B.E. (Comp) (IT) Sem VIII (R)

Con. 5461-09.

EL-II : Neural Networks & Fuzzy System

SP-6869

(3 Hours)

17/12/09

10-30 to 1-30

[Total Marks : 100

N.B. : (1) Question No. **1** is **compulsory**.
(2) Draw **neat** diagrams wherever **necessary**.
(3) Attempt any **four** out of remaining **six** questions.
(4) **All sub-questions** of the **same** question should be answered at **one** place only in their serial order and not scattered.
(5) Write everything in **ink** (no **pencil**) only.

1. (a) Explain support of a fuzzy set. **20**
(b) Explain composition of fuzzy relation.
(c) Explain K-means algorithm.
(d) Compare RBF and MLP network.

2. (a) Training input vector – **10**

$$x_1 = \begin{bmatrix} 1 \\ -2 \\ 0 \\ -1 \end{bmatrix}, \quad x_2 = \begin{bmatrix} 0 \\ 1\cdot5 \\ -0\cdot5 \\ -1 \end{bmatrix}, \quad x_3 = \begin{bmatrix} -1 \\ 1 \\ 0\cdot5 \\ -1 \end{bmatrix}$$

Desired response for x_1, x_2, x_3 are $d_1 = -1$, $d_2 = -1$, $d_3 = 1$, respectively
Initial weight vector

$$w^1 = \begin{bmatrix} 1 \\ -1 \\ 0 \\ 0\cdot5 \end{bmatrix}$$

Use delta learning rule to train the neural n/w.

(b) To which of the two paradigms, learning with a teacher and learning without teacher, do the following algorithms **5**
(i) nearest neighbour rule
(ii) K-nearest neighbour rule
(iii) Hebbiar learning
(iv) Boltzmann learning rule
belong ? Justify your answers.

(c) Let A = { (1, 0·2), (2, 0·5), (3, 0·8), (4, 1), (5, 0·7), (6, 0·3) }. List all possible α - level sets. **5**

3. (a) Unsupervised learning can be implemented in an off-line or on-line fashion. Discuss the physical implications of these two possibilities. **5**

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(b) Consider the following orthonormal sets of key patterns, applied to a correlation matrix memory : **15**

$x_1 = [\,1, 0, 0, 0\,]^T$

$x_2 = [\,0, 1, 0, 0\,]^T$

$x_3 = [\,0, 0, 1, 0\,]^T$

The respective stored patterns are

$y_1 = [\,5, 1, 0\,]^T$

$y_2 = [\,-2, 1, 6\,]^T$

$y_3 = [\,-2, 4, 3\,]^T$

(i) Calculate the memory matrix M

(ii) Show that the memory associates perfectly.

4. (a) An autoassociative memory is trained on the following key vectors – **6**

$$x_1 = \frac{1}{4}\left[-2,\ -3,\ \sqrt{3}\right]^T$$

$$x_2 = \frac{1}{4}\left[2,\ -2,\ \sqrt{8}\right]^T$$

$$x_3 = \frac{1}{4}\left[3,\ -1,\ \sqrt{6}\right]^T$$

Calculate the angles between these vectors. How close are they do orthogonality w.r.t. each other ?

(b) The correlation matrix R_x of the input vector x(n) in the LMS algorithm is defined by $R_x = \begin{bmatrix} 1 & 0\cdot5 \\ 0\cdot5 & 1 \end{bmatrix}$ **8**

Define the range of values for the learning rate parameter η of the LMS algorithm for it to be convergent in the mean square. Also, list limitations of LMS algorithm.

(c) Let $A = \{a_1, a_2\}$, $B = \{b_1, b_2, b_3\}$, $C = \{c_1, c_2\}$ **6**

Let R be a relation from A to B defined by matrix.

	b_1	b_2	b_3
a_1	0·4	0·5	0
a_2	0·2	0·8	0·2

Let S be a relation from B to C defined by

	c_1	c_2
b_1	0·2	0·7
b_2	0·3	0·8
b_3	1	0

Then max-min composition of R and S ?

5. (a) In this problem, we consider an exact solution of XOR problem using an RBF network with four hidden units, with each radial-basis function center being determined by each piece of input data. The four possible i/p patterns are defined by (0, 0), (0, 1), (1, 1), (1, 0), which represents the cyclically ordered corners of a square 10

(i) Construct the interpolation matrix Φ for the resulting RBF n/w. Hence, compute the inverse matrix Φ^{-1}.

(ii) Calculate the linear weights of the o/p layer of the n/w.

(b) What is fuzzification ? Explain support and grade fuzzification. 6

Let universe of discourse be

$$U = 1 + 2 + 3 + 4 \text{ and let}$$

$$A = \frac{0\cdot 8}{1} + \frac{0\cdot 5}{2}$$

Assume $K(1) = \frac{1}{1} + \frac{0\cdot 3}{2}$ and

$$K(2) = \frac{1}{2} + \frac{0\cdot 3}{1} + \frac{0\cdot 2}{3}$$

Then (i) Find Support fuzzification SF (A ; K)

(ii) Find Grade fuzzification GF (A ; K)

(c) List various types of fuzzy relations. 4

6. (a) Consider a stochastic, two-state neuron j operating at temperature T. This neuron flips from state x_j to state $-x_j$ with probability. 12

$$P\left(x_j \to -x_j\right) = \frac{1}{1+\exp\left(-\Delta E_j / T\right)}$$

Where ΔE_j is the energy change resulting from such a flip. The total energy of a Boltzmann machine is defined by

$$E = -\frac{1}{2} \sum_{i} \sum_{j} w_{ji}\, x_i\, x_j \qquad i \neq j$$

Where w_{ji}, is the synaptic weight from neuron i to neuron j,

with $w_{ji} = w_{ij}$ and $w_{ii} = 0$

(i) Show that, $\Delta E_j = -2x_i V_j$

Where, V_j is the induced local field of neuron j.

(ii) Hence, show that for an initial state $x_j = -1$ the probability that neuron j is flipped into state +1 is $\dfrac{1}{\left(1+\exp\left(-2V_j / T\right)\right)}$

(iii) Show that the same formula in part (2) holds for neuron j flipping into state −1 when it is initially in state +1.

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(b) Let fuzzy relation P given by $P = \begin{bmatrix} 0.1 & 0.5 \\ 0.3 & 0.2 \end{bmatrix}$ 8

and universe of discourse X = Y = [1, 2] determine, whether system is stable, oscillating or unstable ?

7. (a) Consider a simple Hopfield n/w made up of two neurons. The synaptic weight 11

matrix of n/w is $W = \begin{bmatrix} 0 & -1 \\ -1 & 0 \end{bmatrix}$

The bias applied to each neuron is zero. The four possible states of the network are

$X_1 = [+1, +1]^T$
$X_2 = [-1, +1]^T$
$X_3 = [-1, -1]^T$
$X_4 = [+1, -1]^T$

(i) Determine that states X_2 and X_4 are stable, whereas states X_1 and X_3 exhibit a limit cycle. Do this demonstration using following tool –
   (1) The alignment (stability) condition
   (2) The energy function.

(ii) What is the length of the limit cycle characterizing states X_1 and X_3 ?

(b) Write short note on any **three** of following :– 9

(i) Fuzzy control system design
(ii) Learning factors in MLP back propagation algorithm
(iii) Performance comparison of computer and Biological neural n/w
(iv) Stopping criteria of Back propagation algorithm
(v) Solving EXOR problem using MLP and RBF
(vi) RBF learning strategies.