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NPTEL Live Sessions

on Deep Learning (noc24_ee04)

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

By

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Content of the live session

1. Glimpse of week 1 ~ a revisit !!

2. Solving numerical problems from week 0 and 1 content

3. Quick hands on session on hand crafted feature extraction

Machine learning vs. deep learning:

$\vec{v} = \begin{bmatrix} h \\ l_t \\ \text{Texture} \end{bmatrix}$

features

$\vec{v}_{cat} \rightarrow$ ML $\rightarrow$ Cat / Dog

$\vec{v}_{dog}$

Entropy
Energy $\rightarrow$ ML

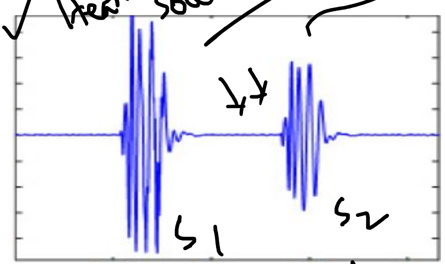
$\rightarrow$ DL

AI
ML
DL

Hand crafted feature extraction

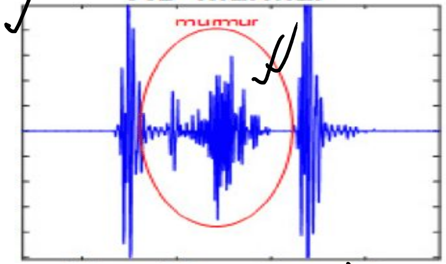
Energy

Heart sound



S1 S2

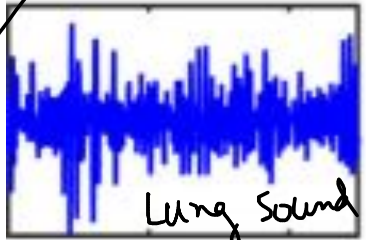
Normal



Abnormal

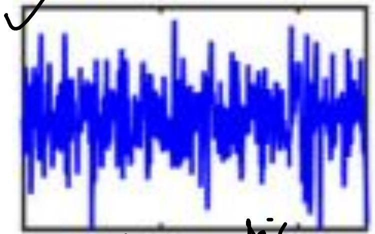
Eland

Red buck



Lung sound

Health



Asthmatic

Bayes Minimum error classifier:

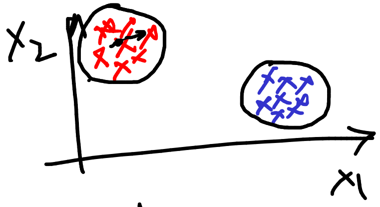
$$P(x,\omega) = p(x|\omega)\cdot P(\omega)$$
$$= p(\omega|x)\cdot P(x)$$

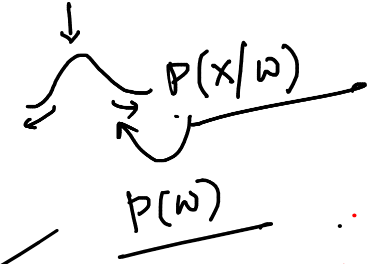
$$\Rightarrow \quad p(\omega|x) = \frac{p(x/\omega)\cdot p(\omega)}{p(x)}$$

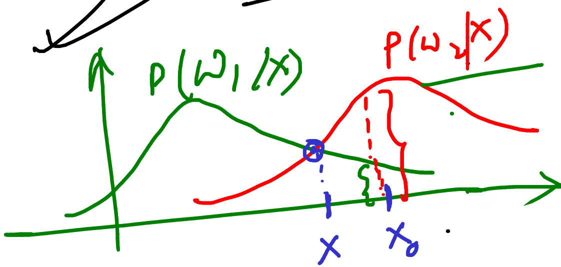
$$P(\omega_1/x) = \frac{p(x/\omega_1)\, P(\omega_1)}{\cancel{p(x)}}$$

$$P(\omega_2/x) = \frac{p(x/\omega_2)\, P(\omega_2)}{\cancel{P(x)}}$$

$$\boxed{p(\omega_1/x) + p(\omega_2/x) = 1}$$







Total = 1

error = $1 - p(\omega_2/x)$

$= p(\omega_1/x)$

$x \in \omega_1$:- $p(\omega_1|x) > p(\omega_2|x)$

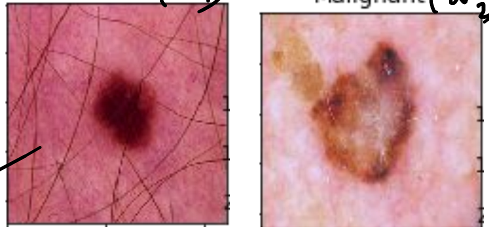
$x \in$? (can't be decided)

$p(\omega_1|x) = p(\omega_2|x)$

$$\text{Error} = p(\omega_1|x) = \min\{p(\omega_1|x),\, p(\omega_2|x)\}$$
$$= p(\omega_1|x)$$

Bayes Minimum risk classifier:

$X \in \omega_1, \omega_2$



$\omega :- \omega_1, \omega_2$

$\rightarrow \alpha :- \alpha_1, \alpha_2.$

$$\boxed{\begin{aligned}&\lambda \text{ (Penalty factor)}\\ &= \lambda(\alpha_i / \omega_j) = \lambda_{ij}\end{aligned}}$$

$\lambda_{12} \rightarrow$ high

$\lambda_{22} \rightarrow$ Low.

$\lambda(\alpha_2/\omega_2) \downarrow$

$$R(\alpha_i/x) = \sum_j P(\omega_j/x) \cdot \lambda_{ij} \quad \text{[expectation]}$$

$X \in \omega_1 :-$

$$R(\alpha_1/x) = \lambda_{11} \underbrace{P(\omega_1/x)} + \lambda_{12} \underbrace{P(\omega_2/x)}$$

$$R(\alpha_2/x) =$$

$$\boxed{\begin{aligned}&P(\omega_2/x)\\ &= 1 - P(\omega_1/x)\end{aligned}}$$

$X \in \omega_1 :-$

$$\underbrace{R(\alpha_1|x)} < \underbrace{R(\alpha_2/x)}.$$

$$\frac{P(\omega_1/x)}{P(\omega_2/x)} > \frac{\lambda_{12} - \lambda_{22}}{\lambda_{21} - \lambda_{11}}$$

$$E(x) = \underbrace{\sum x P(x)}$$

$\lambda(\alpha_1/\omega_1)$

$\lambda(\alpha_2/\omega_1) \rightarrow$

$\lambda(\alpha_1/\omega_2) \rightarrow$

Find $y = x^3 \ln x$. Find $\frac{dy}{dx}$

a. $3x^2 \ln x$

b. $3x^2 \ln x + x^2$

c. x^2

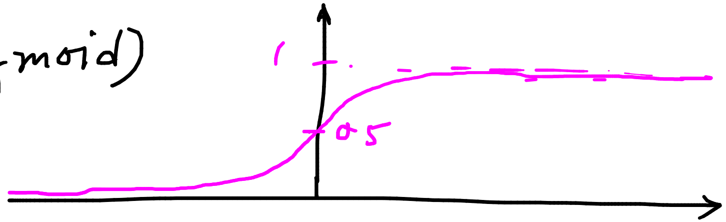
d. $3x$

$y = x^3 \ln x$.

$y = 3x^2 \cdot \ln x + \frac{1}{x} \cdot x^3$

$= x^2 + 3x^2 \ln x$.

Find $\frac{d\sigma}{dx}$, where $\sigma(x) = \frac{1}{1+e^{-x}}$ (Sigmoid)



(Assymptotic curve)

a. $\frac{d\sigma}{dx} = 1 - \sigma(x)$

b. $\frac{d\sigma}{dx} = 1 + \sigma(x)$

c. $\frac{d\sigma}{dx} = \sigma(x)(1 - \sigma(x))$

d. $\frac{d\sigma}{dx} = \sigma(x)(1 + \sigma(x))$

$$\sigma'(x) = \frac{(1+e^{-x}).0 - 1(0+e^{-x} \times (-1))}{(1+e^{-x})^2}$$

$$= \frac{e^{-x}}{1+e^{-x}} \times \frac{1}{1+e^{-x}} \rightarrow \sigma(x)$$

$$= \left(1 - \frac{1}{1+e^{-x}}\right) \rightarrow (1-\sigma(x))$$

$$\sigma'(x) = \sigma(x).(1-\sigma(x))$$

There are 5 black 7 white balls. Assume we have drawn two balls randomly one by one without any replacement. What will be the probability that both balls are black?

a. 20/132
b. 25/144
c. 20/144
d. 25/132

First ball to be black $P(A) = \frac{5}{5+7} = \frac{5}{12}$

second case $P(B) = \frac{4}{4+7} = \frac{4}{11}$

$P(A, B) = P(A) \cdot P(B)$

$= \frac{5}{12} \cdot \frac{4}{11} = \frac{20}{132}$

A bag contains 2 red, 3 green and 2 blue balls. Two balls are drawn at random. What is the probability that none of the balls drawn is blue?

a. 10/21
b. 11/21
c. 2/7
d. 5/7

Total = 2+3+2 = 7.

(S) Sample Space = $^7C_2$

E = two ball will be drawn, none are blue.
= $^5C_2$.

$$P = \frac{^5C_2}{^7C_2}.$$

What is the probability of getting a sum 9 from two throws of a dice?

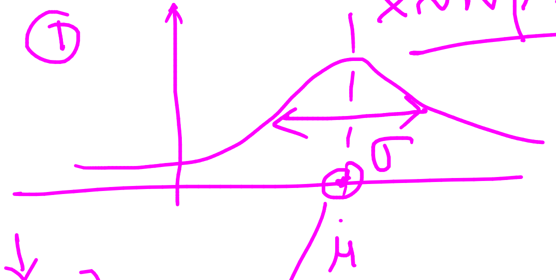
a. 1/6
b. 1/8
c. 1/9
d. 1/12

$S = \{ \quad \} = 36.$

$E = \{(3,6), (4,5), (5,4), (6,3)\}$

$4/36 = 1/9$

① $X \sim N(\mu, \sigma)$



The area under a standard normal curve is ?

a. 0
b. 1
c. 0.5
d. Not defined

② $X \sim N(0,1)$

$$\boxed{Z = \frac{x - \mu}{\sigma}.}$$

$$Z = \frac{\mu - \mu}{\sigma} = 0.$$

$\int Pdf =$ Total probability $= 1$

Z score normalization

Covariate shift

x_1, x_2, x_3 are the linearly independent vectors. If $x_1 = \begin{bmatrix} 1 \\ 3 \\ 0 \end{bmatrix}$, $x_2 = \begin{bmatrix} -2 \\ 4 \\ -5 \end{bmatrix}$, what is the possible value of x_3?

a. $\begin{bmatrix} -1 \\ 7 \\ -5 \end{bmatrix}$

b. $\begin{bmatrix} 0 \\ 10 \\ -5 \end{bmatrix}$

c. $\begin{bmatrix} 3 \\ 4 \\ 5 \end{bmatrix}$

d. $\begin{bmatrix} 5 \\ -5 \\ 10 \end{bmatrix}$

$v = \{v_1, v_2, v_3\}$. $\rightarrow$ LI :-

① $a_1 \vec{v}_1 + a_2 \vec{v}_2 + a_3 \vec{v}_3 = 0.$

only when $a_1, a_2, a_3 = 0$

② (Colinear vector) linearly dependent

$v_1 (2,4)$.

$v_2 (4,8)$

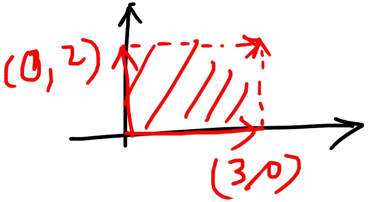
$v_1 = 2v_2$

$1 v_1 - 2 v_2 = 0$

$a \rightarrow x_1 + x_2 = x_3$

$x_2 + 2x_1 = x_3$

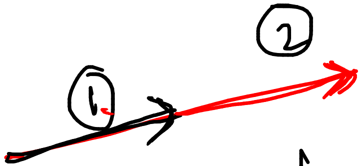
$\boxed{\det(x_1, x_2, x_3) \neq 0}$



Area = $3 \times 2 = 6$.

$$\begin{array}{cc} \begin{bmatrix} 3 & 0 \\ 0 & 2 \end{bmatrix} \\ \downarrow \quad \downarrow \\ x_1 \quad x_2. \end{array}$$

$$|A| = \begin{vmatrix} 3 & 0 \\ 0 & 2 \end{vmatrix} = 6.$$



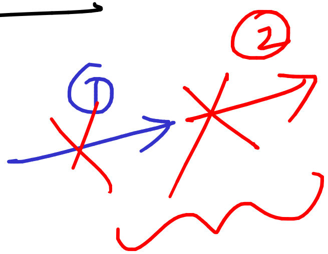
Area = 0. $\quad |A| = 0$

$\rightarrow$ dependent.

$|A| \neq 0$

$\rightarrow$ independent.

c



$$x + 2y - z = 1 \quad \cdots\cdots\cdots (1)$$

$$-2x - 4y + 2z = -2 \quad \cdots\cdots\cdots (2)$$

$$z = 2 \quad \cdots\cdots\cdots (3)$$

What are the values of x, y, z?

a. $x = 0, y = 0, z = 2$

b. $z = 2$ and infinitely possible x, y

c. $z = 2$ and no possible x, y

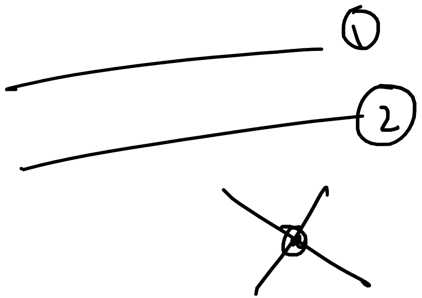
d. None of the above

$x + 2y = 3.$ —— 1

$-2x - 4y = -6.$

$x + 2y = 3.$ —— 2

$-2(x + 2y) = -2 \times 3.$



What are the eigen values of the matrix A?

$$A = \begin{bmatrix} 5 & 4 \\ -3 & -2 \end{bmatrix}$$

a. $4, -3$

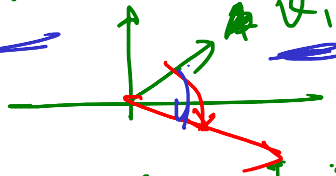
b. $5, -2$

c. $-2, -1$

d. $2, 1$

① $AX = \lambda X$.

Rotation.

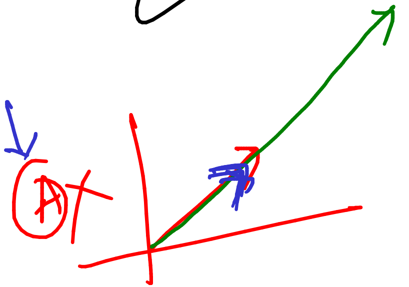


$v = \begin{bmatrix} 4 \\ 3 \end{bmatrix}$,

$$\det|A - \lambda I| = 0.$$

$\lambda > 1$

$$\begin{vmatrix} 5-\lambda & 4 \\ -3 & -2-\lambda \end{vmatrix} = 0.$$



$\lambda < 1$

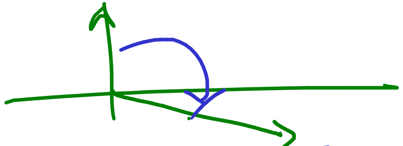
PCA

$$(5-\lambda)(-2-\lambda) + 12 = 0.$$

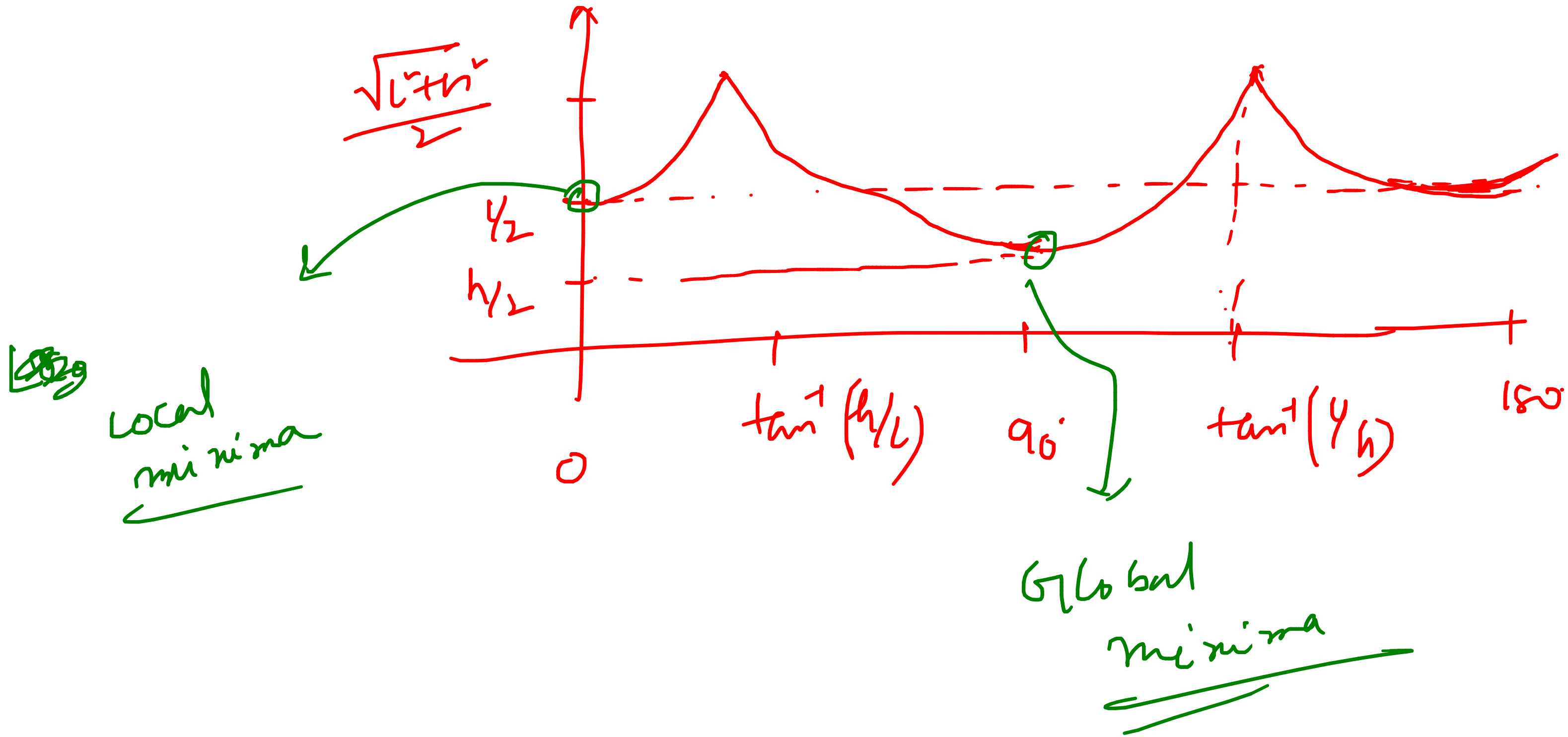
$$\Rightarrow \lambda^2 - 3\lambda + 2 = 0.$$

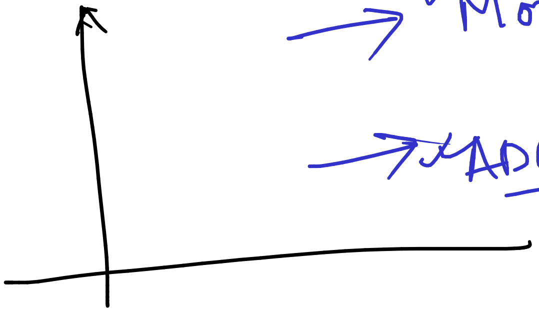
$$\lambda = 2, 1$$

$A = \begin{bmatrix} 5 & 4 \\ -3 & -2 \end{bmatrix}$.



$\begin{bmatrix} \cos\theta & 0 \\ 0 & \sin\theta \end{bmatrix}$


$\frac{\sqrt{l^2+h^2}}{2}$
$l/2$
$h/2$
0
$\tan^{-1}(h/l)$
90°
$\tan^{-1}(l/h)$
180
Local minima
Global minima



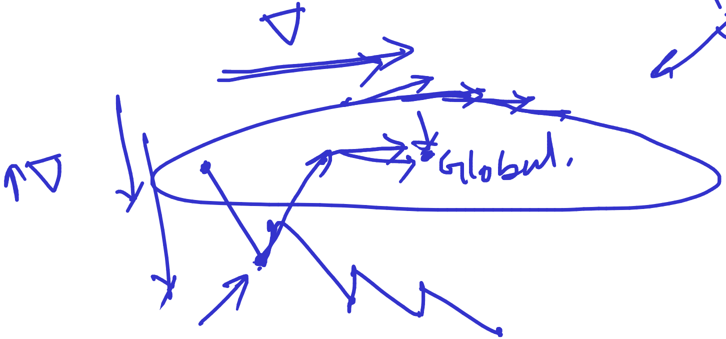
Momentum optimizer

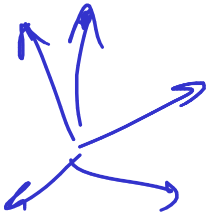
ADGRAD.

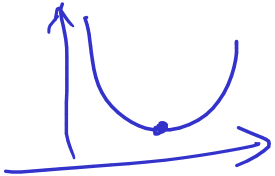
Local minima

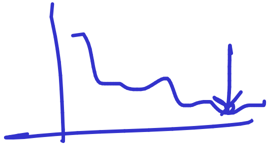
Global

10M

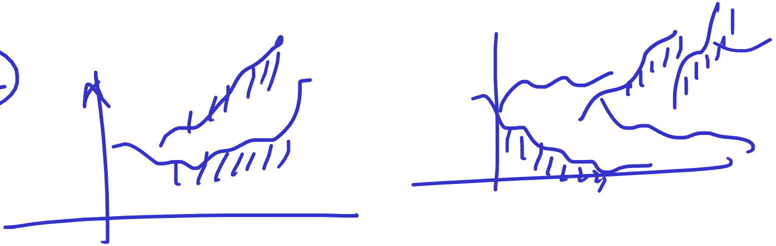




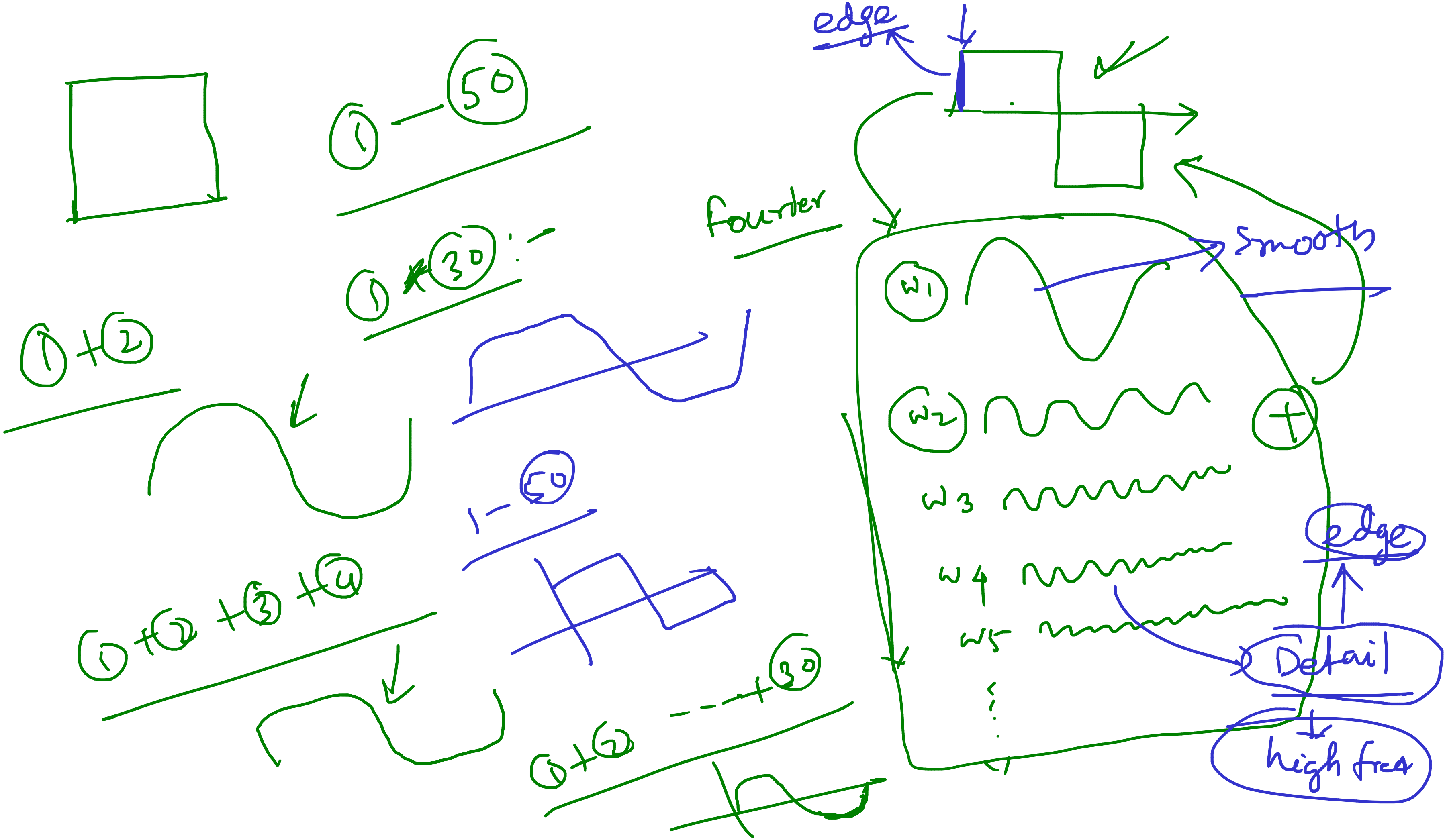




②



ICLR, CVPR


edge
1 — 50
1 + 30 : —
fourier
1 + 2
1 — 50
1 + 2 + 3 + 4
1 + 2 - - - + 30
w1
w2
w3
w4
w5
smooth
+
edge
Detail
high freq

specifying the displacement vector d = (dx, dy). Let the position operator be specified as (1, 1), which has the interpretation: one pixel to the right and one pixel below.

5 x 5 = 25

2	1	2	0	1
0	2	1	1	2
0	1	2	2	0
1	2	2	0	1
2	0	1	0	1

PATCH

(0, 1, 2)

GLCM :→

$A_{\langle 1, \theta \rangle}^{(i,j)}$

Distance

orientation of pixel

0 - 255.

256 x 256

5x5

224 x 224.

Max(GLCM)

→ Normalizing factor

$A_{(1,1)}(i,j)$

3x3

GLCM

$$\begin{array}{c|ccc} & 0 & 1 & 2 \\ \hline 0 & 0 & 0 & 1 \\ 1 & 0 & 1 & 1 \\ 2 & 0 & 1 & 2 \end{array}$$

$A_{(1,1)}(1,1) =$

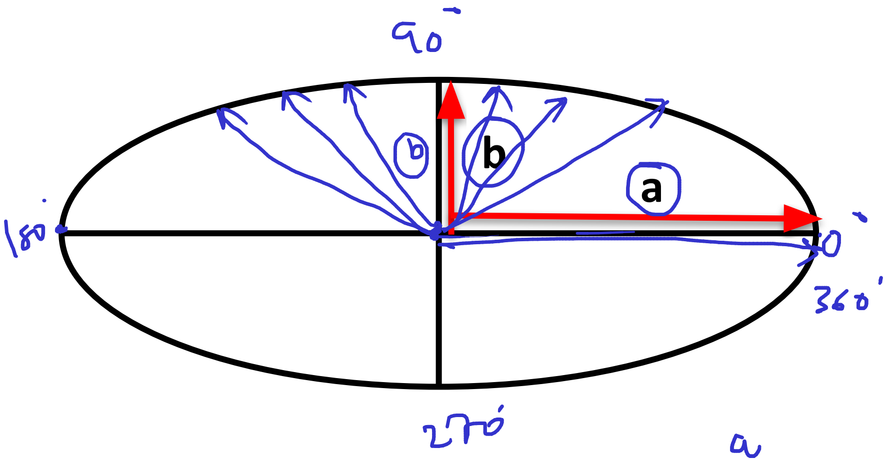
$A_{(1,1)}(0,0)$

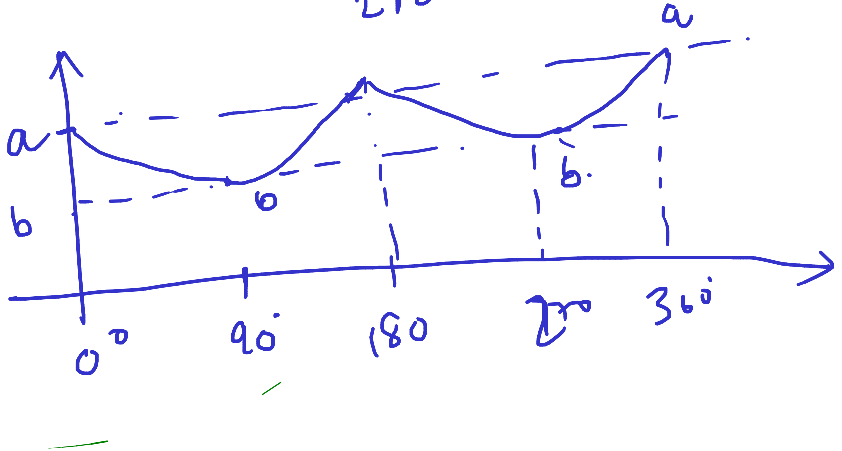
$A_{(1,1)}(2,2) = 1 + 1 = 2$

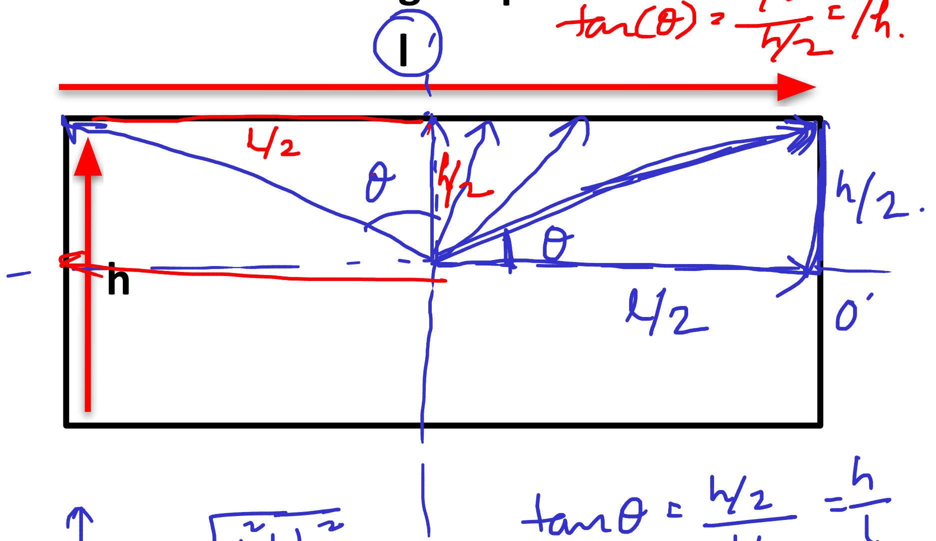
$\frac{2}{6}$

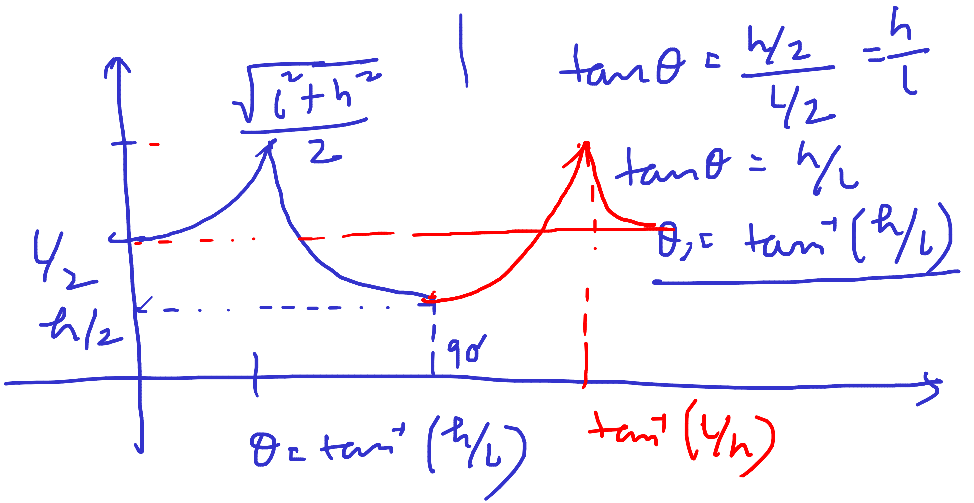
max(cii) $= \frac{2}{25}$

Draw the signature based boundary descriptors of of the following shapes









which of following is strictly true for a two-class problem Bayes minimum error classifier?

(The two different classes are ω_1 and ω_2, and input feature vector is x)

~~a.~~ Choose ω_1 if $P(x/\omega_1) > P(x/\omega_2)$

~~b.~~ Choose $\omega 1$ if $P(\omega_1)>P(\omega_2)$

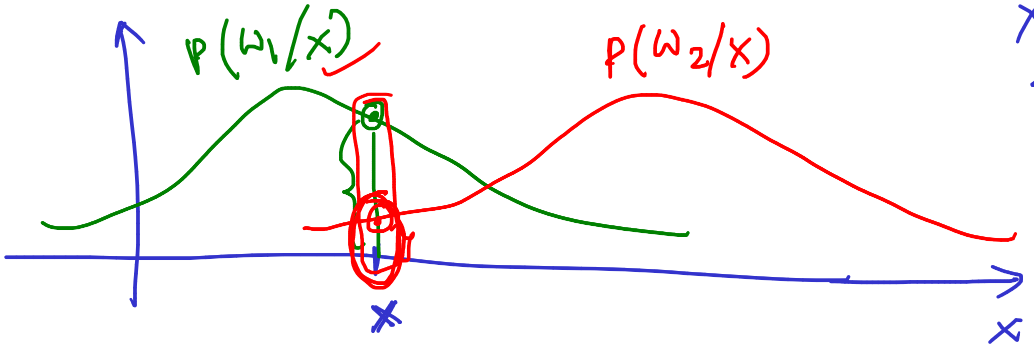
~~c.~~ Choose $\omega 2$ if $P(\omega_1/x)>P(\omega_2/x)$

d. Choose $\omega 1$ if $P(\omega_1/x)>P(\omega_2/x)$

$x \in \omega_1$:-

① $P(\omega_1/x) > P(\omega_2/x)$

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



Total prob $= P(\omega_1/x) + P(\omega_2/x)$
$= 1.$

$x \in \omega_1$ as $P(\omega_1/x) > P(\omega_2/x)$.

E. Correct prob. for $\in \omega_1 = P(\omega_1/x)$

Error = Total − Correct
$= 1 - P(\omega_1/x)$
$= P(\omega_2/x)$

Consider two class Bayes' Minimum Risk Classifier. Probability of classes W1 and W2 are, P (ω_1) =0.2 and P (ω_2) =0.8 respectively. P (x| ω_1) = 0.75, P (x| ω_2) = 0.5 and the loss matrix values are

$$\begin{bmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \end{bmatrix}$$

If the classifier assigns x to class W1, then which one of the following is true for all values of λ_{ij}.

a. $\frac{\lambda_{21}-\lambda_{11}}{\lambda_{12}-\lambda_{22}} < 2.67$

b. $\frac{\lambda_{21}-\lambda_{11}}{\lambda_{12}-\lambda_{22}} > 1.5$

c. $\frac{\lambda_{21}-\lambda_{11}}{\lambda_{12}-\lambda_{22}} < 1.5$

d. $\frac{\lambda_{21}-\lambda_{11}}{\lambda_{12}-\lambda_{22}} > 2.67$

$x \in \omega_1$: $R(\alpha_1|x) < R(\alpha_2|x)$

$$\Rightarrow \frac{P(\omega_1/x)}{P(\omega_2/x)} > \frac{\lambda_{12}-\lambda_{22}}{\lambda_{21}-\lambda_{11}}$$

$$\Rightarrow \frac{P(\omega_1).P(x|\omega_1)}{P(\omega_2).P(x|\omega_2)} > \frac{\lambda_{12}-\lambda_{22}}{\lambda_{21}-\lambda_{11}}$$

$$\frac{0.2 \times 0.75}{0.8 \times 0.5} = 0.375.$$

$$0.375 > \frac{\lambda_{12}-\lambda_{22}}{\lambda_{21}-\lambda_{11}}$$

$$\frac{\lambda_{21}-\lambda_{11}}{\lambda_{12}-\lambda_{22}} > \frac{1}{0.375}$$

Local Binary Patterns

10>7

10	12	9
6	7	19
7	10	16

3x3

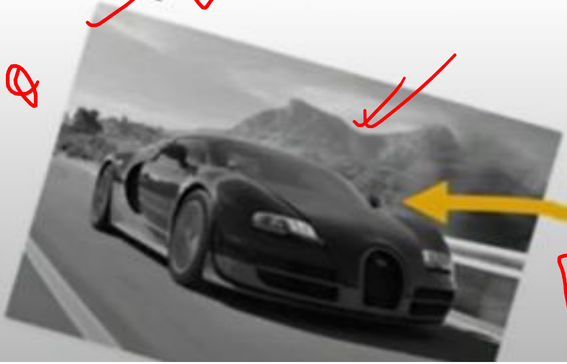
8bit binary pattern

1	1	1	1	1	1	1	0

$P_0=254$

$$b_k = \begin{cases} 1 & if\ g_k \geq g(\mathbf{x}) \\ 0 & otherwise \end{cases}$$

7=7



6	10	12
7	7	9
10	16	19

0	1	1	1	1	1	1	1

$P_7=127$

Credit: Deep Learning For Visual Computing - IITKGP

Local Binary Patterns

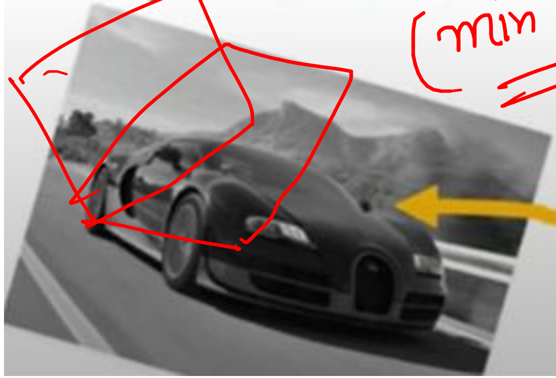
10	12	9
6	7	19
7	10	16

8 bits

	1	1	1	1	1	1	1	0	$P_0=254$
1	1	1	1	1	1	1	0	1	$P_1=253$
2	1	1	1	1	1	0	1	1	$P_2=251$
3	1	1	1	1	0	1	1	1	$P_3=247$
4	1	1	1	0	1	1	1	1	$P_4=239$
5	1	1	0	1	1	1	1	1	$P_5=223$
6	1	0	1	1	1	1	1	1	$P_6=191$
7	0	1	1	1	1	1	1	1	$P_7=127$

$$b_k = \begin{cases} 1 & \text{if } g_k \geq g(\mathbf{x}) \\ 0 & \text{otherwise} \end{cases}$$

$(\min\{P_i\})$



6	10	12
7	7	9
10	16	19

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