INDIAN INSTITUTE OF TRCHNOLOGY KHARAGPUR

End Semester Examination Spring 2015-'16

Subject: **EC 60502** - Pattern Recognition and Image Understanding

Full Marks: 60 Time: 3-00 hrs.

Note: Answer all questions
Graph paper to be provided

1. The following set of 2-D feature vectors from two classes A and B are used to train a Fuzzy Min-Max neural network with compensatory neuron. The feature vectors are presented to the neural network in the given sequence of serial numbers. Assuming that hyperboxes in any dimension can not grow beyond 0.2, answer the following.

   (a) Draw the hyperboxes generated during training showing clearly the respective min points and the max points.

   (b) Design the Fuzzy Min-Max neural network with compensatory network for the above hyperboxes and show it diagrammatically.

Sl. No.	Feature Vector	Class
1	0.9, 0.9	A
2	0.8, 0.8	A
3	0.5, 0.73	B
4	0.35, 0.6	B
5	0.4, 0.5	B
6	0.2, 0.3	B
7	0.7, 0.7	A
8	0.6, 0.8	A

Sl. No.	Feature Vector	Class
9	0.45, 0.65	A
10	0.35, 0.38	A
11	0.75, 0.5	B
12	0.6, 0.3	B
13	0.25, 0.2	A
14	0.85, 0.35	A
15	0.65, 0.2	A

   (c) Using the above neural network, classify the feature vectors (0.55, 0.6) and (0.73, 0.32). Assume the fuzzyness parameter $\gamma = 10$.

5+5+5=15

2. (a) Explain the iterative clustering algorithm using minimum-sum-of-squared-error criterion.

   (b) Explain how a pattern is stored in Hopfield Network.

   (c) In a robot vision application the vision system is to distinguish between two types of shapes- R and T. The boundaries of the shapes are uniquely represented by their corresponding vertices. It is assumed that the image processing module performs proper segmentation and identifies the vertices by using low level image processing algorithms. The classifier module uses two independent features - Eccentricity (E) and Compactness (C) as defined below to distinguish between the two shapes.

$$Eccentricity = \frac{length\ of\ longer\ diagonal}{length\ of\ smaller\ diagonal}$$

$$Compactness = \frac{Perimeter^2}{Area}$$

   For both the shapes the standard deviation of Eccentricity is 0.2 and standard deviation of Compactness is 0.4. A representative R shape has vertices at (2, 3), (2, 15), (14, 3) and (10, 15). A representative T shape has vertices at (4, 4), (5, 16), (19, 4) and (17, 16). Classify a shape S having vertices at (1, 1), (1, 13), (14, 1) and (11, 13) to either R or T. Assume both R and T are equally probable.

5+5+5=15

3. The following sets of feature vectors from two linearly non-separable classes A and B are given.

$$\{(5,2)', (7,1)', (6,9)', (8,10)'\} \in A$$
$$\{(6,5)', (8,6)'\} \in B$$

(a) Design a set of suitable transformations that will transform the above feature vectors such that the transformed vectors belonging to classes A and B will be linearly separable.
(b) Show clearly that the linear separability is really achieved by the above transformations.
(c) Design a RBF Neural Network that performs the above task. The design should be complete in all respects.

7+4+4=15

4. (a) Explain the forward-backward learning algorithm for a HMM.

(b) A hidden Markov Model (HMM) θ_1 with four hidden states ω_i, (i = 0, 1, 2, 3) and another HMM θ_2 with five hidden states ω_i $(i = 0,1,2,3,4)$ are specified by $a_{ij}^{\theta_1}, b_{jk}^{\theta_1}$ and $a_{ij}^{\theta_2}, b_{jk}^{\theta_2}$ respectively. Both the HMMs have five visible symbols v_j, (j = 0, 1, 2, 3, 4).

$$a_{ij}^{\theta_1} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0.2 & 0.3 & 0.1 & 0.4 \\ 0.2 & 0.5 & 0.2 & 0.1 \\ 0.6 & 0.1 & 0.2 & 0.1 \end{bmatrix} \qquad b_{jk}^{\theta_1} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0.3 & 0.4 & 0.1 & 0.2 \\ 0 & 0.1 & 0.1 & 0.7 & 0.1 \\ 0 & 0.5 & 0.2 & 0.1 & 0.2 \end{bmatrix}$$

$$a_{ij}^{\theta_2} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.1 & 0.4 & 0.2 & 0.1 & 0.2 \\ 0.3 & 0.1 & 0.1 & 0.4 & 0.1 \\ 0.2 & 0.3 & 0.1 & 0.2 & 0.2 \\ 0.1 & 0.2 & 0.2 & 0.3 & 0.2 \end{bmatrix} \qquad b_{jk}^{\theta_2} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0.2 & 0.3 & 0.1 & 0.4 \\ 0 & 0.3 & 0.2 & 0.4 & 0.1 \\ 0 & 0.1 & 0.3 & 0.4 & 0.2 \\ 0 & 0.4 & 0.2 & 0.1 & 0.3 \end{bmatrix}$$

Find out which is the most likely HMM to generate the visible symbol sequence

$$V^5 = (v_1, v_3, v_4, v_2, v_0)$$

Assume ω_1 to be the initial state and ω_0 to be the terminal state in both the HMMs.

5+10=15