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NPTEL Week 2 Live Sessions

on Deep Learning (noc24_ee04)

A course offered by: Prof. Prabir Kumar Biswas, IIT Kharagpur

- Python coding: Feature Engineering
- Week 2 practice questions

By

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Content of the live session

1. Python coding for week-1 content
2. Glimpse of week 2 ~ a revisit !!
3. Solving numerical problems from week 2

Feature extraction

MFCC

STFT

LBP

GLCM

Wavelet

Gabor.

Boundary

Signature

hidden pattern

MNIST. — handwritten 0–9

Cifar-10

Python → Google Colab.

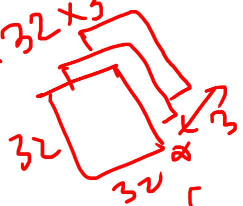
TPU, GPU

2D

$2\times2 \to \begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix}$

3D

$32\times32\times3$



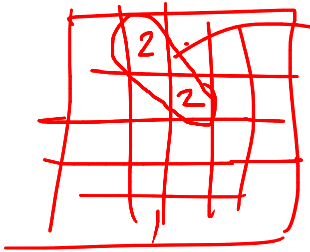
$A\,(i, j)$

$\langle 1, \theta \rangle \to$ Angle.

↓

distance

$A^{(2,2)}$ $(1,1)$



$A = \begin{bmatrix} 5 & 10 \\ 15 & 13 \end{bmatrix}$ 2×2

Norm: - $\max(A_{ij})$

$= 15$

$\begin{bmatrix} 5/15 & 10/15 \\ 15/15 & 13/15 \end{bmatrix}$

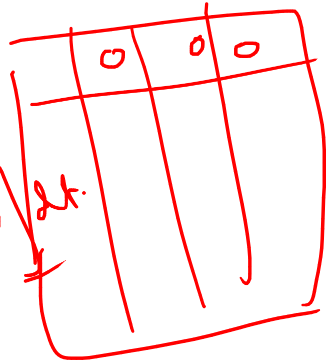
$X(\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt$

$e^{-i\theta}$

$\int_{-\infty}^{\infty} x(t) \left[\cos\theta - j\sin\theta \cdot x(t)\right] dt$

Real

Img



$z = a + jb$

$|z|^2 = \left(\sqrt{a^2+b^2}\right)^2$

$1 \to 9\times1$

$50000 \to 50000\times9$

Column Axis = 1

Axis = 0

$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{bmatrix}$

50000 × 32 × 32 × 3 .

(4D) → Tensor

Tensor → scalar 1 .

Tensor → 2D 2 × 2

Tensor → 3D M × N × L

Tensor → M×N×L×D . . .

Multidimensional array → Tensor

Tensor → TPU

$$P(\omega_1|x) = \frac{P(x|\omega_1)\cdot P(\omega_1)}{P(x)}$$

$$P(\omega_2/x) = \frac{P(x/\omega_2)\cdot P(\omega_2)}{P(x)}$$

$$\rightarrow P(x) = P(\omega_1)\cdot P(x/\omega_1) + P(\omega_2)P(x/\omega_2)$$

$x \in \omega_1$:- $\quad P(\omega_1|x) > P(\omega_2/x)$

$$\Rightarrow \frac{P(x/\omega_1)\cdot P(\omega_1)}{\cancel{P(x)}} > \frac{P(x/\omega_2)\, P(\omega_2)}{\cancel{P(x)}}$$

The class conditional probability density function for the class ω_i, i.e. $P(x|\omega_i)$ for a multivariate normal (or Gaussian) distribution (where x is a d dimensional feature vector) is given by

a. $p(x|\omega_i) = \frac{1}{(2\pi)^{d/2}|\Sigma_i|^{1/2}} \exp(-\frac{1}{2}(x-\mu_i)^T\Sigma_i^{-1}(x-\mu_i))$

b. $p(x|\omega_i) = \frac{1}{(2\pi)^{d/2}} \exp\left(-\frac{1}{2}(x-\mu_i)^T\Sigma_i^{-1}(x-\mu_i)\right)$

c. $p(x|\omega_i) = \frac{1}{(2\pi)^{d/2}} \exp(-\frac{1}{2}(x-\mu_i)^T(x-\mu_i))$

d. None of the above

$\Sigma \rightarrow$ general

$d \times 1$

$\Sigma \; 1 \times 1$

Σ ✗

$\Sigma_{2d} = \begin{bmatrix} \sigma_1^2 & \sigma_2^2 \\ \sigma_3^2 & \sigma_4^2 \end{bmatrix}$

$\Sigma_{1d} = \sigma^2$

Σ ✗

$x = \begin{bmatrix} \text{Gender}(x_1) \\ \text{Profession}(x_2) \end{bmatrix}_{2\times 1}$

$\Sigma = \begin{bmatrix} & \\ & \end{bmatrix}$

For n dim:

$\frac{1}{\sqrt{2\pi \Sigma_{nd}}}$

$|\Sigma|^{1/2}$

$\begin{vmatrix} a_1 & a_2 \\ a_3 & a_4 \end{vmatrix} = a_1 a_4 - a_3 a_2$

$\frac{1}{\sqrt{2\pi}(\sigma)} = \frac{1}{\sqrt{2\pi\sigma^2}}$

$x \in R^{d\times 1}$

$\Sigma \in R^{d\times d}$

$\frac{1}{\sqrt{2\pi \Sigma}}$

1d: $\frac{1}{\sqrt{2\pi\Sigma_{1d}}}$

$\frac{1}{\sqrt{2\pi\sigma^2}}$

2d: $\frac{1}{\sqrt{2\pi\Sigma_{2d}}}$

There are some data points for two different classes given below.

Class 1 points: $\{(2,6),(3,4),(3,8),(4,6)\}$

Class 2 points: $\{(3,0),(1,-2),(5,-2),(3,-4)\}$

Compute the mean vectors μ_1 and μ_2 for these two classes and choose the correct option.

a. $\mu_1 = \begin{bmatrix}2\\6\end{bmatrix}$ and $\mu_2 = \begin{bmatrix}3\\-1\end{bmatrix}$

b. $\mu_1 = \begin{bmatrix}3\\6\end{bmatrix}$ and $\mu_2 = \begin{bmatrix}2\\-2\end{bmatrix}$

c. $\mu_1 = \begin{bmatrix}3\\6\end{bmatrix}$ and $\mu_2 = \begin{bmatrix}3\\-2\end{bmatrix}$

d. $\mu_1 = \begin{bmatrix}3\\5\end{bmatrix}$ and $\mu_2 = \begin{bmatrix}2\\-3\end{bmatrix}$

$\mu = E(\cdot)$

$$\mu_1 = \frac{\begin{bmatrix}2\\6\end{bmatrix}+\begin{bmatrix}3\\4\end{bmatrix}+\begin{bmatrix}3\\8\end{bmatrix}+\begin{bmatrix}4\\6\end{bmatrix}}{4}$$

$$= \frac{\begin{bmatrix}12\\24\end{bmatrix}}{4} = \begin{bmatrix}3\\6\end{bmatrix}$$

$$\mu_2 = \frac{\begin{bmatrix}3\\0\end{bmatrix}+\begin{bmatrix}1\\-2\end{bmatrix}+\begin{bmatrix}5\\-2\end{bmatrix}\begin{bmatrix}3\\-4\end{bmatrix}}{4}$$

$$= \begin{bmatrix}3\\-2\end{bmatrix}$$

$\text{Avg}(D_1, D_2, D_3 \dots D_n)$

There are some data points for two different classes given below.

Class 1 points: $\{(2,6),(3,4),(3,8),(4,6)\}$

Class 2 points: $\{(3,0),(1,-2),(5,-2),(3,-4)\}$

Compute the covariance matrices Σ_1 and Σ_2 and choose the correct option.

a. $\Sigma_1 = \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 2 & 0 \\ 0 & 0.5 \end{bmatrix}$

b. $\Sigma_1 = \begin{bmatrix} 0.5 & 0 \\ 0 & 2 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$

c. $\Sigma_1 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

d. $\Sigma_1 = \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

$\mu_1 = \underbrace{\begin{bmatrix} 3 \\ 6 \end{bmatrix}}_{2\times 1}$ $\quad \underbrace{\Sigma}_{2\times 2} = \text{Exp}\left((x-\mu)(x-\mu)^t\right)$

~~for~~ first data point

$(x-\mu)(x-\mu)^t = \begin{bmatrix} -1 \\ 0 \end{bmatrix} \begin{bmatrix} -1 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$

$\begin{bmatrix} 0 \\ -2 \end{bmatrix} \begin{bmatrix} 0 & -2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 4 \end{bmatrix}$

$\begin{bmatrix} 0 \\ 2 \end{bmatrix} \begin{bmatrix} 0 & 2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 4 \end{bmatrix}$

$\begin{bmatrix} 1 \\ 0 \end{bmatrix} \begin{bmatrix} 1 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$

Exp → Avg.

$$\frac{\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 4 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 4 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}}{4}$$

$= \begin{bmatrix} 0.5 & 0 \\ 0 & 2 \end{bmatrix}$

off diag $= 0 \rightarrow$ They are statistically independent.

There are some data points for two different classes given below.

Class 1 points: $\{(2,6),(3,4),(3,8),(4,6)\}$

Class 2 points: $\{(3,0),(1,-2),(5,-2),(3,-4)\}$

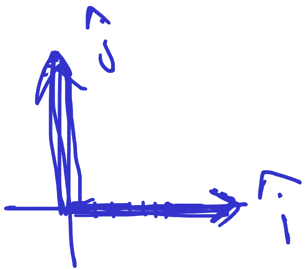
Compute the covariance matrices Σ_1 and Σ_2 and choose the correct option.

a. $\Sigma_1 = \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 2 & 0 \\ 0 & 0.5 \end{bmatrix}$

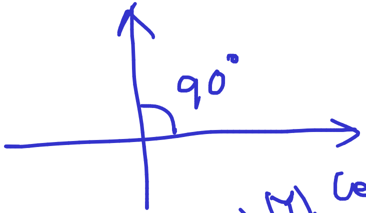
b. $\Sigma_1 = \begin{bmatrix} 0.5 & 0 \\ 0 & 2 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$

c. $\Sigma_1 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

d. $\Sigma_1 = \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix}$ and $\Sigma_2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$



$3\hat{i} + 0\hat{j}$



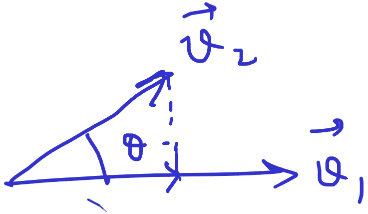
independence Means → No dependence in the axis.

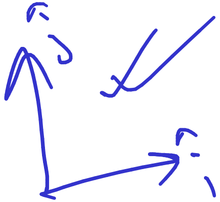
$\langle x, x\rangle$ $\langle x_1, x_2\rangle$

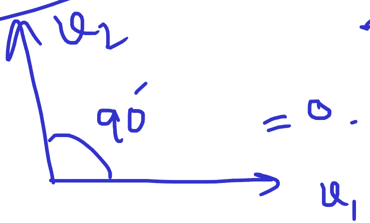
$\langle x, y\rangle = |x||y|\cos 90^\circ$

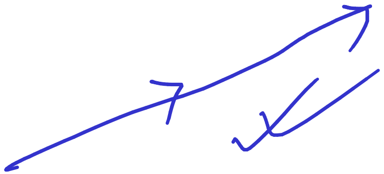
$= |\hat{i}||\hat{j}|\cos 90^\circ$

$= 0$









Let Σ_i represents the covariance matrix for i^{th} class. Assume that the classes have the same co-variance matrix. Also assume that the features are statistically independent and have same co-variance. Which of the following is true?

a. $\Sigma_i = \Sigma_j$ (diagonal elements of Σ are zero) X

b. $\Sigma_i = \Sigma_j$ (diagonal elements of Σ are non-zero and different from each other, rest of the elements are zero) X

c. $\Sigma_i = \Sigma_j$ (diagonal elements of Σ are non-zero and equal to each other, rest of the elements are zero)

d. None of these

$$\Sigma_i = \Sigma_j$$

$$= \begin{bmatrix} \sigma^2 & 0 \\ 0 & \sigma^2 \end{bmatrix}_{2\times 2}$$

$$= \sigma^2 I$$

$$\Sigma_i = \Sigma_j = \sigma^2 I$$

$$\sigma^2 \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$|\sigma^2 I| = \sigma^2$$

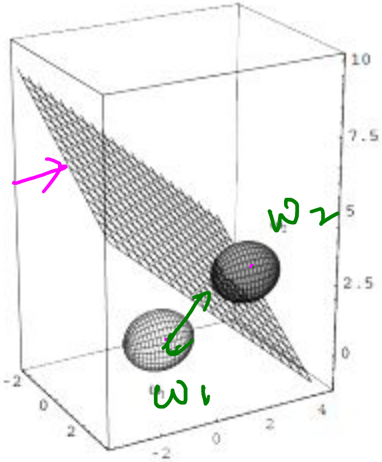
$$I \rightarrow 1.$$

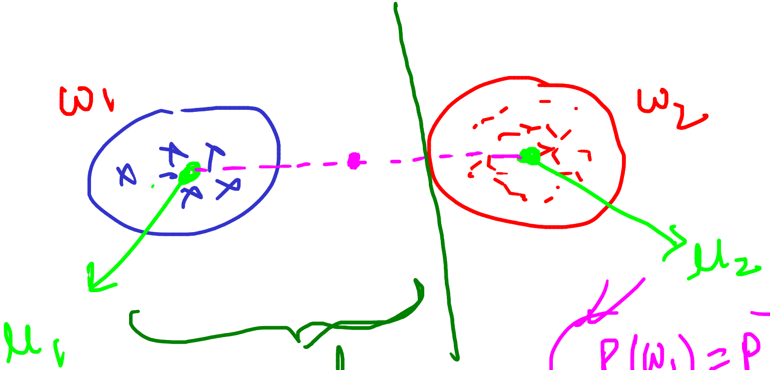
$$\sigma^2 \qquad \sigma^2 I \qquad I.$$

The decision surface between two normally distributed class ω_1 and ω_2 is shown on the figure. Can you comment which of the following is true?

$$\Sigma_i = \Sigma_j = \sigma^2 I.$$

$$\underbrace{= \begin{bmatrix} \sigma^2 & 0 \\ 0 & \sigma^2 \end{bmatrix}}_{\text{what is the decision surface?}}$$





Biased to ω_1

$P(\omega_1) > P(\omega_2)$

$P(\omega_1) = P(\omega_2)$

a. $p(\omega_1) = p(\omega_2)$

b. $p(\omega_2) > p(\omega_1)$

c. $p(\omega_1) > p(\omega_2)$

d. None of the above.