

Find the following membership functions:

(i) Temperature not very low

(ii) Temperature not very high

(iii) Temperature not very low and not very high.

6C. Using the inference approach, find the membership values for each of the triangular shapes (I,R,IR,E,T) for each of the following triangles:

(i) $80^0, 75^0, 25^0$

(ii) $55^0, 65^0, 60^0$.

[5+3+2]