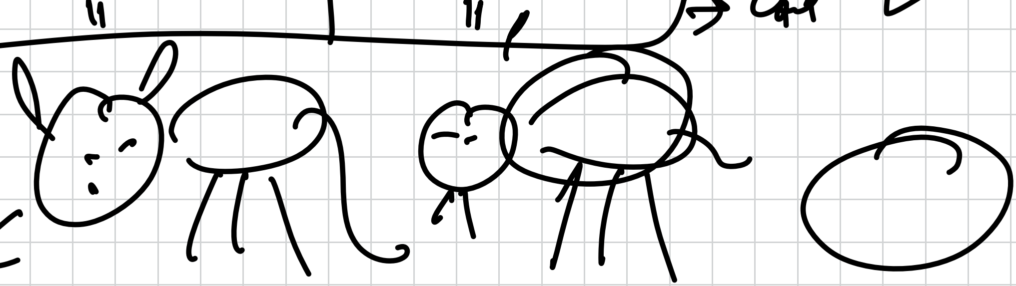
Cat	Dog
1	1
2	2
3	3
4	⋮
⋮	
10	10
11	11

Train

X

→ Cat ✓



features

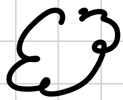
"pattern"

image

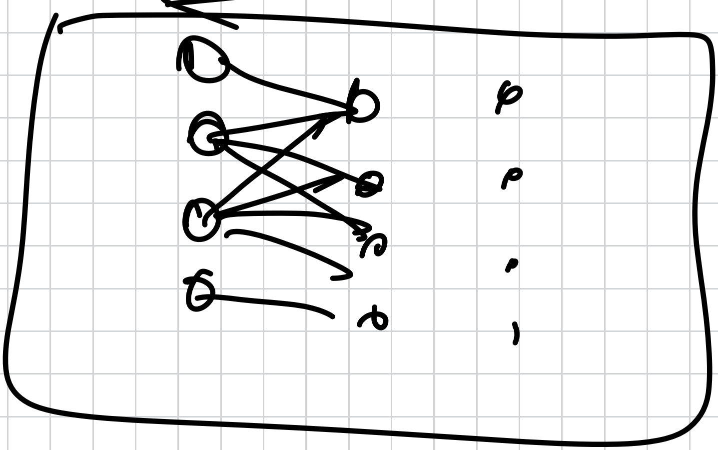
Color

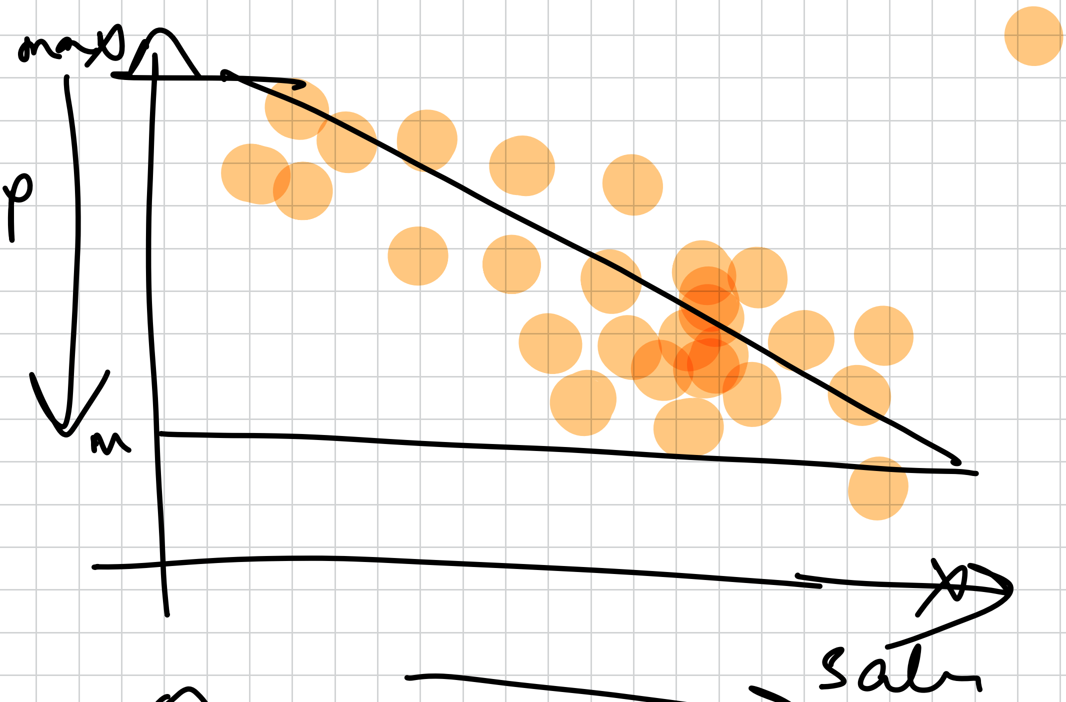
ML } → LR
LR
SVM
RF
Boost ←
DT
⋮

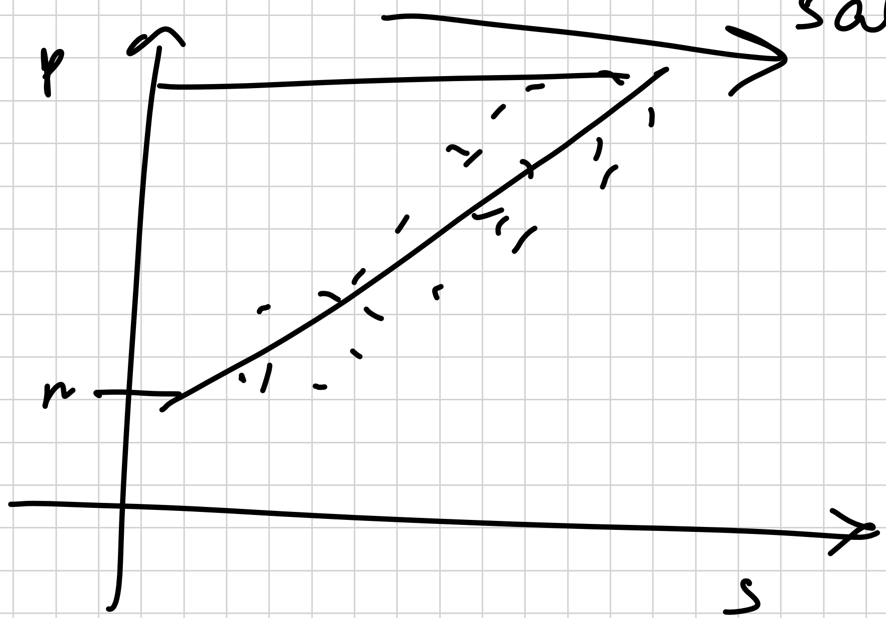
DL : NN → Neuron → Perceptron

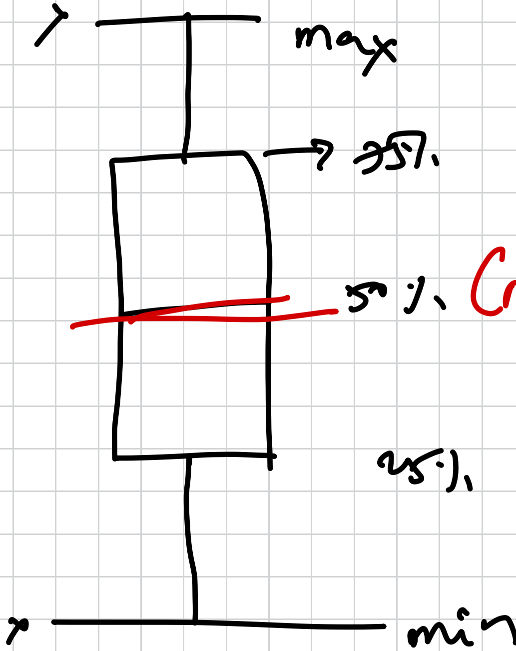


ANN




max
p
m
salary


p
m
s



1, 2, 3, 4, 5

1, 2, $\boxed{3, 4}$, 5, 6

$\frac{3+4}{2} = 3.5$

1, 2, 3, 4, 5, 6, 7, 8, 9, ~~10~~ 200B

50k 60k 70k 80k 40 50 60 90 1cr

sum ( )

60k

20B

Avg

$\frac{20B}{10}$

40, 50, 50, 60, 60, 70, 80, 90, 100, 200B

Median:

$\frac{60+70}{2} = 65k$

Data: Table (DB, Excel) → PA

2-m

: Image (Video) → CV

2 (++)

: Text → NLP

2-2.

4-5m

DS ML

60-70% → 30-40

Gen AI

(SLR?

m LLM ?)

70-80

20-30

FTC

Man NLP NN Tran

GPT

> [illegible] ✓

> [illegible]

> RL

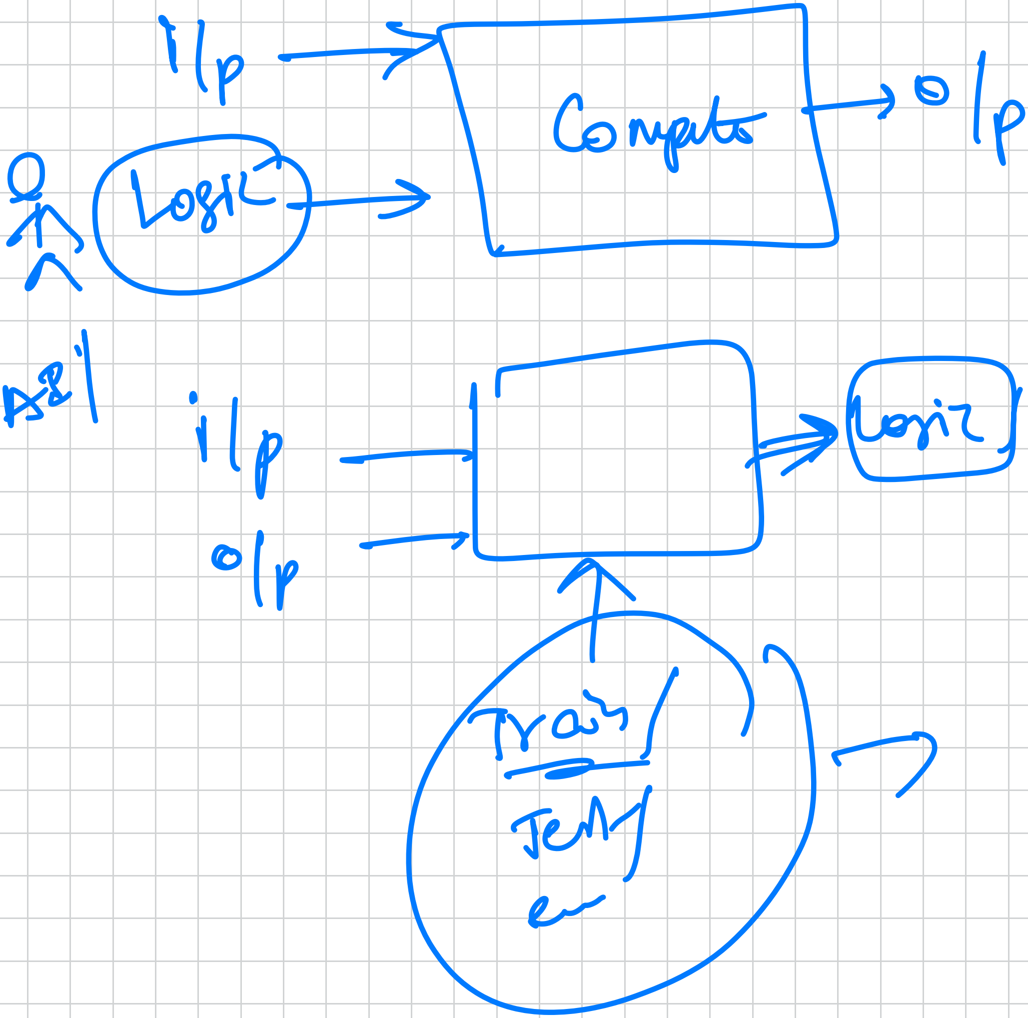
> [illegible]

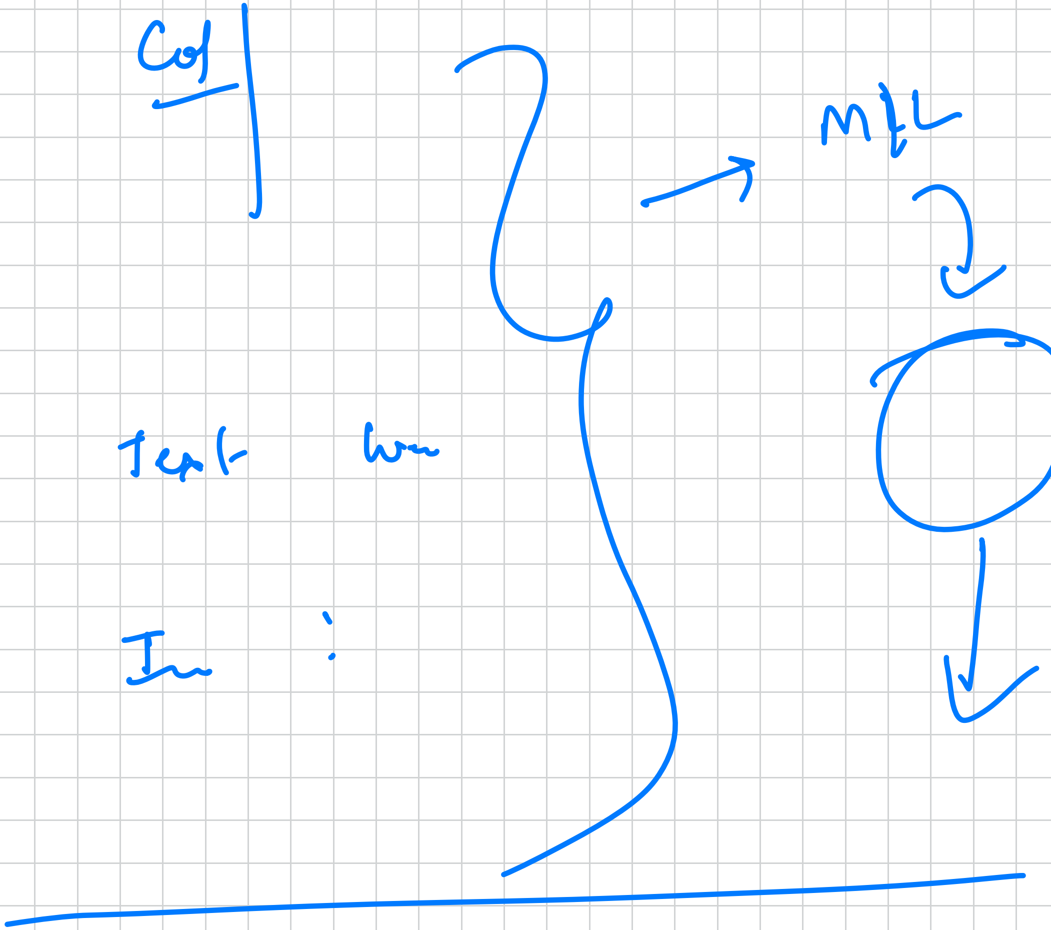
S/w E (Gen AI)

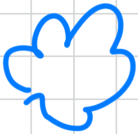
DS (Gen AI)

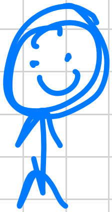
MLE (Gen AI)

I/p ⇒









Dog

Cat

10

Train

1 → Black
2 → Brown
3 → White
4 → Pink

10

1 Brn
2 B
3 Wt
4
5

10

Eyes, ears, body, size, legs, teeth,

Test

11

2021

3.5

Generative AI

Text

CPU x

GPU

Nvidia

AMD Radeon

T40

A100

H100

100+

Chat-3.5

4.0

4.mo

G

model (LLM)

LR

LR

RF

SVM

Bn

DT

ML

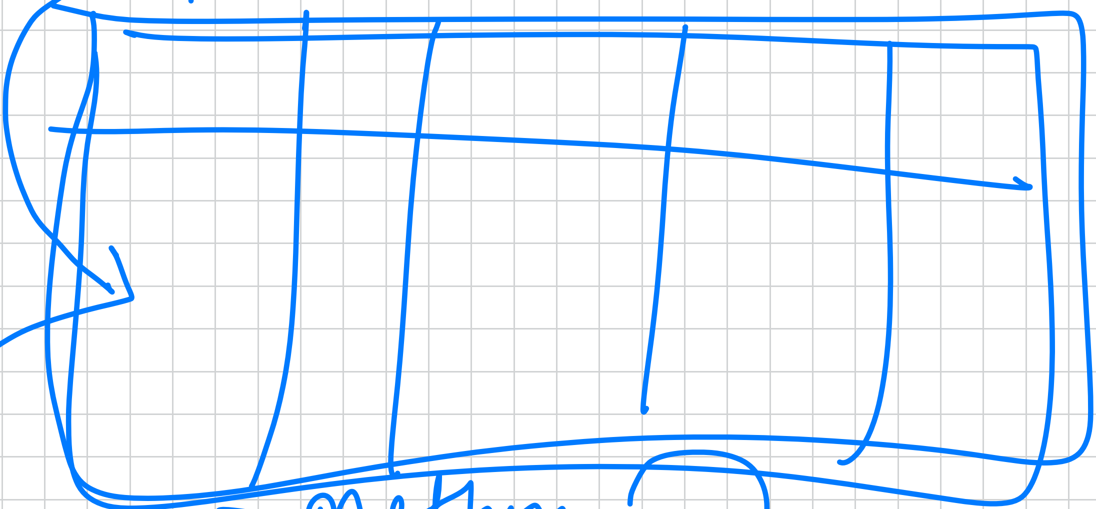
GPT → Generat pre Train

> Text → NLP

> Images (Videos) → CV

> ~~Speech (Text)~~

> tabular C



> mathm

> Statistics

> ML/AI

> Deploy

ML Engineer = DS + SE

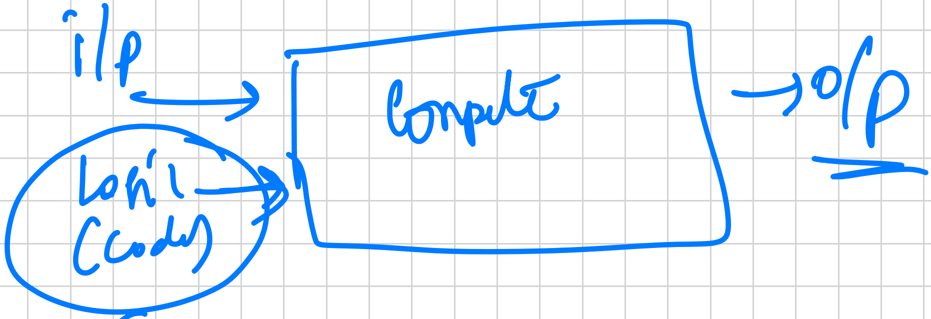
GenAI

python

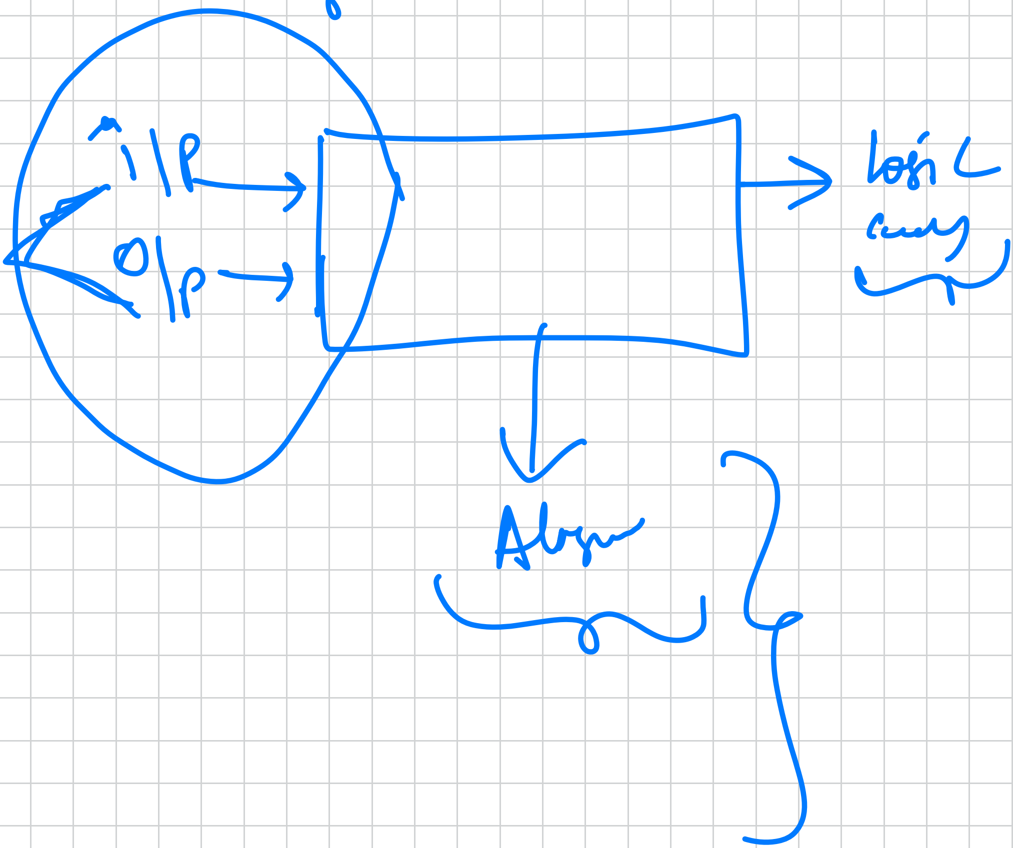
NLP

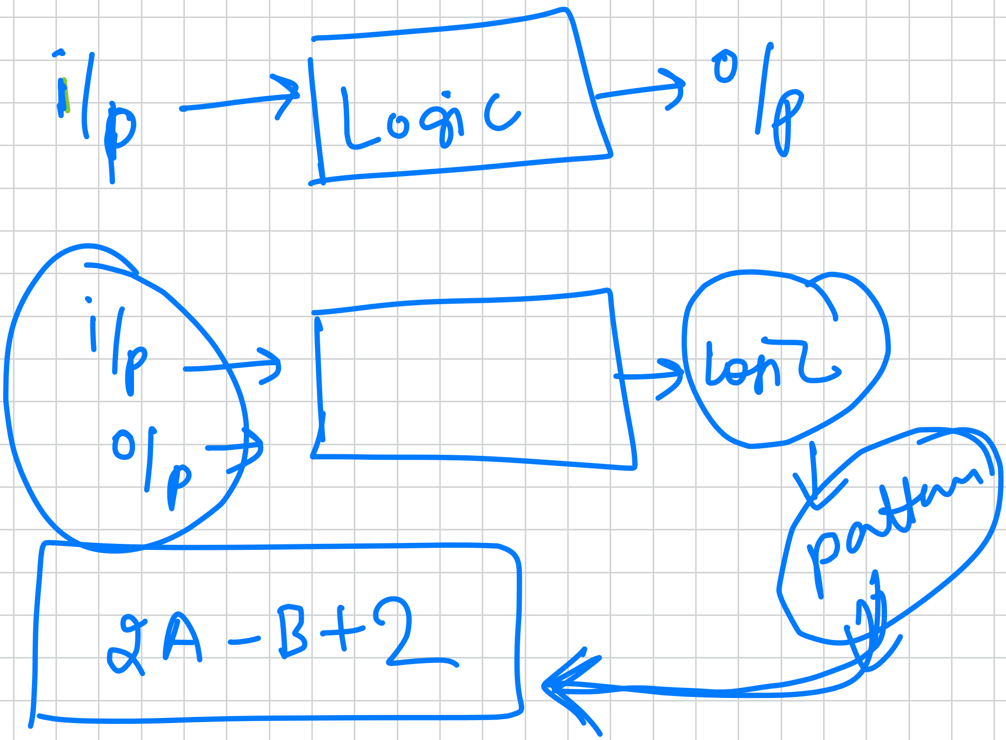
NN

Transfor



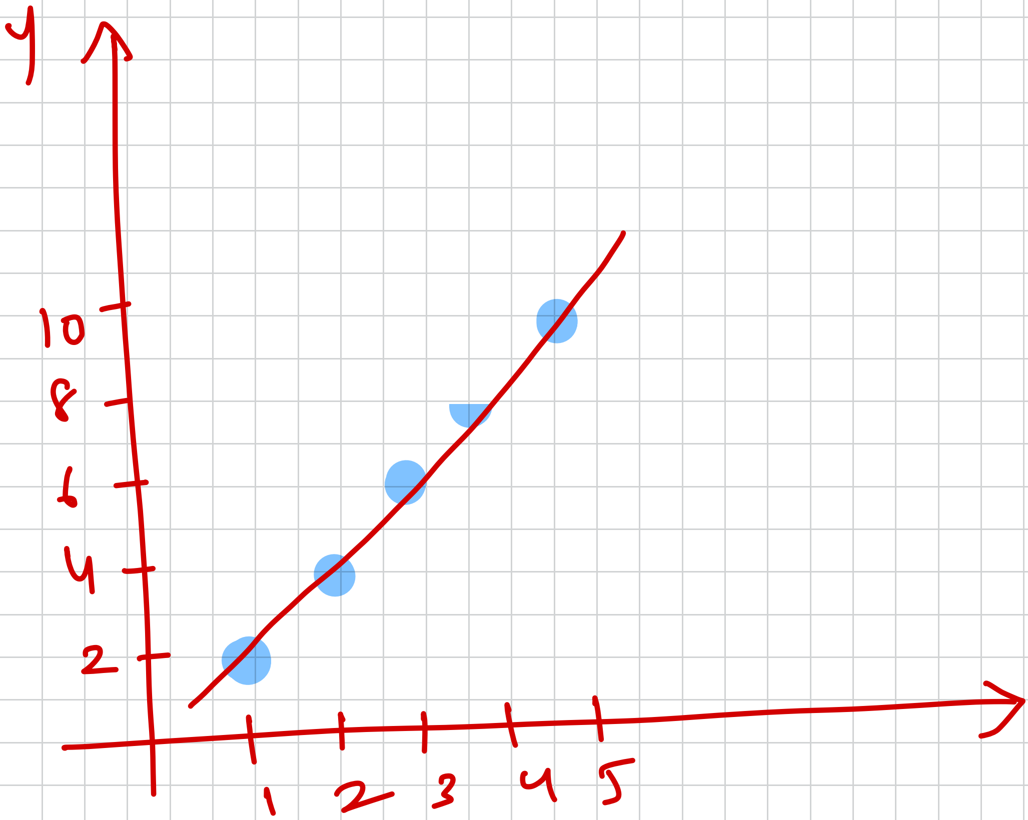
$$\Rightarrow (2\underset{\substack{\uparrow\\5}}{a}+\underset{\substack{\uparrow\\6}}{b}-c)*5 = x$$

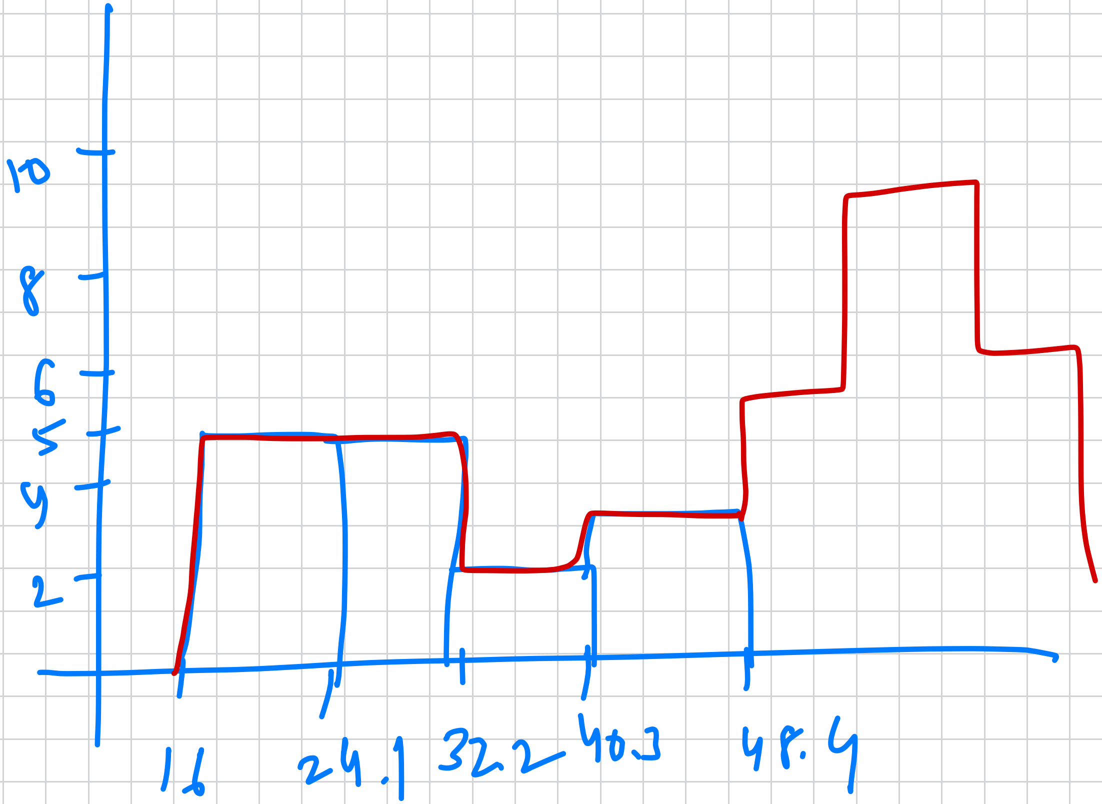




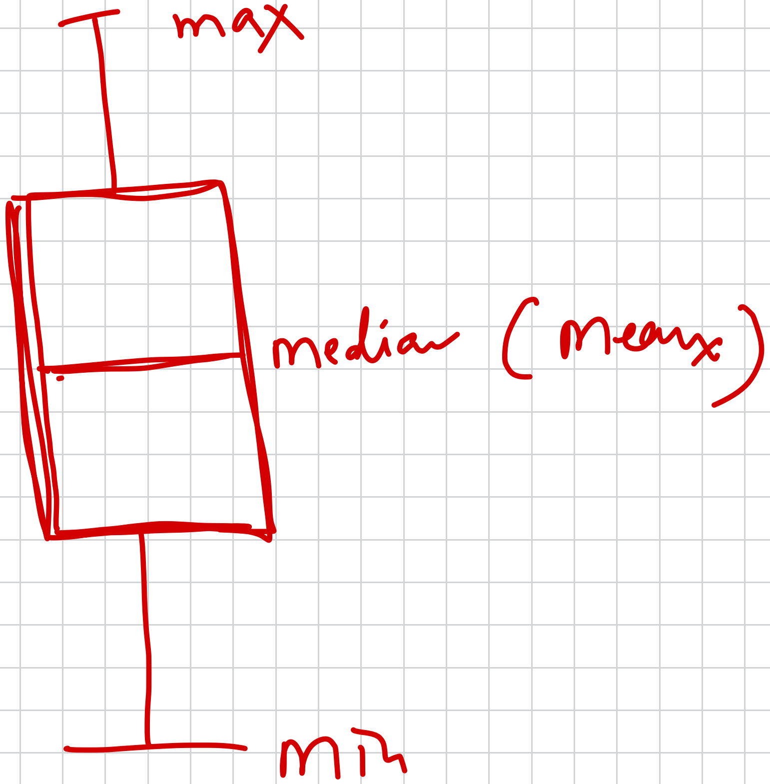
Algori

Rep

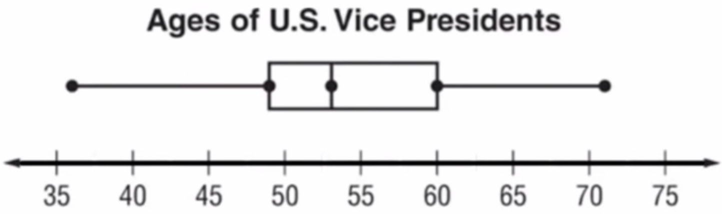

y
10
8
6
4
2
1
2
3
4
5



10
8
6
5
4
2
16
24.1
32.2
40.3
48.4


max
median (mean)
min

Let's analyze the data in the box plot...



1) What is the median age?

2) T or F: More presidents were between ages 53-60 than 49-53.

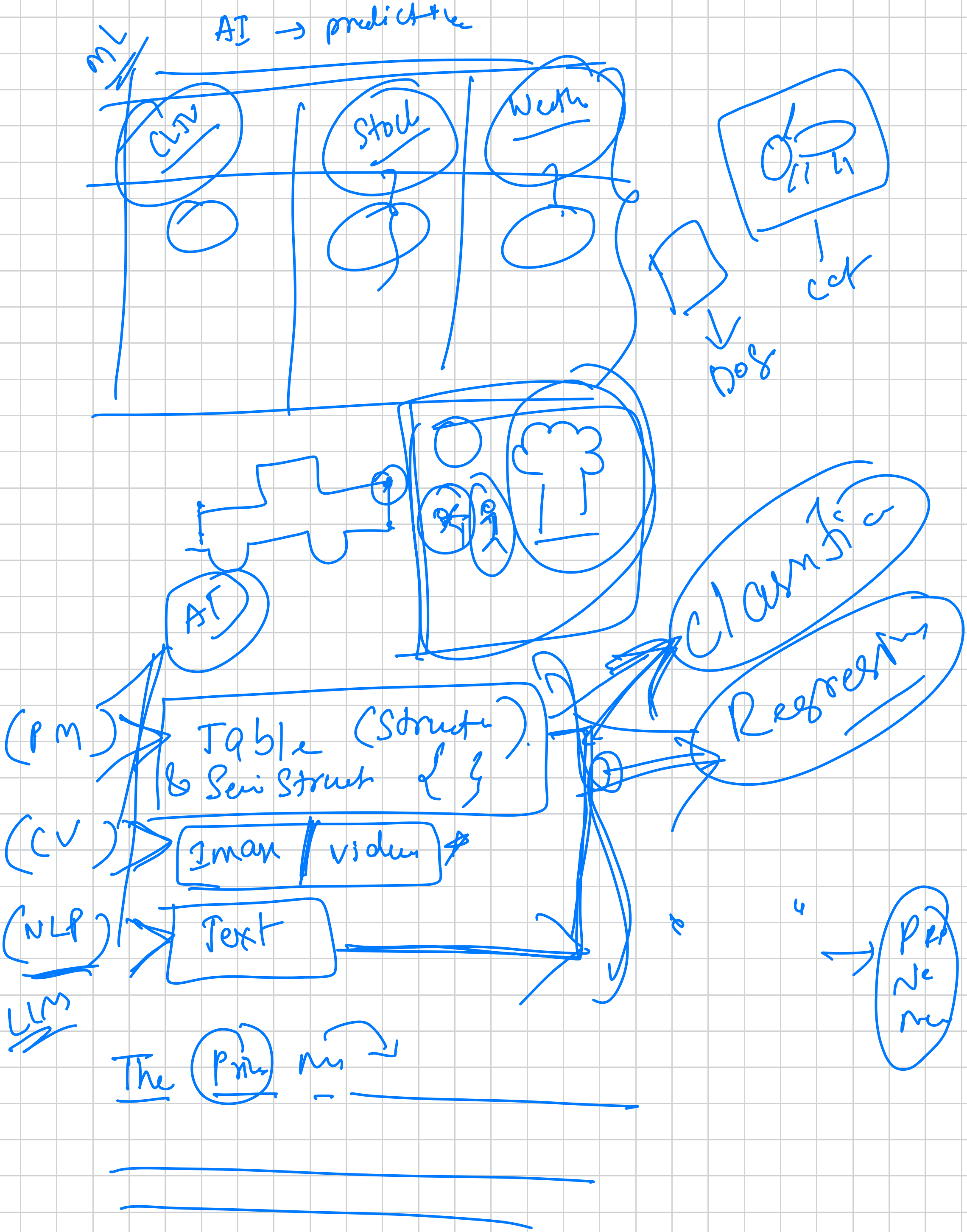
3) What is the difference between the range and the IQR?

4) What percent of the vice presidents were at least 60 years old?

5) Can you determine if any vice presidents took office at age 55?

6) What percent were between 49 and 60 when they took office?

7) T or F: Half of the vice presidents were between the ages of 36-49 and 60-70.



AI → predictive
ML
CLN
Stock
Weath
Dog
cat
AI
(PM)
Table (Structure)
& Semi Struct { }
(CV)
Image / video
(NLP)
Text
LLM
Classific
Regression
The Prin

Statistics ①

Data Analyst

ML ②

NLP

DL ③

NN

Generative AI ④

2.5 m — 3

1 year

NLP

GPU

8

RL

CNN

LLMS

2 —

[5.62 58.- . . . .]

2000 t

(H100)

2000 cr

+ CE

Dog

Cat

DL

eye

4

6

Tr

Sh

M

t

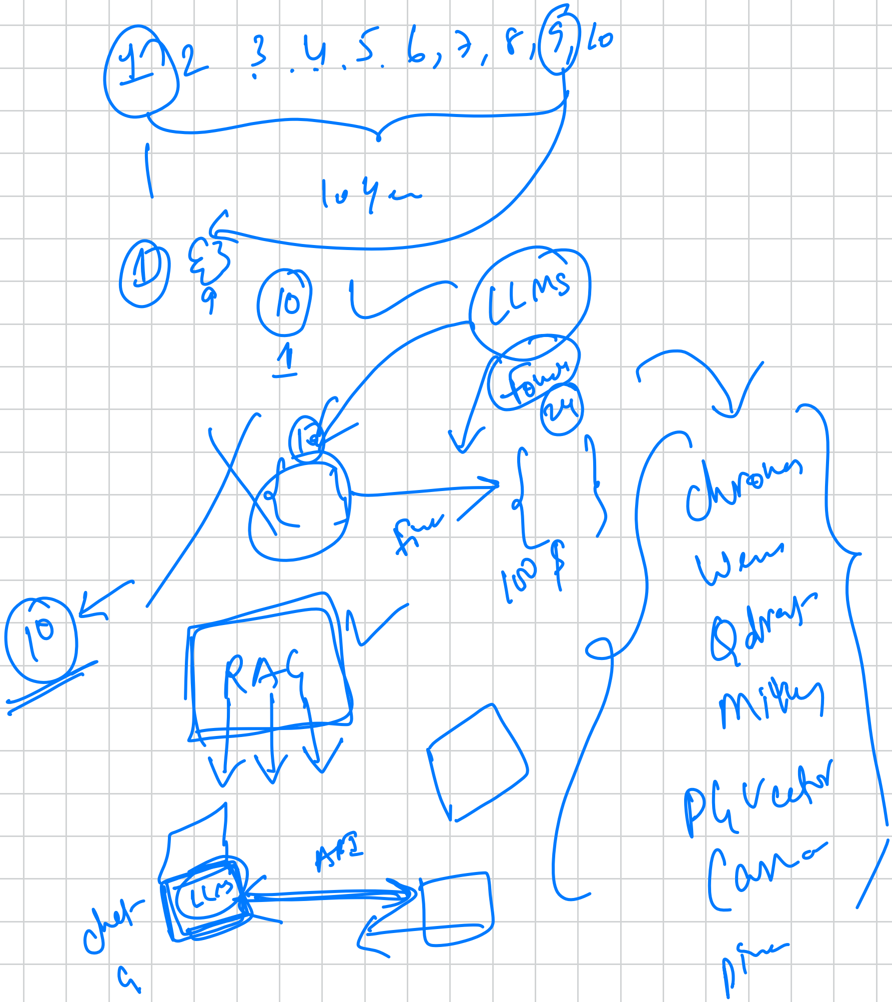
10

8

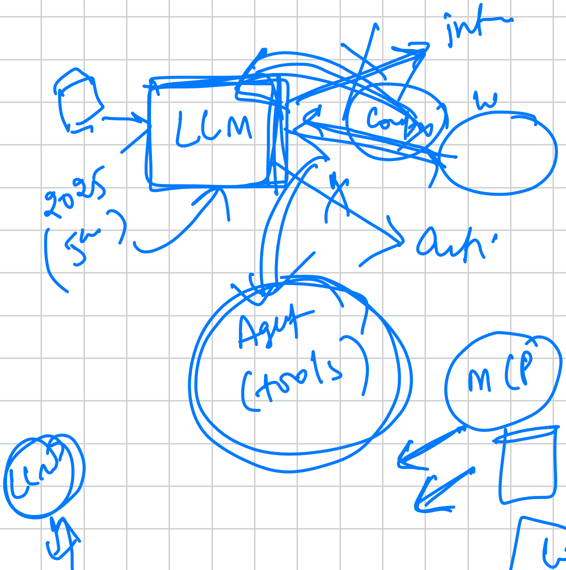
11

100%

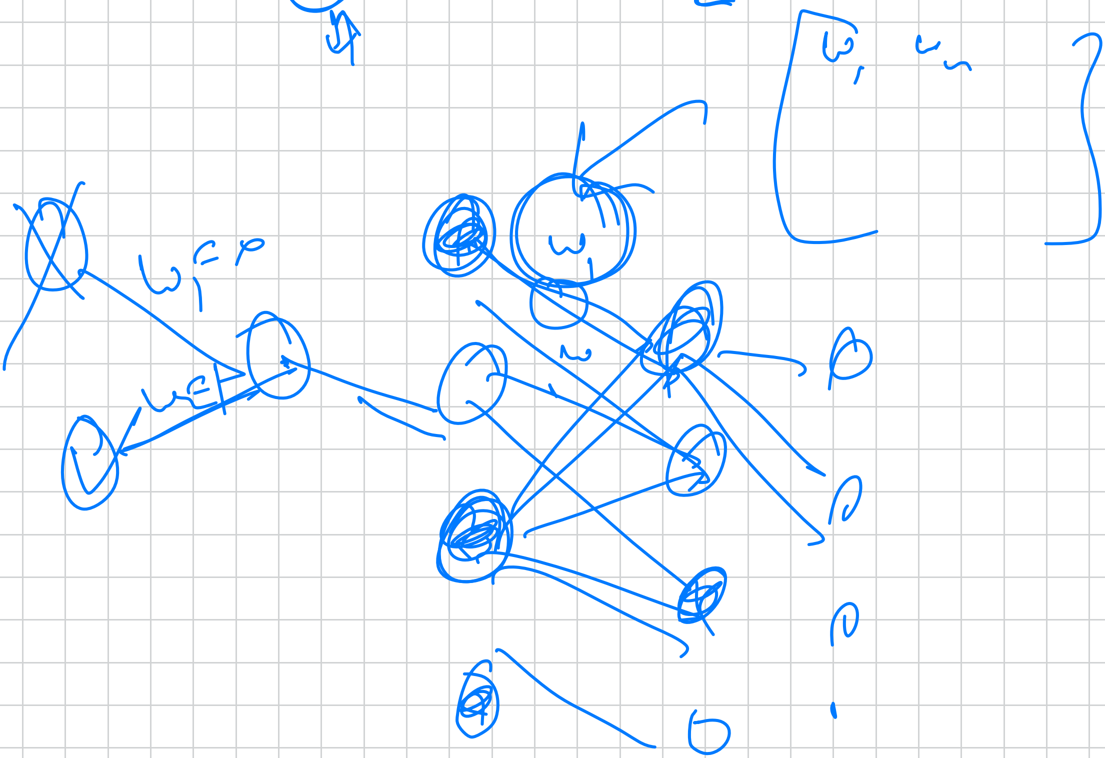
80%



1 2 3 . 4 . 5 . 6, 7, 8, 9, 10
LLMS
10
10
RAG
100 $
API
LLMS
chroma
Qdrant
Milvus
PG vector



LLM
2025
MCP
LLM



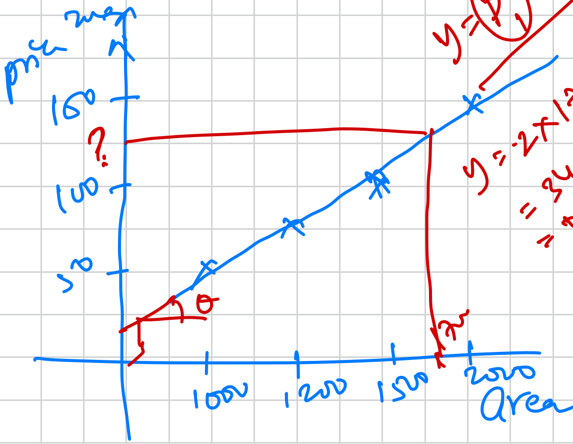
area	price
1000	50k
1500	100k
1200	80k
2000	150k

$y = \beta_0 + \beta_1 ar + \beta_2 n$

$+ \beta_3 (\ )$

$y = mx + c$

$y = \beta \, area + \beta_0$



$y = 2 \times 1700 + 3$

$= 3400 + 3$

$= 3403$

$[\beta_0, \beta_1, \beta_2 \ldots]$

numpy

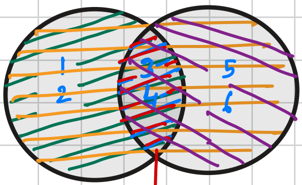
$[1, 2.5, 3.6 \ldots]$

$$\begin{bmatrix} 1, & 2, & 3, & 4 \\ 5, & 6, & 7, & 8 \end{bmatrix}_{m \times n}$$

$$\underline{\underline{2 \times 4}}$$

inner

Leftside



{3, 4}

Inner:

ID	Name	Age
3	✓	✓
4	✓	✓

Right:

ID	Name	Age
3	✓	✓
4	✓	✓
5	✗	✓
6	✗	✓

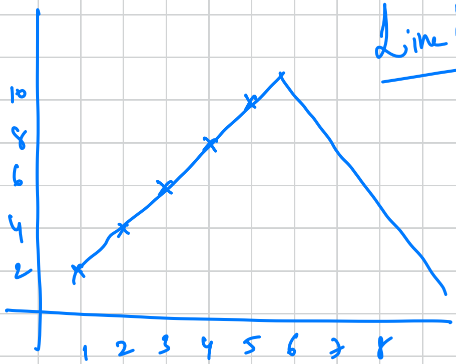
Left

ID	Name	Age
1	✓	✗
2	✓	✗
3	✓	✓
4	✓	✓

Outer:

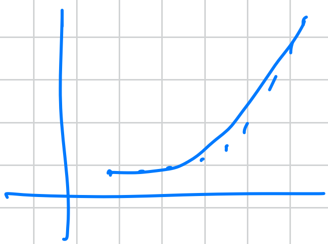
ID	Name	Age
1	✓	✗
2	✓	✗
3	✓	✓
4	✓	✓
5	✗	✓
6	✗	✓

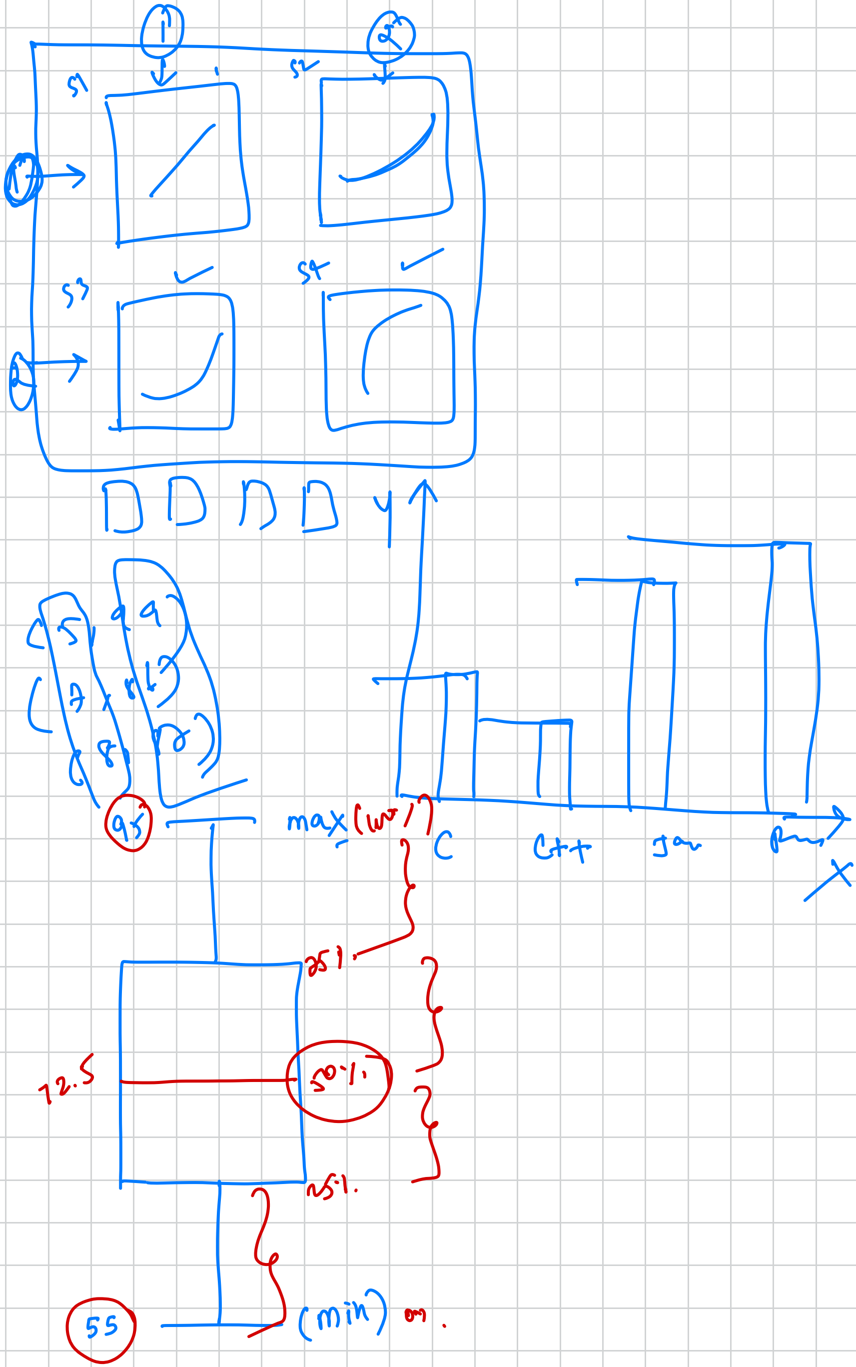
Line plot



(1, 2)
(2, 4)
(3, 6)
(4, 8)
(5, 10)
(6, 8)
(7, 2)

[1, 2, 3, 4, 5]
[1, 8, 27, 64, 125]




s1
s2
s3
s4
y
x
C
C++
95
max
25%
72.5
50%
25%
55
(min)

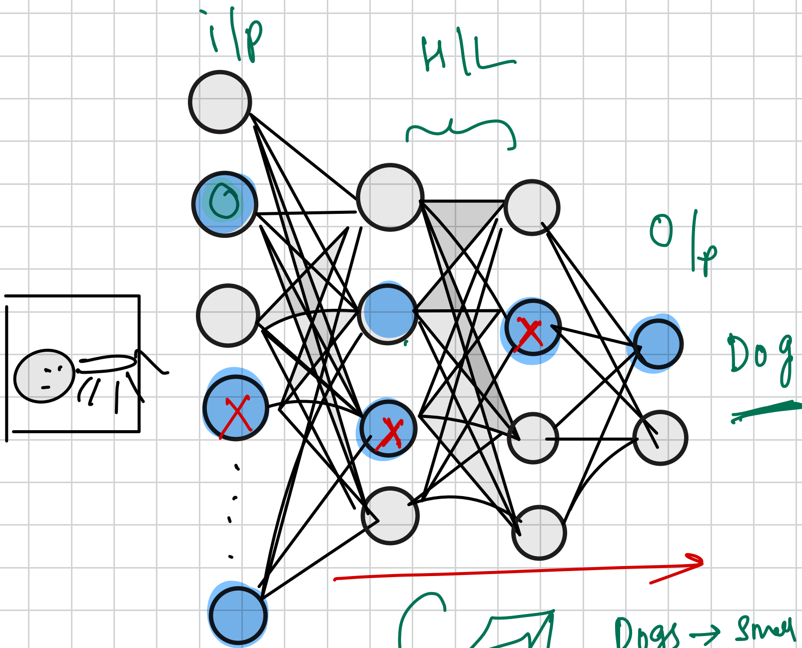
$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

$P(A)$

$P(A) = 0.3$

$P(B) = 0.5$

$P(A|B) = 0.6$



2^n

$2^6 = 256$

2^7

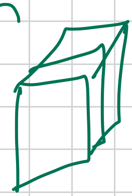
2^8

2^5

100

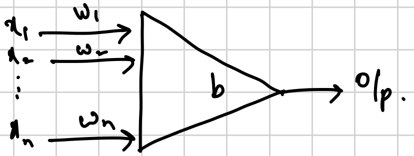
200

eyes
tail
4 leg
short ten
fur



Dogs → smell
→ moth
→ blow
→ bm
→ p~
→

$x_{1(1)}$ x_{12} x_{13}



$$w^T \cdot x = w_1 x_1 + w_2 x_2 + \dots w_k x_k$$

Cumpulative I/p = $\underline{w}^T x + b$

$$x_1 w_1 + x_2 w_2 + x_3 w_3$$

$$= 1(0.5) + \underbrace{0\,(0.3)} + 1\,(0.2)$$

$$= 0.5 + 0 + 0.2 = \underline{\underline{0.7}}$$

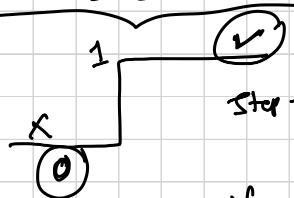
Assume $b = -0.7$

$$\underbrace{x_1 w_1 + x_2 w_2 + x_3 w_3} + b$$

$$0.7 - 0.7 = \underline{0}$$

$$0.7 - 0.6 = 0.1$$

$$\underbrace{x_1 w_1 + x_2 w_2 + x_3 w_3 + \dots x_n w_n + b} \quad \begin{matrix} > 0 \ ✓ \\ \leq 0 \ ✗ \end{matrix}$$



$y = 1$ if $x > 0$ ✓

$y = 0$ if $x \leq 0$ ✗

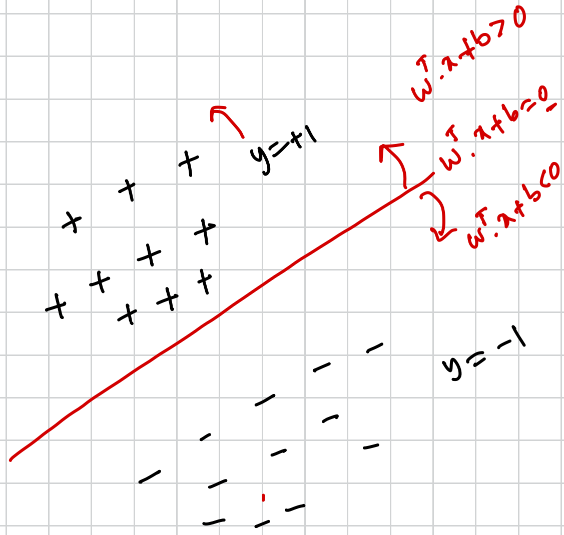
Cumulative I/p $= \underbrace{w_1 x_1 + w_2 x_2 + \dots w_k x_k} + b$

$$\underline{w} = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_k \end{bmatrix} \qquad \underline{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_k \end{bmatrix}$$

$$\underline{k \times 1} \neq \underline{k \times 1}$$

$$w^T = \begin{bmatrix} w_1 & w_2 & \dots & w_k \end{bmatrix} \qquad x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_k \end{bmatrix}$$

$$1 \times k \longleftrightarrow k \times 1$$



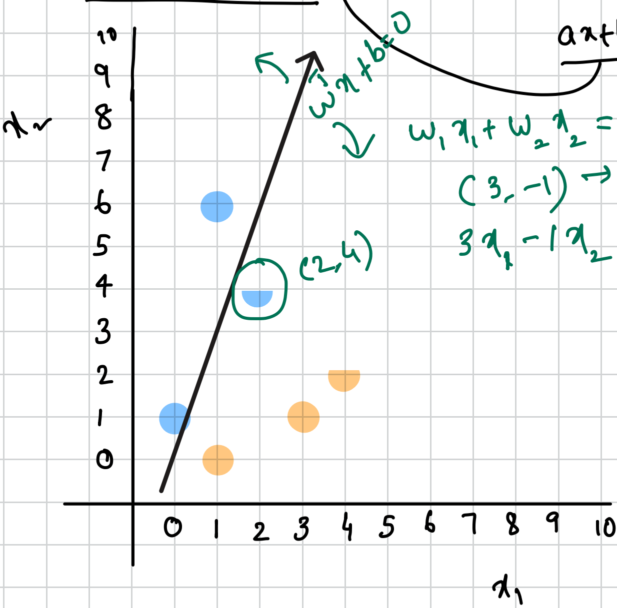
$w^T \cdot x + b = 0$

$w_1 x_1 + w_2 x_2 + \ldots b = 0$

$y = mx + c$

$mx - y + c = 0$

$ax + by + c = 0$



$w_1 x_1 + w_2 x_2 = 0$

$(3, -1) \rightarrow$

$3x_1 - 1x_2 = 0$

$$W_0 = \begin{bmatrix} 3 \\ -1 \\ 0 \end{bmatrix}$$

-1

+1

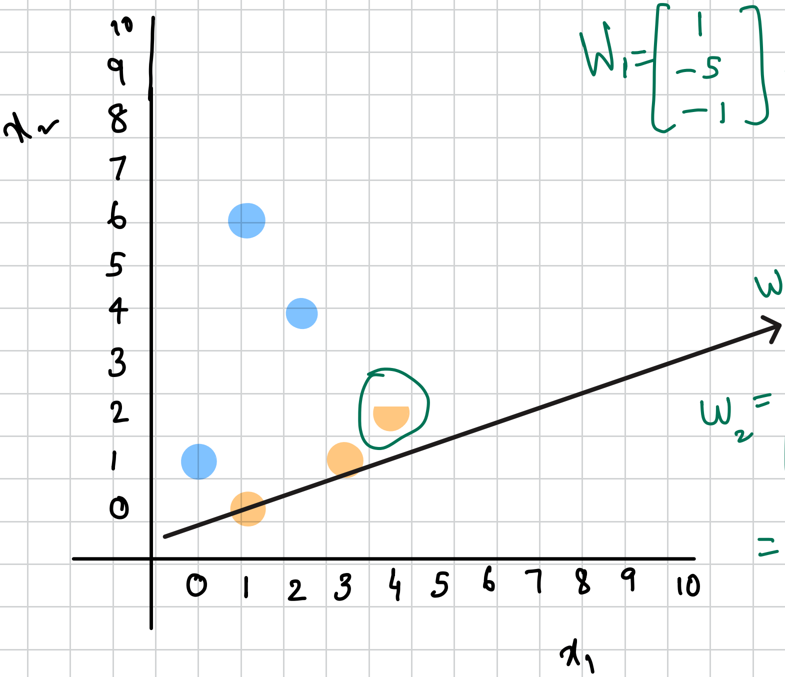
$$W_{t+1} = W_t + y_{it} \cdot x_{it}$$

$$= \begin{bmatrix} 3 \\ -1 \\ 0 \end{bmatrix} + (-1) \begin{bmatrix} 2 \\ 4 \\ 1 \end{bmatrix}$$

$$W_1 = \begin{bmatrix} 1 \\ -5 \\ -1 \end{bmatrix}$$

$W_1 = \begin{bmatrix}1\\-5\\-1\end{bmatrix} = 1x_1 - 5x_2 = -1$

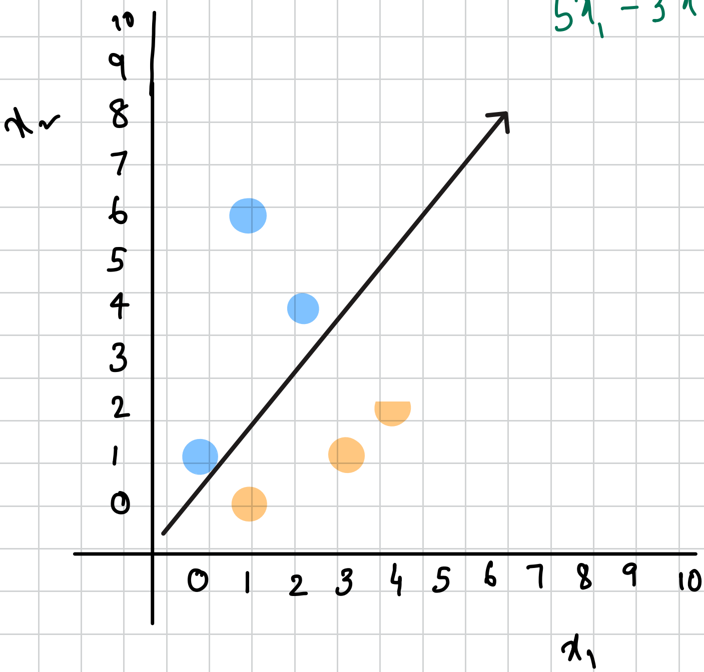
$w_2 x_1 + w_2 x_2 = 0$

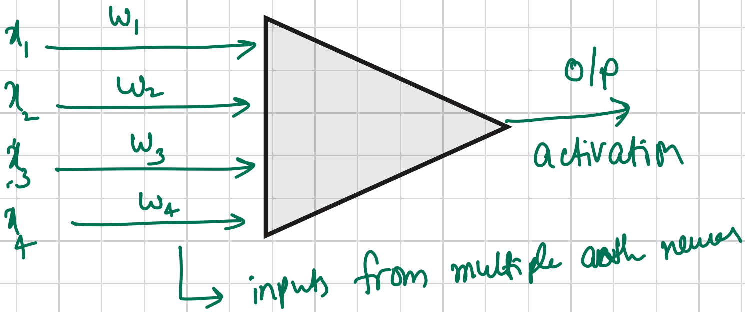


$W_2 = \begin{bmatrix}1\\-5\\-1\end{bmatrix} + (+1)\begin{bmatrix}4\\2\\1\end{bmatrix}$

$= \begin{bmatrix}5\\-3\\0\end{bmatrix}$

$5x_1 - 3x_2 = 0$





Activation fn $= f(x_1 w_1 + x_2 w_2 + x_3 w_3 + x_4 w_4)$

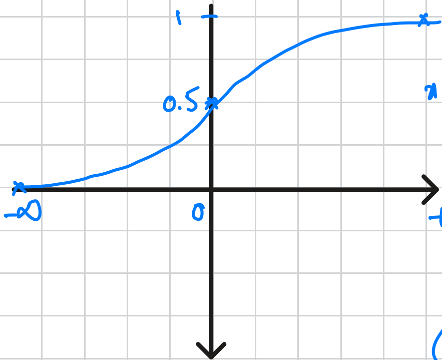
① Logistic function (Sigmoid)

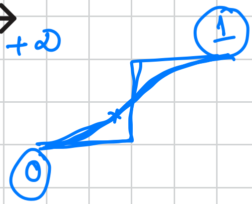
$$f(x) = \frac{1}{1+e^{-x}}$$

$x = 0 \rightarrow \frac{1}{1+e^{0}} = \frac{1}{2} = 0.5$

$x = +\infty = \frac{1}{1+e^{-\infty}} = \frac{1}{1+\frac{1}{e^{\infty}}} = 1$

$x = -\infty = \frac{1}{1+e^{\infty}} = \frac{1}{\infty} = 0$





$0 \longrightarrow 1$

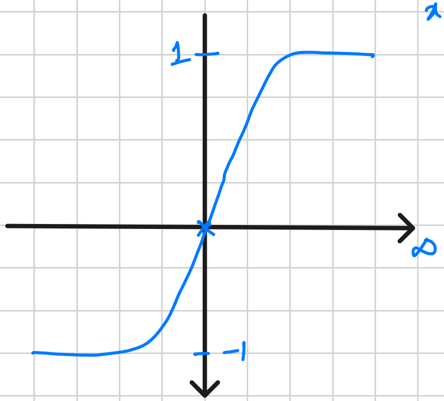
② $$\mathrm{Tanh}(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$$

$x = 0 \rightarrow \frac{1-1}{1+1} = 0$

$x = \infty \rightarrow \frac{e^{\infty} - e^{-\infty}}{e^{\infty} + e^{-\infty}}$

$= \frac{e^{\infty} - \frac{1}{e^{\infty}}}{e^{\infty} + \frac{1}{e^{\infty}}}$

$= \frac{e^{\infty}}{e^{\infty}} = 1$

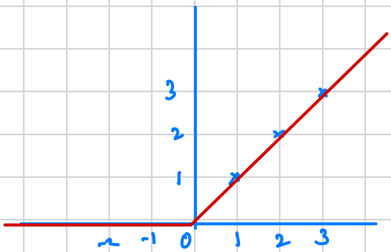


$x = -\infty \Rightarrow -1$

$[-1, 1]$

③ Rectilinear Unit (ReLU)

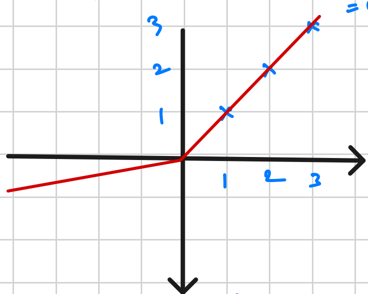
$$o/p = \underline{x} \quad \text{for } x \geq 0$$
$$= \underline{0} \quad \text{otherwise}$$



$x=1, y=1$
$x=2, y=2$
$\left.\begin{matrix} x=-1 \\ x=-2 \end{matrix}\right\} y=0$

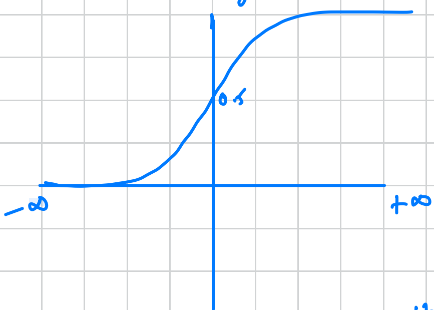
④ Leaky ReLU

$$\text{Output} = \underline{x} \quad \underline{\text{for } x \geq 0}$$
$$= \underline{\alpha x} \quad \underline{\text{othw}}$$



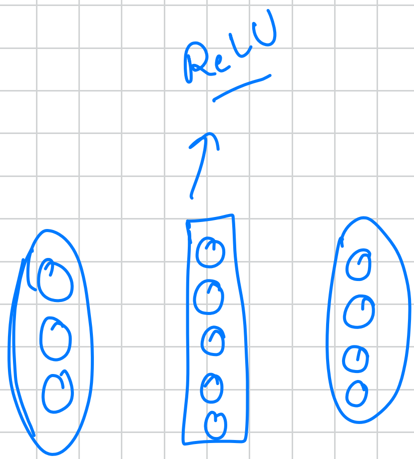
⑤ Softmax

$$\left\{ \frac{e^{x_i}}{\sum_{j=1}^{K} e^{x_j}} \right\}$$



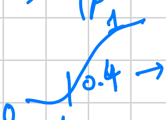
$w^T.x+b \Rightarrow w_1x_1 + w_2x_2 + \dots + b$

$f(w^T.x+b) \rightarrow$



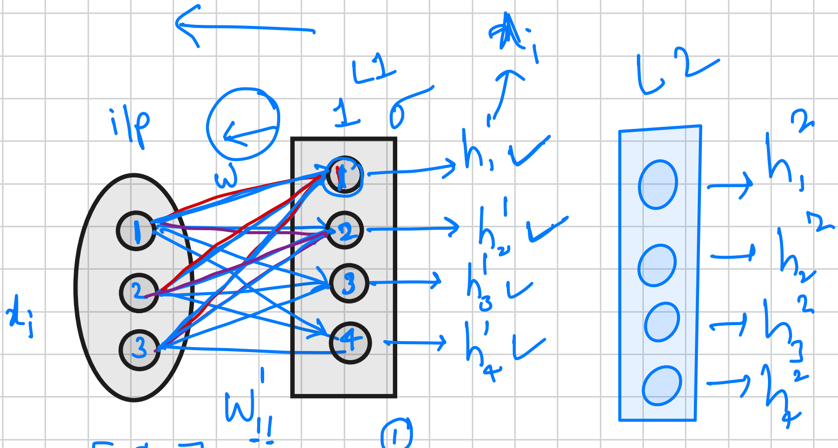
Binary classification

$\rightarrow o/p \rightarrow \underline{\text{Sigmoid}}$



Multi class class

$\rightarrow o/p \rightarrow \underline{\text{Softmax}}$



$h^{(1)}_{(1)}$

$$x_i = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}_{3\times 1} \qquad h^1 = \begin{bmatrix} h_1^1 \\ h_2^1 \\ h_3^1 \\ h_4^1 \end{bmatrix}_{4\times 1}$$

$$W^1 = \begin{bmatrix} W_{11}^1 & W_{12}^1 & W_{13}^1 \\ W_{21}^1 & W_{22}^1 & W_{23}^1 \\ W_{31}^1 & W_{32}^1 & W_{33}^1 \\ W_{41}^1 & W_{42}^1 & W_{43}^1 \end{bmatrix}_{4\times 3}, \quad b^1 = \begin{bmatrix} b_1^1 \\ b_2^1 \\ b_3^1 \\ b_4^1 \end{bmatrix}$$

$$W^1 x_i + b^1 = \begin{bmatrix} W_{11}^1 & W_{12}^1 & W_{13}^1 \\ W_{21}^1 & W_{22}^1 & W_{23}^1 \\ W_{31}^1 & W_{32}^1 & W_{33}^1 \\ W_{41}^1 & W_{42}^1 & W_{43}^1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}_3 + \begin{bmatrix} b_1^1 \\ b_2^1 \\ b_3^1 \\ b_4^1 \end{bmatrix}$$

$$W^1 x_i + b^1 = \begin{bmatrix} w^1_{11} & w^1_{12} & w^1_{13} \\ w^1_{21} & w^1_{22} & w^1_{23} \\ w^1_{31} & w^1_{32} & w^1_{33} \\ w^1_{41} & w^1_{42} & w^1_{43} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}_3 + \begin{bmatrix} b^1_1 \\ b^1_2 \\ b^1_3 \\ b^1_4 \end{bmatrix}$$

$$= \begin{bmatrix} w^1_{11} x_1 + w^1_{12} x_2 + w^1_{13} x_3 \\ w^1_{21} x_1 + w^1_{22} x_2 + w^1_{23} x_3 \\ w^1_{31} x_1 + w^1_{32} x_2 + w^1_{23} x_3 \\ w^1_{41} x_1 + w^1_{42} x_2 + w^1_{43} x_3 \end{bmatrix} + \begin{bmatrix} b^1_1 \\ b^1_2 \\ b^1_3 \\ b^1_4 \end{bmatrix}$$

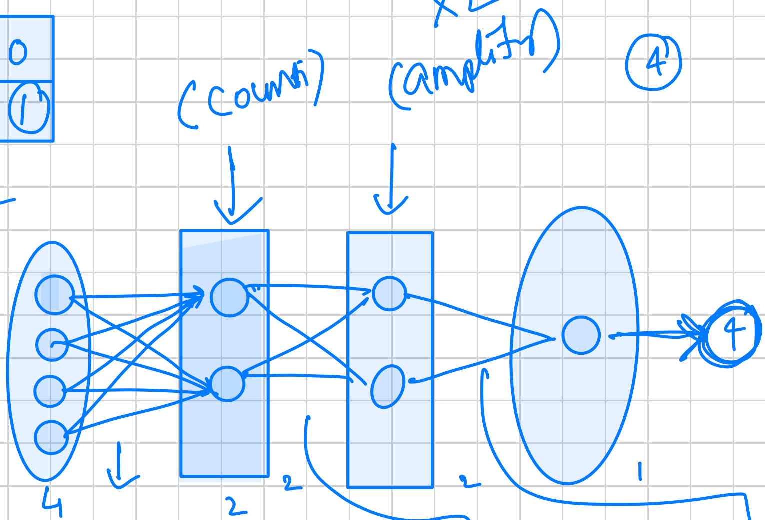
$$h^1 = \sigma(W^1 x_i + b^1) = \begin{bmatrix} \sigma(w^1_{11} x_1 + w^1_{12} x_2 + w^1_{13} x_3 + b^1_1) \\ \sigma(w^1_{21} x_1 + w^1_{22} x_2 + w^1_{23} x_3 + b^1_2) \\ \sigma(w^1_{31} x_1 + w^1_{32} x_2 + w^1_{23} x_3 + b^1_3) \\ \sigma(w^1_{41} x_1 + w^1_{42} x_2 + w^1_{43} x_3 + b^1_4) \end{bmatrix} \begin{matrix} \to h^1_1 \\ \to h^1_2 \\ \to h^1_3 \\ \to h^1_4 \end{matrix}$$

$$h^2 = \sigma(W^2 h^1 + b^2) \longrightarrow \begin{bmatrix} h^2_1 \\ h^2_2 \\ h^2_3 \\ h^2_4 \end{bmatrix}$$

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

2x2

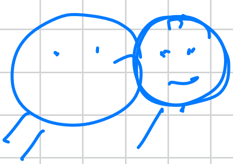
$x = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix}$



$$\underset{W}{\begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}} \underset{x}{\begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix}} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 2 \end{bmatrix} = 4$$



	x_1 area	x_2 bedrooms	y price	$\hat{y}$	error
✓	1200	2	70	80	$(-10)^2$
✓	1500	3	120	110	$(10)^2$
✓	2100	4	230	240	$(-10)^2$
✓	1100	3	105	95	$(10)^2$
✓	1300	2	90	85	$(5)^2$
✓	900	1	55	60	$(-5)^2$
					0 ✓
				50	450 ✓

price = $x_1 * w_1 + x_2 * w_2$ + bias

$$y = \sum_{i=0}^{n} w^i x^i + b$$

$|-10|$

$|10|$

$|-10|$

$|10|$

$|5|$

$|-5|$

50 = (MAE)

1200 $\xrightarrow{1}$

2 $\xrightarrow{1}$

$y = 1 * \text{area} + 1 * br + 1$
$= 1200 + 2 + 1$
$\rightarrow 1203 = \hat{y}$

$y = 70$

error $y - \hat{y}$ =
$= 1133$

Mean Squared Error $= \sqrt{\dfrac{450}{6}} = \sqrt{\ }$

(MSE)

$$\text{LOSS} = \text{MSE} = \frac{\sum_{i=0}^{n} (y-\hat{y})^2}{n}$$

$$\sqrt{(10)^2}$$

$$\text{LOSS} = \underline{\text{RMSE}} = \sqrt{\frac{\sum_{i=0}^{n} (y-\hat{y})^2}{n}}$$

$$(y-\hat{y})^2 = e^2 \checkmark$$

" Minimise Error " → maths

$$L = (y-\hat{y})^2$$

$$= \Big(y - \underbrace{(w_1 * x_1 + w_2 * x_2)}\Big)^2$$

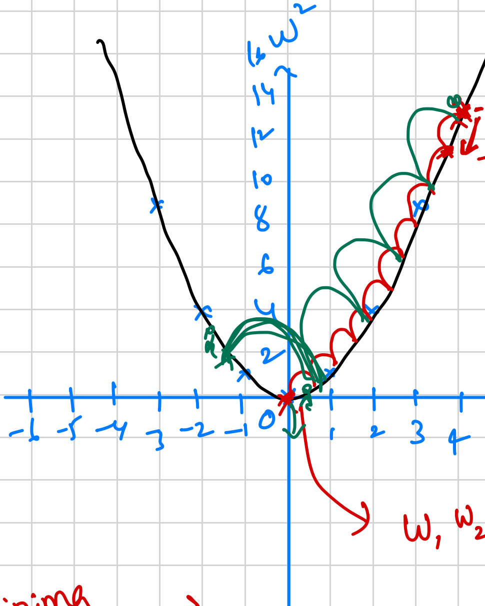
$$f(x) = x^2$$

$$\underbrace{L = w^2}$$

Gradient Descent

$y \quad x$

$L = w^2$



$w^1 = w_0 - \alpha \frac{\partial L}{\partial w}$

?

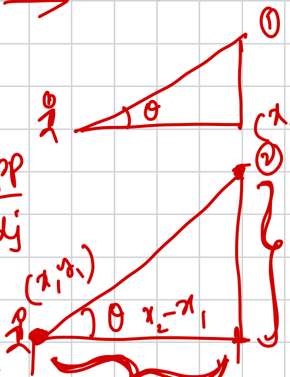
(Learning rate)

$w^2 = w^1 - \alpha \frac{\partial L}{\partial w}$

w_1, w_2 ✓

$\alpha \rightarrow$ T.T

minima $\rightarrow$



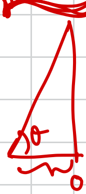
$\theta = 0 \sim 0 \downarrow$

$\theta = 90 \sim \uparrow$

$\tan\theta = \frac{Opp}{Adj}$

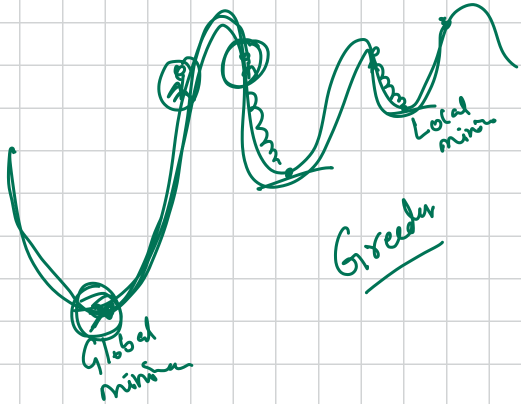
$\frac{Opp}{Adj} = \frac{\quad}{0} = \infty$

$\tan\theta = \frac{y_2 - y_1}{x_2 - x_1}$



$= \frac{\Delta y}{\Delta x} \sim \frac{dy}{dx} \rightarrow$ Gradient

GD



Greedy

$$\cancel{\frac{\partial |w|}{\partial w} = x}$$

$$\frac{\partial\, w^2}{\partial w}$$

$y = x^2$

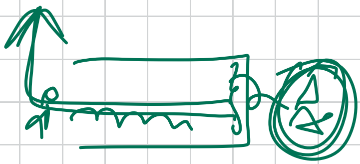
$$\frac{dy}{dx} = 2x$$

$$y = x^n = x^2$$

$$\frac{dy}{dx} = n x^{n-1}$$

$$= 2x$$

$$= 2 \cdot 1$$



SGD

↓

RMSProp

↓

Adam

W_1

W_2

$$w_1^{1} = w_1^{0} - \alpha \frac{\partial L}{\partial w_1}$$

$$w_1^{2} = w_1^{1} - \alpha \frac{\partial L}{\partial w_1}$$

⋮

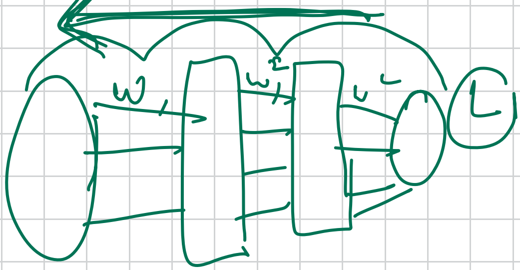
$$w_2^{1} = w_2^{0} - \alpha \frac{\partial L}{\partial w_2}$$

$$w_2^{2} = w_2^{1} - \alpha \frac{\partial L}{\partial w_2}$$

⋮

$$b_{new} = b_{old} - \alpha \frac{\partial L}{\partial b}$$

$$L = (y - w_1 x_1 + w_2 x_2 + b)^2$$



$$\frac{\partial L}{\partial w_1} =$$

$$\frac{\partial L}{\partial w_2} =$$

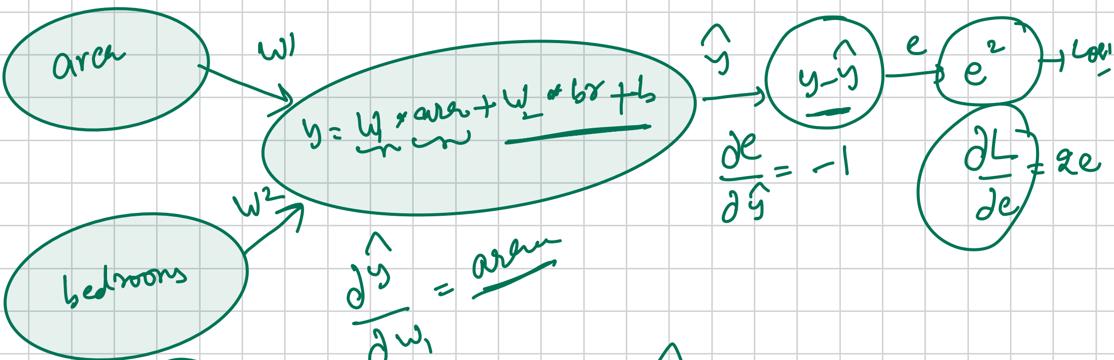
$$\frac{\partial L}{\partial b} =$$

$y = a \times w_1$

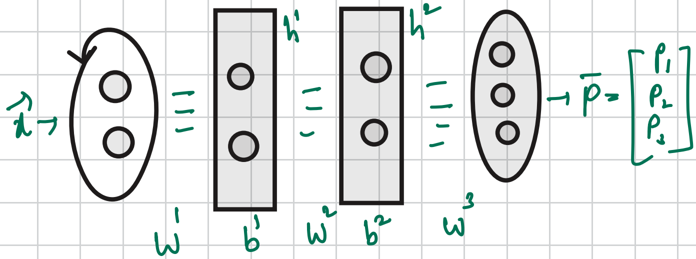
$\frac{dy}{dx} = a$

$y = 3x$

$\frac{dy}{dx} = 3 \cdot 1 \, x^{1-1} = 3$



$$\frac{\partial L}{\partial w_1} = \underbrace{\frac{\partial L}{\partial e} \times \frac{\partial e}{\partial \hat{y}} \times \frac{\partial \hat{y}}{\partial w_1}} = 2e \times (-1) \times area = -2e \times area$$



$$h^1 = \sigma(W^1 x + b^1)$$

$$h^2 = \sigma(W^2 h^1 + b^2)$$

$$\vec{p} = \frac{e^{W^3 h^2}}{(\_\_\_)} \Rightarrow \text{normalized}\,(e^{W^3 h^2})$$

Cross-entropy:

$$\Rightarrow -\big(\underset{1}{y_1} \underbrace{\log(p_1)}_{1} + y_2 \log(p_2) + y_3 \log(p_3)\big)$$

$y_1 \neq 0$ $\qquad$ $0<1$

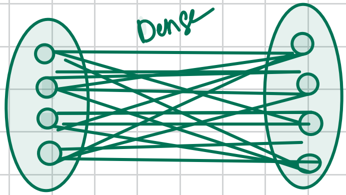
$70 - 70 \rightarrow 70 - 70 = 0$ $\qquad$ $0 \cdot \log(0) = 0$

$\underset{1}{y_1} \leftrightarrow \underset{1}{p_1} = 1 \rightarrow \text{Loss} = 0$

$$\text{CE LOSS} \Rightarrow y = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} \qquad p = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix}$$

$$\underbrace{-y^T \cdot \log(p)}_{} = -\begin{bmatrix} y_1 & y_2 & y_3 \end{bmatrix} \begin{bmatrix} \log p_1 \\ \log p_2 \\ \log p_3 \end{bmatrix}$$

$=$


Dense