Question Paper

Exam Date & Time: 23-Nov-2022 (09:00 AM - 12:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

DEPARTMENT OF INFORMATION AND COMMUNICATION TECHNOLOGY
VII SEMESTER B.TECH (CCE/IT) END SEMESTER EXAMINATIONS, NOV 2022

Pattern Recognition [ICT 4053]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1)

A) Three discriminant functions for each of the three classes are as follows: (5)

$$G_1(x) = 10x_1 - x_2 - 10$$
$$G_2(x) = x_1 + 2x_2 - 10$$
$$G_3(x) = x_1 - 2x_2 - 10$$

Find the decision boundaries and sketch the decision space for these three classes. To which class would the data(3,0) belong?

B) Demonstrate the use of Bayesian Risk in decision-making in a two-class problem setup. (3)

C) Outline the design cycle of a pattern recognition system developed to separate oranges from bananas. (2)

2)

A) Consider the data samples (5)

$$\left\{ \begin{pmatrix}1\\6\end{pmatrix}, \begin{pmatrix}2\\7\end{pmatrix}, \begin{pmatrix}3\\8\end{pmatrix}, \begin{pmatrix}4\\9\end{pmatrix}, \begin{pmatrix}5\\10\end{pmatrix} \right\}$$

and

$$\left\{ \begin{pmatrix}7\\1\end{pmatrix}, \begin{pmatrix}8\\1\end{pmatrix}, \begin{pmatrix}9\\1\end{pmatrix}, \begin{pmatrix}10\\1\end{pmatrix}, \begin{pmatrix}11\\1\end{pmatrix} \right\}$$

belonging to class 1 and 2, respectively. Apply Fisher discriminant to find the line of projection on 1D space.

B) How does the Fisher linear discriminant present itself as a solution in a multi-class problem to maximize the separability among the classes? (3)

C) How does the Widrow-Hoff procedure used while estimating the weight vector? (2)

3)

A) Find the equation for the decision boundary between two classes when the covariance matrix is arbitrary and different for each class with (5)

$$A_1 = \begin{pmatrix}-1 & 0\\ 0 & -1/4\end{pmatrix},\ B_1 = \begin{pmatrix}6\\3\end{pmatrix},\ C_{10} = -18$$

$$A_2 = \begin{pmatrix}-1/4 & 0\\ 0 & -1/4\end{pmatrix},\ B_2 = \begin{pmatrix}3/2\\-1\end{pmatrix},\ C_{20} = 13/4.$$

B) When an exhaustive search for clustering becomes infeasible, we use iterative optimization. the basic idea of iterative optimization is to find some reasonable initial partition and move samples say $\hat{x}$ from D_i to D_j, if such move improves the value of criteria function, J_e. Show that the transfer of $\hat{x}$ from D_i to D_j is advantageous only if it meets the following criteria (3)

$$\frac{n_i}{n_i - 1}||\hat{x} - m_i||^2 > \frac{n_j}{n_j + 1}||\hat{x} - m_j||^2$$

C) What is the role of the conjunction rule in fuzzy classification? (2)

4)

A) For the data given in Table.Q.10 demonstrate the formation of two clusters using a complete linkage algorithm. (5)

Table: Q.10

Sample	x_1	x_2
1	7.1	4.2
2	-1.4	-4.3
3	4.5	0
4	6.3	1.6
5	4.2	1.9
6	1.4	-3.2

B) (3)

Let $\mathbf{x}_1 = \binom{4}{5}, \mathbf{x}_2 = \binom{1}{4}, \mathbf{x}_3 = \binom{0}{1}$ and $\mathbf{x}_4 = \binom{5}{0}$, and consider the following partitions:

1. $\mathcal{D}_1 = \{\mathbf{x}_1, \mathbf{x}_2\}$, $\mathcal{D}_2 = \{\mathbf{x}_3, \mathbf{x}_4\}$
2. $\mathcal{D}_1 = \{\mathbf{x}_1, \mathbf{x}_4\}$, $\mathcal{D}_1 = \{\mathbf{x}_2, \mathbf{x}_3\}$
3. $\mathcal{D}_1 = \{\mathbf{x}_1, \mathbf{x}_2, \mathbf{x}_3\}$, $\mathcal{D}_2 = \{\mathbf{x}_4\}$.

Show that by the sum-of-square error criterion, J_e the third partition is favored, whereas by the determinant criterion, J_d the first two partitions are favored.

C) Consider the two-category problem in which the components of the feature vector are binary-valued and conditionally independent. Derive the equation for the discriminant function, clearly specifying the weight vectors. (2)

5) A) Hidden Markov Model (HMM) can be represented as a probabilistic automata. Consider the probabilistic automata given in Fig.Q.13, where the symbol • represent full stop. The emission symbol set and probability, B for the model is given as, (5)

$$V = \{am, i, mit, manipal, of, student\}$$

, and

$$B = \begin{bmatrix} 0.1 & 0.3 & 0.1 & 0.2 & 0.2 & 0.1 & 0 \\ 0.1 & 0.1 & 0.5 & 0.1 & 0.1 & 0.1 & 0 \\ 0.3 & 0.2 & 0.1 & 0.1 & 0.2 & 0.1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

where the matrix index begins at 1. Assume that at $t = 0$ the model is in the starting state as indicated by the automata. Answer the following for the given HMM:

i) Find the probability it (HMM) generates for the sequence

$$\mathbf{V}^7 = \{i, am, student, of, mit, manipal, .\}.$$

ii) With a neat trellis diagram, show the sequence of hidden state which has lead to the generation of emitted symbol sequence in (i).

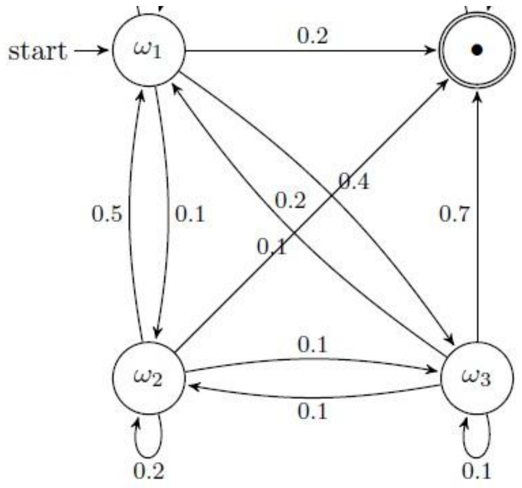

Fig.Q.13

B) Briefly describe the following terms: (3)

i. Markov assumption
ii. Markov model
iii. Markov process
iv. Markov chain
v. Hidden Markov model
vi. First-order HMM.

C) For the given transition matrix, draw a neat probabilistic automata with all the required labels. (2)

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ c_{11} & c_{12} & c_{13} & c_{14} & c_{15} \\ d_{11} & d_{12} & d_{13} & d_{14} & d_{15} \\ e_{11} & e_{12} & e_{13} & e_{14} & e_{15} \end{bmatrix}$$

Assume that at time $t = 0$, automata starts in first hidden state, and the matrix indexes begins at 0.

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