

B.E.Instrumentation and Electronics Engineering. 4thYear. 2nd Semester Examination, 2025

Subject: Data Analysis for Instrumentation System.

Time: Three hours

Full Marks : 100

Instructions: Figures in the margin indicate marks for all items of Questions.(in three Pages)

Module: I [Answer any one Question; Marks: 1x10 =10]

1. Prove that the validity of the following probability density function (PDF):

PDF is defined as $p(x, y) = 6(1-x-y)$; if $0 \leq x$, $0 \leq y$ and $x+y \leq 1$

$=0$; otherwise. [10]

2. Prove that for Bivariate Normal Density, the contours of constant probability density,

$p(x, y) = c$, always form ellipses in the xy-plane. [10]

Module :II [Answer any two Questions; Marks : 2x19 =38]

3. a)What is the Purpose of Fisher's Linear Discriminant Analysis. [3]

b) If the projected mean of class 1 is m_{1p} and the same for class 2 is m_{2p} , and if s^2_{1p} & s^2_{2p} is the projected within class scatter of class 1 patterns class 2 patterns, then the Fisher's criterion is :

$$J(V) = \frac{|m_{1p} - m_{2p}|^2}{(s^2_{1p} + s^2_{2p})}$$

Prove that the solution for V is: $V = W^{-1}(m_1 - m_2)$. [16]

4. Consider ten two dimensional feature vector points : $(1,2)^t$; $(3,5)^t$; $(4,3)^t$; $(5,6)^t$; $(7,5)^t$ of Class 1 and $(6,2)^t$; $(9,4)^t$; $(10,1)^t$; $(12,3)^t$; $(13,6)^t$ of Class 2.

a) Calculate normalised projection Vector V_N . [14]

b) Consider two feature vector points $P_1 = (4,4)^t$ and $P_2 = (12,4)^t$ and confirm its Classification. [3]

c) Prove the projection of $(m_1 - m_2)$ onto $V_N = 4.875$ [2]

5. Consider ten two dimensional feature vector points : $(1,2)^t$; $(3,5)^t$; $(4,3)^t$; $(5,6)^t$; $(7,5)^t$; $(6,2)^t$; $(9,4)^t$; $(10,1)^t$; $(12,3)^t$; $(13,6)^t$.

a) Calculate Covariance Matrix. [13]

b) Calculate Eigen Vector and Eigen Values. [4]

c) Calculate PC1 and PC2 for the first feature vector point. [2]

[Turn over

Module :III [Marks : 1x10=10]

6. sklearn.preprocessing package provides several common utility functions and transformer classes to change raw feature vectors into representation that is more suitable for downstream estimators. Describe briefly the purpose and functionality of Polynomial Features from sklearn.preprocessing, and explain how it is used for data pre-processing. [10]

Module :IV [Answer any three Questions; Marks : 3x14=42]

7. Prove that the equation of decision boundary between classes C_i and C_j of the two d-dimensional Multivariate Normal classes is as under:

$$\mathbf{x}^T \mathbf{A} \mathbf{x} + \mathbf{b}^T \mathbf{x} + c = 0 \quad [14]$$

8. (a) Construct a Neural Net having two input nodes (excluding Bias), two hidden nodes (excluding Bias), and one output node. Consider x_0 values for both input and hidden layer is unity. [3]

(b) Compute all gradient back flow (upto right side of hidden layer) as per back propagation Algorithm and Sequential MSE with Steepest (Gradient) Descent Algorithm and indicate in the Neural Net drawing. [11]

9.(a) Consider Turbine supervisory Instrumentation and control system having Polygonal Decision Boundary [ABCDEF counter clockwise] bounded by the following equations.

Line AB: $y = 0.81617x + 75.596$; Line BC: $x = 520$; Line CD: $y = 530$;

Line DE: $y = 0.7647x + 247.06$; Line EF: $y = 400$; Line FA: $x = 25$

Operating points inside the polygon are in Recommended zone and outside points of the polygon are Not- Recommended zone.

Coordinate of lowest point/vertex A is (25, 96). Coordinates other points/vertex are B(520,500) ; C(520,530); D(370,530); E(200,400); F(25,400); Construct Neural Net with Hidden Layer for classification of Recommended and Not-Recommended zone of safe operation of the Turbine. Where x indicate the Middle wall temperature of Main control valve casing and y indicate the Main Steam Temperature. [11]

(b) Also check the operating points (200,260) and (300,490) and classify (Recommended or Not-Recommended). [3]

10(a) What is the Advantage of Adaptive Decision Boundary Algorithm over Simple Perceptron Algorithm. [2]

(b) Write a Program in Python for calculating final weights for Non linear Decision boundary with adaptive algorithm with the following feature vector points in Allowed and Not-allowed

operating zone of Turbine supervisory Instrumentation and control system (Allowable maximum main Steam Pressure ahead of Turbine when opening of MS Stop Valve.)

Allowed zone :

(2 ,0.8 ,4, 1.6,0.64)^t ; (5 ,1.1 ,25, 5.5,1.21)^t ; (8 ,1.8 ,64, 14.4,3.24)^t ; (10 ,2.5 ,100, 25,6.25)^t ;
(13,4,169,52,16)^t ; (15,5 ,225, 75,25)^t ; (20 ,8.5 ,400, 170,72.25)^t ; (30 ,20.5 ,900, 615,420.25)^t

Not-Allowed zone :

(2 ,1.2 ,4, 2.4,1.44)^t ; (5 ,1.5 ,25, 7.5,2.25)^t ; (8 ,2.3 ,64, 18.4,5.29)^t ; (10 ,3.2 ,100, 32,10.24)^t ;
(13,4.8,169,62.4,23.04)^t ; (15,5.8,225,87,33.64)^t ; (20,9.2,400,184,84.64)^t ; (30,21.8,900, 654,475.24)^t

[12]

11a) Write a program in Python for calculating final weights for linear Decision boundary with simple Perceptron algorithm with the following feature vector points in Recommended and Not-Recommended operating zone of Turbine supervisory Instrumentation and control system (Recommended maximum reheat temperature before Turbine is loaded).

Recommended zone :

(40,210)^t ; (100,245)^t ; (140,280)^t ; (200,325)^t ; (240,350)^t ; (300,390)^t ; (400,460)^t ;

Not -Recommended zone :

(40,230)^t ; (100,275)^t ; (140,300)^t ; (200,340)^t ; (240,370)^t ; (300,410)^t ; (400,480)^t

[7]

b) Discuss features of ReLu and Softmax activation functions.

[7]

12. Consider Novel Feature Vector for ECG Classification Technique using Deep Learning:

a) Draw scheme of Methodology that performs the Classification.

[3]

b) Construct with block diagram the Scheme of the utilised CNN.

[11]