INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
End-Spring Semester 2017-18

Date of Examination : 20/04/2018 Session (FN/AN) AN Duration 3 hrs
Subject No.: EC60502 Subject Name : PATTERN RECOGNITION & IMAGE UNDERSTANDING
Department/Center/School : E & ECE
Specific charts, graph paper, log book etc., required : Graph Paper to be provided
Special Instructions (if any) : Answer all questions. Answers to parts of a question must be grouped together.

1.(a) Explain the Back-Propagation Learning algorithm for a Multilayer Neural Network.

(b) The training vectors belonging to three classes C_1, C_2 *and* C_3 are as given below. Design a multilayer neural network with three output layer nodes that will output vectors $(1\ 0\ 0)^t, (0\ 1\ 0)^t$ *and* $(0\ 0\ 1)^t$ for input vectors belonging to classes C_1, C_2 *and* C_3 respectively.

$$C_1 \Rightarrow \begin{bmatrix}2.5\\1\end{bmatrix}\begin{bmatrix}2\\2\end{bmatrix}\begin{bmatrix}3.5\\2\end{bmatrix}\begin{bmatrix}3\\3\end{bmatrix} \qquad C_2 \Rightarrow \begin{bmatrix}3.5\\4\end{bmatrix}\begin{bmatrix}4.25\\2.25\end{bmatrix}\begin{bmatrix}7\\1.5\end{bmatrix}\begin{bmatrix}5\\2.5\end{bmatrix} \qquad C_3 \Rightarrow \begin{bmatrix}3.5\\1\end{bmatrix}\begin{bmatrix}4.5\\1.5\end{bmatrix}\begin{bmatrix}6.5\\1\end{bmatrix}\begin{bmatrix}5\\0.5\end{bmatrix}$$

5+10 =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 and the features E and C are statistically independent. 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

PTO

3. (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

$$V^4 = < v_1, v_4, v_2, v_0 >$$

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

5+10=15

4.(a) Generate three clusters from the following set of points using Minimal Spanning Tree.

(2,2), (3,1), (3,2), (2,3), (3,3), (3,5), (4,3), (4,5), (5,4), (5,5), (6,2), (6,3), (7,2), (7,3).

(b) Generate three clusters from the set of points given in Q. 4(a) above using Batchelor-Wilkins algorithm.

(c) Which of the above two algorithms (Minimal Spanning Tree based and Btchelor-Wilkins) form better clusters in terms of Sum-of_Squared Error.

5+5+5=15