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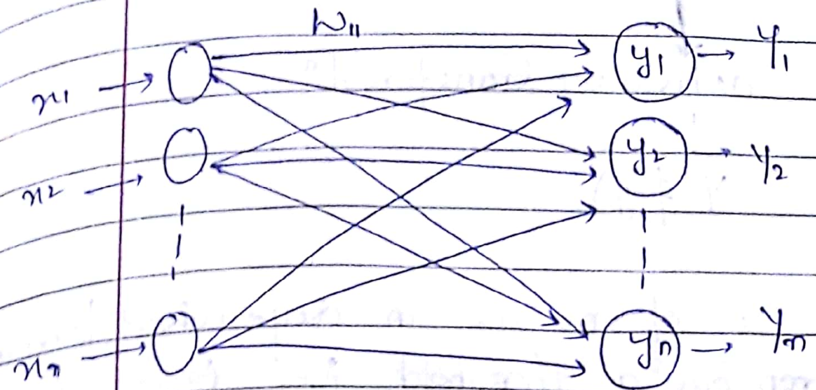
• Artificial Neural Network (ANN)



(i/p layer) (o/p Layer)

net i/p and further processing is done to get o/p. Y

Single layer feed forward artificial neural network

Single layer → one stage of transfer is there only

feed forward → ∵ feeding data in forward dirn only

✓ All connections are weighted.

W_{11} represent connection from x_1 to y_1 with some wt.

$$x \rightarrow O \xrightarrow{w} (y) \rightarrow y$$

$$\boxed{y = wx}$$

y → net i/p

wt

+ve → Excitatory wt. (∵ inc o/p)

−ve → inhibitory wt. (∵ dec o/p)

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$\boxed{y = xw}$

↓

activation/transfer f^n

↓

$Y = f(y)$

net i/P is of no use in supervised learning

- Every neuron has a threshold i.e. θ

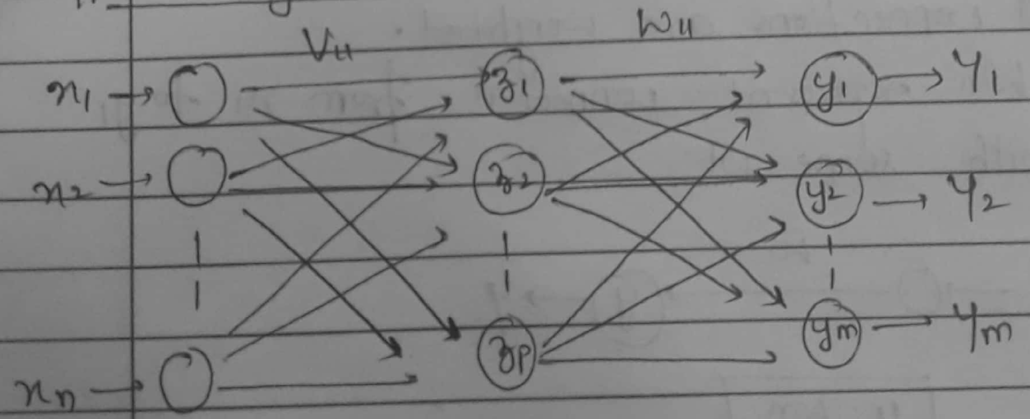
→ When neuron exceed its threshold then only it comes in firing state and generate o/p.

→ Rest, it remains in non-firing state

→ After acheiving firing state once, each neurons needs come rest before again acheiving firing state.

- While retraining, we change wt. of connections.

Multilayer Architecture



$\boxed{z_1 = xv}$

↓

activation f^n

$\boxed{f(z_1) = Z_1}$

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$$\downarrow$$

$$\boxed{y_1 = z_1 w}$$

$$\downarrow$$

activation f^n

$$Y_1 = f(y_1)$$

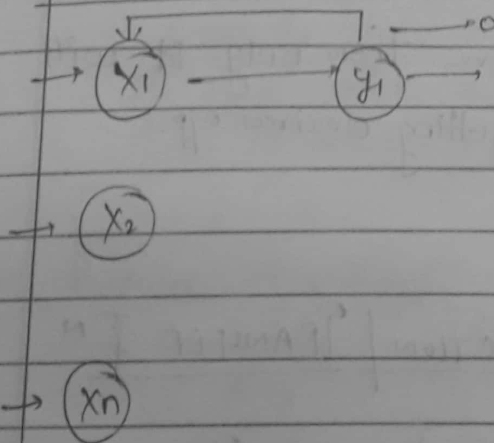
✓ Any layer added b/w first and last layer is called hidden layer.

✓ There is no restriction on no. of hidden layers as well as on no. of neurons in each layer.

(individual multiplication as well as matrix multiplication both depend on coding style)

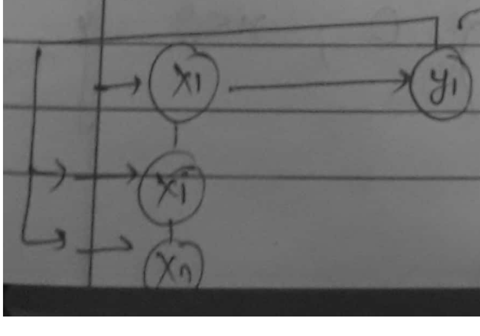
Feedback Architecture

o/p is fed to the same i/p



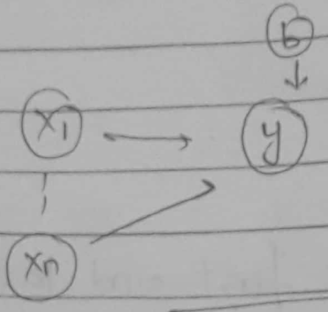
Recurrent Architecture (Eg. Hop field Network)

o/p is fed to other neurons except the same one.



Bias Architecture

extra wt. applied to neurons and has a unit activation i.e. const. (+1) *



$$\boxed{y = xw + b} \equiv \boxed{y = mx + c}$$

st. line eqn

Hence 'b' decides shape of curve.

Importance of bias wt.

→ It helps in better conversion

→ Conversion closer to the desired o/p

Why b is +ve

→ b if +ve then only it will help in getting desired o/p.

Activation Function / Transfer fn

1. Identity fn : $f(x) = x ; \ \forall x$

2. Binary fn : $f(x) = \begin{cases} 1 ; & x \geq 0 \\ 0 ; & x < 0 \end{cases}$

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(3). Bipolar step f^n : $f(x) = \begin{cases} 1 & ; x \geq 0 \\ -1 & ; x < 0 \end{cases}$

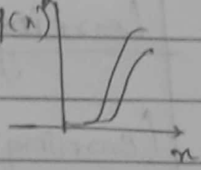
discrete function

→ equality sign can be shifted for desired o/p's.

(4). Binary sigmoidal f^n :

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

→ stepness f^n



$$\boxed{f'(x) = \lambda f(x) [1 - f(x)]}$$

derivative of $f(x)$

* $\lambda \rightarrow$ scalar
generally (0.5 to 1)
if not given, assume ($\lambda=1$)

(5). Bipolar sigmoidal :

$$f(x) = \frac{2}{1+e^{-\lambda x}} - 1$$

continuous activation f^n (mainly used in back propogation f^n.)

$$\boxed{f'(x) = \frac{1}{2} \left(1 + f(x)\right) \left(1 - f(x)\right)}$$

derivative

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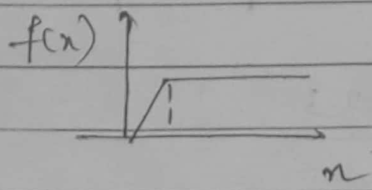
⑥. Ramp f^n :

$$f(x) = \begin{cases} 1 & ; \; x > 0 \\ x & ; \; x = 0 \\ 0 & ; \; x < 0 \end{cases}$$

$$\begin{cases} 1 & ; \; x > 0 \\ 0 & ; \; x = 0 \\ -1 & ; \; x < 0 \end{cases}$$

→ for perceptual neuron



Learning rate α'

Learning machine to get desired o/p which we already know.

if, actual o/p ≠ desired o/p

Retraining is done by changing wt.
Δw is calculated using α' to get desired o/p
α need to smaller to provide fast learning.

α → not given

assume, $\alpha = 1$ → for case of computation.

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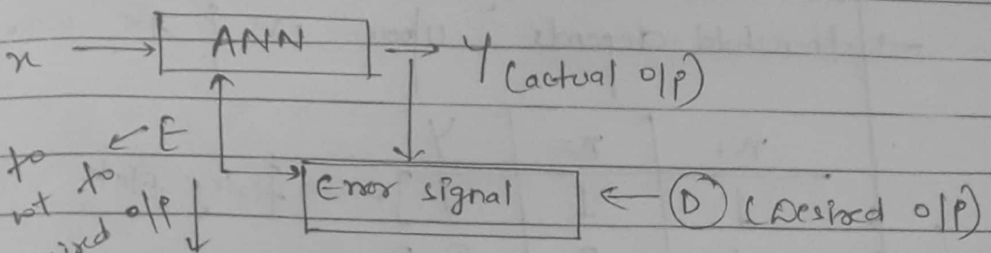
Types Of Learning :-

① Superwised Learning Eg. Classification



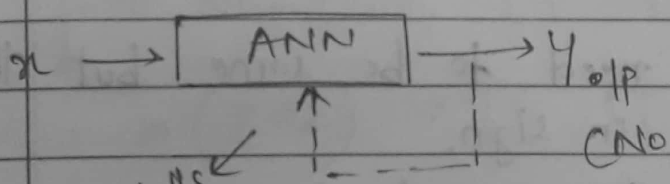
used to update wt to get desired o/p

least mean square error.

$$LMS(E) = \frac{1}{2}(D-Y)^2$$

↳ random factor to cancel out 2 at time of derivative.

② Unsuperwised Eg. Clustering (Have learing rule)

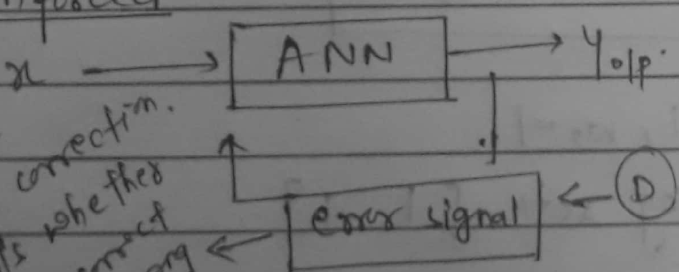


(No error calculation)

neither tells right or wrong

③ Reinforced (b/w superwised & unsuperwised)

↳ may not give correct result



to compare with only

not used in producing of correction. only tells whether o/p is correct or wrong

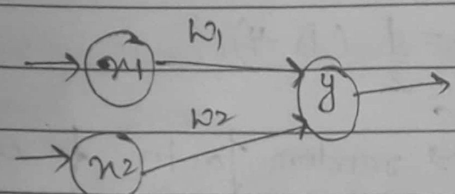
Mc Culloch Pitts Model (MCP)

- the i/p & o/p value will be 0 or 1.
- discrete binary step fn. (activation)
- Uses both exhibitory or inhibitory model
- threshold depends upon -ve & +ve wt. applied

	x_1	x_2	y	
1.	1	1	1	→ firing state
2.	1	0	0	non-firing state.
3.	0	1	0	
4.	0	0	0	

training pairs.

(single layer feed forward model)



x, y or s:t

string   target

values of wt need to be same but they can differ in sign.

Eg. if 2 then -2 not -1

y_{in} → denotes net input

$$\boxed{y_{in} = x_1 w_1 + x_2 w_2}$$

→ $w_1 = 1$, $w_2 = 1$

1st training set: [1 1]

$y_{in_1} = 2$

→ [1 0]

$y_{in_2} = 1$

→ [0 1]

$y_{in_3} = 1$

→ [0 0]

$y_{in_4} = 0$

Find threshold value.

$$y = \begin{cases} 1 \; ; & y_{in} \geq \theta \\ 0 \; ; & y_{in} < \theta \end{cases}$$

From computation, [1 1] results in 2.

$\Rightarrow$ ($\theta = 2$) $\because$ [1 1] is the only firing state.

$$y = \begin{cases} 1 \; ; & y_{in} \geq 2 \\ 0 \; ; & y_{in} < 2 \end{cases}$$

Assumption model for realisation

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Decision Boundary

if the pts. can be demarked on two sides of a line then it is linearly separable.

Q. Realise OR gate using MCP model.

x_1	x_2	y
1	0	1
0	1	1
1	1	1
0	0	0

] firing states

] non-firing "

$w_1 = w_2 = 1$

$x_1 w_1 + x_2 w_2 = y_{in}$

[1   1]

$y_{in} = 1 + 1 = 2$

[1   0]

$y_{in} = 1 + 0 = 1$

$\theta = 1$ based on computation.

[0   1]

$y_{in} = 1$

[0   0]

$y_{in} = 0$

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$$y = \begin{cases} 1 ; & y_{in} \geq 1 \\ 0 ; & y_{in} < 1 \end{cases}$$

AND-NOT gate. $(x_1 \wedge x_2')$

and first variable with not of second variable.

x_1	x_2	x_2'	y
1	1	0	0
1	0	1	1 → firing state.
0	1	0	0
0	0	1	0

[1 1] ($w_1 = 1$ & $w_2 = 1$) ✗

$y_{in} = x_1 w_1 + x_2 w_2$

$= 1 + 1 = 2.$

[1 0] ✓

$y_{in} = 1 + 0 = 1$

[0 1]

$y_{in} = 1$

[0 0]

$y_{in} = 0$

✗

✓

$\boxed{w_1 = 1 \quad w_2 = -1}$

$1(1) + 1(-1)$

$= 1 - 1 = 0$

$1(1) + 0(-1)$

$1 + 0 = 1$ ✓

$0(1) + 1(-1)$

$= -1$

$0(1) + 0(-1)$

$= 0$

$\Rightarrow \theta = 1$

$$y = \begin{cases} 1 ; & y_{in} \geq 1 \\ 0 ; & y_{in} < 1 \end{cases}$$

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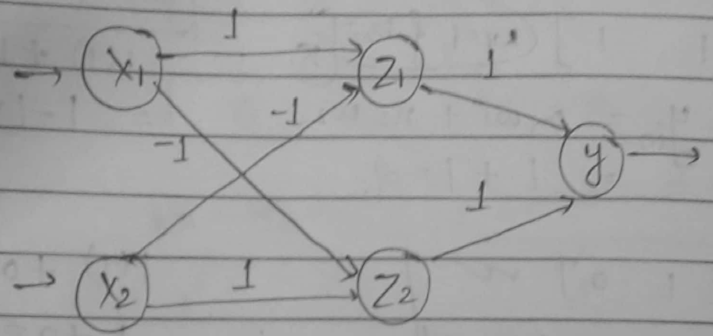
XOR Gates

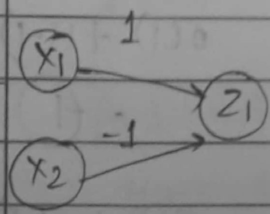
x_1	x_2	y
0	0	0
0	1	1
1	0	1
1	1	0

On computing, we unable to get a linear seprable architecture.

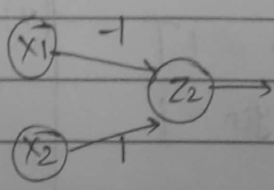
Now, we'll go for multilayer architecture by introducing a hidden layer.



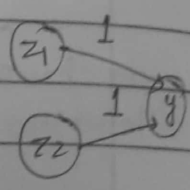
x_1 and not x_2



x_2 and not x_1



~~z_1 or z_2~~



find θ for each three gates.

x_1	x_2	z_1		
0	0	0	1	$0\times1+0(-1)=0$
0	1	0	0	$0\times1+1(-1)=-1$
1	0	1	1	$1\times1+0\times(-1)=1$
1	1	0	0	$1\times1+1\times(-1)=0$

$\theta=1$

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x_2 and not x_1

x_1	x_2	$z2$
0	0	0
0	1	1
1	0	0
1	1	0

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

$0 \times (-1) + 0(1) = 0$

$0 \times (-1) + 1(1) = 1$

$1 \times (-1) + 0(1) = -1$

$1 \times (-1) + 1(1) = 0$

$\theta = 1$

Z_1 or Z_2

x_1	x_2	z_1	z_2	w
0	0	0	0	0
0	1	0	1	1
1	0	1	0	1
1	1	0	0	0

$0(1) + 0(1) = 0$

$0(1) + 1(1) = 1$

$1(1) + 0(1) = 1$

$0(1) + 0(1) = 0$

$\theta = 1$

$$\begin{cases} 1 ; & y_{in} \geq 1 \\ 0 ; & y_{in} < 1 \end{cases}$$

LINEAR SEPRABILITY

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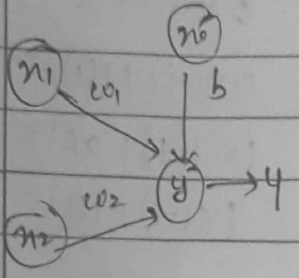


$$y_{in} = x_1 w_1 + x_2 w_2 + b$$

if, pt. lies on line.

$\Rightarrow y_{in} = 0$

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

$$\Rightarrow \boxed{x_2 = \frac{-x_1 w_1}{w_2} - \frac{b}{w_2}}$$

eq^n for decision line.

compare to, $\boxed{y = mx + c}$

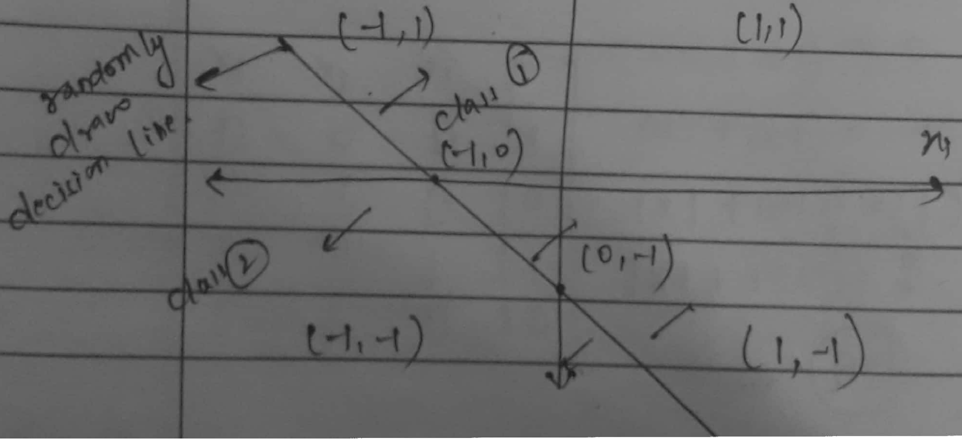
Eg. (1).

OR Gate

x_1	x_2	y
1	1	1
1	-1	1
-1	1	1
-1	-1	-1

Rows 1–3: same o/p $\Rightarrow$ belongs to same class.

Row 4: — Class 2



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Outliers → can never be classified under any class.
→ They do not listen to problem.
→ Every problem consist of such pts.
∴ Ignore them as they will always dec. the performance.

Now,

$(x_1, y_1) = (-1, 0)$

$(x_2, y_2) = (0, -1)$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = -1$$

$$y_1 = m x_1 + c$$

$$0 = (-1)(-1) + c$$

$$\Rightarrow c = -1$$

$$\Rightarrow \boxed{y_1 = -x_1 - 1}$$

Now compare it with standard eqn.

$$\boxed{x_2 = -x_1 \frac{w_1}{w_2} - \frac{b}{w_2}}$$

$$\Rightarrow \frac{w_1}{w_2} = 1 \qquad \frac{b}{w_2} = 1$$

$$\Rightarrow \boxed{w_1 = w_2 = b}$$

Now, for ease of computation take them 1.

$$\boxed{w_1 = w_2 = b = 1}$$

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const. activation of (+1).

x_1	x_2	x_0	y_{in}	y
1	1	1	3	1
1	-1	1	1	1
-1	1	1	1	1
-1	-1	1	-1	-1

firing state in original one

$\Rightarrow \theta = 1$

table based on this eq^n

$$\boxed{y_{in} = x_1 w_1 + x_2 w_2 + x_0 b}$$

Compare with Y to see 'θ'

$$Y = \begin{cases} 1 & y_{in} \geq +1 \\ -1 & y_{in} < 1 \end{cases}$$

$\therefore$ θ can be figured out.

$\Rightarrow$ OR gate is linearly Separable.

(if coming Y is same as expected or desired Y.) $\Rightarrow$ linearly separable.

Q. 2. Check whether AND NOT gate is linearly Separable or not.

x_1	x_2	x_2'	y
1	1	-1	-1 ✓
1	-1	1	1 — 2nd class
-1	1	-1	-1 ✓
-1	-1	1	-1 ✓

I class

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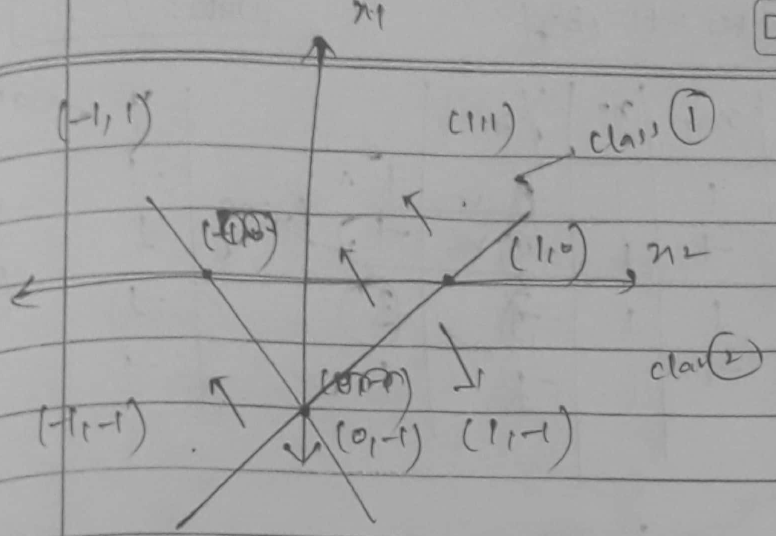

$(x_1, y_1) = (-1, 0)$

$(x_2, y_2) = (0, -1)$

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{-1 - 0}{0 - (-1)} = -1.$$

$$\boxed{y_1 = -x + c}$$

compare.

(1, 0) $0 = x + c$

$0 = 1 + c$

$c = -1$

$$\boxed{y_1 = x - 1}$$

$$x_2 = -x_1 \frac{w_1}{w_2} \quad \frac{-b}{w_2}$$

$$\Rightarrow \frac{w_1}{w_2} = -1 \quad \& \quad \frac{b}{w_2} = +1$$

$$\Rightarrow w_1 = -w_2 = b = 1$$

$$\Rightarrow \boxed{w_1 = -1, \; w_2 = +1 \;\&\; b = +1}$$

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$w_1 = -1,\ w_2 = +1,\ b = 1$

x_1	x_2	x_0	y_{in}		y
1	1	1	~~-1~~	1	-1
1	-1	1	~~-1~~	-1 firing	1
-1	1	1	~~-3~~	3	-1
-1	-1	1	~~-1~~	1	-1

same ∴ linearly separable

$y_{in} = x_1 w_1 + x_2 w_2 + x_0 b$

$= \boxed{-x_1 + x_2 + b}$

$y_{in} = 1 - 1 + 1 = 1$	$-(1) + (1) + (1) = 1$
$1 - (-1) + 1 = -1$	$-(1) + (-1) + (1) = -1$
$-1 - 1 + 1 = -3$	$-(-1) + (1) + (1) = 3$
$-1 - (-1) + 1 = -1$	$-(-1) + (-1) + (1) = 1$

$\theta = 1$

$$y = \begin{cases} -1 & ; y_{in} \geq 1 \\ 1 & ; y_{in} < 1 \end{cases}$$

LEARNING RULES

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$W_{new} = W_{old} + \Delta W$

$\Delta W = \alpha (LS)$ → product of learning rate or signal.

$b_{new} = b_{old} + \Delta b$

$\Delta b = \alpha (LS)$

* It is diffⁿ for each learning rule.

1. Hebb Learning Rule → eg of unsupervised learning.

- If neuron A is in firing mode & B is adjacent to it then, it will push neuron B towards acheiving firing state.

- Bipolar mode → o/p is 1 or -1.
  (ON) (OFF)

- initial value of weights is always 0.
  $w_1 = w_2 = \cdots = w_n = 0$

* { We are finding new wts & training our system bcz. it assumes that old wt. might not be correct. }

$$\Delta W = \alpha (x \cdot y)$$

$$\Delta b = \alpha (1)(y)$$
$$= \alpha y$$

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* taking bias is a compulsion.

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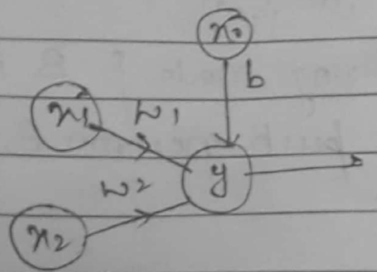
Q. Implement a Hebb Net for AND gate.

	x_1	x_2	x_0	y
1.	1	1	1	1
2.	1	-1	1	-1
3.	-1	1	1	-1
4.	-1	-1	1	-1

IMP. (target o/p y is based only on x_1 and x_2)

bias x_0 is only for implementation purpose.



$w_1 = w_2 = b = 0$

s : t
storage target

Training pair

1). [1 1 1] : 1 ← o/p

∵ unsupervised learning ⇒ no calculation for net i/p

⇒ θ i.e. threshold is not calculated.

⇒ m/c is learned with the pair we provide them.

But for case of computation,

use, $\alpha = 1$

0.2 generally gives good result

$\alpha = 1$

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$\Delta w_1 = \alpha . x_1 . y$
$= (1)(1)(1) = 1$

$\Delta w_2 = \alpha . x_2 . y$
$= (1)(1)(1) = 1$

IMP — o/p depends on sequence of i/p taken.

$(\Delta b = 1)$ $(\alpha . y)$

$w_1 new = 1 + 0 = 1$
$w_2 new = 1 + 0 = 1$
$b\ new = 1 + 0 = 1$

IMP. — one epoch is equal to one iteration i.e. one learning / training cycle.

2). $[\ 1 \quad -1 \quad 1\ ] : -1$

$\Delta w_1 = \alpha . x_1 . y$
$= 1(1)(-1) = -1$

$\Delta w_2 = \alpha . x_2 . y$
$= 1(-1)(-1) = 1$

$\Delta b = \alpha . y = 1(-1) = -1$

IMP. when to stop.
when, $\Delta w = 0$
$\Rightarrow$ wt. will not change.
$\Rightarrow$ ans. has been obtained.

$w_1 new = 1 - 1 = 0$
$w_2 new = 1 + 1 = 2$
$b\ new = 1 - 1 = 0$

3). $[\ -1 \quad 1 \quad 1\ ] : -1$

$\Delta w_1 = \alpha . x_1 . y$
$= 1(-1)(-1) = 1$

$\Delta w_2 = \alpha . x_2 . y = 1(1)(-1) = -1$

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$\Delta b = 1(-1) = -1$

$w_1 new = 0 + 1 = 1$
$w_2 new = 2 + (-1) = 1$
$b new = 0 + (-1) = -1$

diffⁿ implies, $\boxed{w old = w new}$ → consecutive

~~this old no needs to be immediate.~~
~~It could have come in history~~

4). [-1 -1 1] : -1

$\Delta w_1 = \alpha . x_1 . y = 1(-1)(-1) = 1$
$\Delta w_2 = \alpha . x_2 . y = 1(-1)(-1) = 1$
$\Delta b = \alpha . y = 1(-1) = -1$

$w_1 new = 1 + 1 = 2$
$w_2 new = 1 + 1 = 2$
$b new = -1 - 1 = -2$

Q. Implement a Hebb Net for OR gate upto 2 epochs.

x_1	x_2	x_0	y
1	1	1	1
1	-1	1	1
-1	1	1	1
-1	-1	1	-1

** Neural network which uses Hebb Rule is called Hebb Net.

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$\alpha = 1.$

1. [1 1 1] : 1

$\Delta w_1 = \alpha . x_i y$

$= 1(1)(1) = 1$

$\Delta w_2 = \alpha . x_2 . y$

$= 1(1)(1) = 1$

$\Delta b = \alpha . y = 1(1) = 1$

$\Delta w_{1new} = 1 + 0 = 1$

$\Delta w_{2new} = 1 + 0 = 1$

$b_{new} = 1$

$\alpha = 1.$

1. $[1 \quad 1 \quad 1] : 1$

$\Delta w_1 = \alpha . x_i \, y$
$= 1(1)(1) = 1$

$\Delta w_2 = \alpha \, x_2 . y$
$= 1(1)(1) = 1$

$\Delta b = \alpha . y = 1(1) = 1$

$\Delta w_{1new} = 1 + 0 = 1$
$\Delta w_{2new} = 1 + 0 = 1$
$b_{new} = 1$

2. $[1 \quad -1 \quad 1] : 1$

$\Delta w_1 = 1(1)(1) = 1$
$\Delta w_2 = 1(-1)(1) = -1$
$\Delta b = 1(1) = 1$

$w_{1new} = 1 + 1 = 2$
$w_{2new} = 1 + (-1) = 0$
$b_{new} = 1 + 1 = 2$

3. $[-1 \quad 1 \quad 1] : 1$

$\Delta w_1 = 1(-1)(1) = -1$
$\Delta w_2 = 1(1)(1) = 1$
$\Delta b = 1(1) = 1$

$w_{1new} = 2 - 1 = 1$
$w_{2new} = 0 + 1 = 1$
$b_{new} = 2 + 1 = 3$

4. $[-1 \quad -1 \quad +1] : -1$

$\Delta w_1 = (-1)(-1)(1) = 1$
$\Delta w_2 = 1(-1)(-1) = 1$
$\Delta b = 1(-1) = -1$

$w_{1new} = 1 + 1 = 2$
$w_{2new} = 1 + 1 = 2$
$b_{new} = 3 - 1 = 2$

2nd epoch (2, 2, 2)

1. [1 (1) 1] : 1

$\Delta w_1 = 1(1)(1) = 1$

$\Delta w_2 = 1(1)(1) = 1$

$\Delta b = 1(1) = 1$

$w_{1N} = 3$

$w_{2N} = 3$

$b_N = 3$

2. [1 -1 1] : 1

$w_{1N} = 3 + 1 = 4$

$w_{2N} = 3 + (-1) = 2$

$b_N = 3 + 1 = 4$

3. [-1 1 1] : 1

$w_{1N} = 4 - 1 = 3$

$w_{2N} = 2 + 1 = 3$

$b_N = 4 + 1 = 5$

4. [-1 -1 1] : -1

$$\left.\begin{array}{l} w_{1N} = 3 + 1 = 4 \\ w_{2N} = 3 + 1 = 4 \\ b_N = 5 - 1 = 4 \end{array}\right]$$

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Tut – (12 – 1) – Tut - 2

Thurs.

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Q. Create a simple suitable Heb Net to identify the patterns L and U where, L ∈ Class 1 and U ∈ class 2. Find the wt.'s after learning for one epoch.

Class 1   Class 2

L (+1)   U (-1)

3x3 matrix

```
*  .  .          *  .  *
*  .  .          *  .  *
*  *  *          *  *  *
```

Common platform for both.

Min. possible was 3x3 matrix.

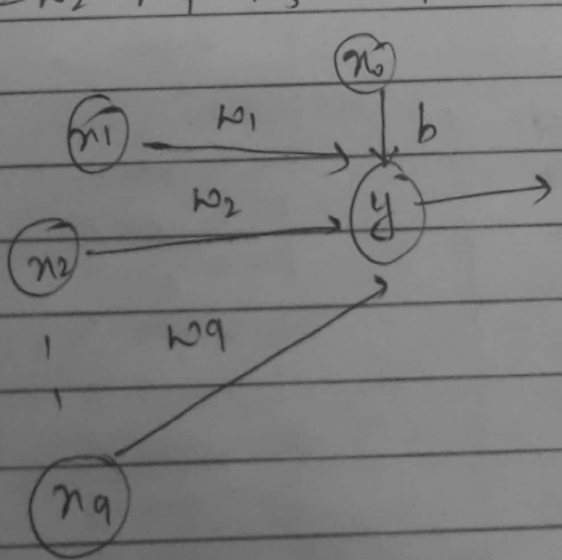
* pst is in firing state i.e. (+1)

. pst is in non-firing state i.e. (-1)

Pattern	I/p's										o/p
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_0	
L	1	-1	-1	1	-1	-1	1	1	1	1	+1
U	1	-1	1	1	-1	1	1	1	1	1	-1

$w_1 = w_2 = w_3 = w_4 = w_5 = w_6 = w_7 = w_8 = w_9 = b = 0$

(initially, wt. = 0.)



$(\alpha = 1)$

$[1 \ -1 \ -1 \ 1 \ -1 \ -1 \ 1 \ 1 \ 1 \ 1] : +1$

$\Delta w_1 = \alpha . x_1 \cdot y$

$= 1 \times 1 \times (1) = 1$

$\Delta w_2 = 1(-1)(1) = -1$

$\Delta w_3 = 1(-1)(1) = -1$

$\Delta w_4 = 1(1)(1) = 1$

$\Delta w_5 = 1(-1)(1) = -1$

$\Delta w_6 = -1$

$\Delta w_7 = 1$

$\Delta w_8 = 1$

$\Delta w_9 = 1$

$\Delta b = \alpha(y) = 1(1) = 1$

w_1 new

w_2 new

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Q. Use the heb net to learn the patterns, I and O. where I ∈ Class 1 and O ∈ Class 2.
Find the final weights after 2 epochs.

*	*	*
.	*	.
*	*	*

I (+1)

*	*	*
*	.	*
*	*	*

O (-1)

Pattern	I/P										O/P
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_0	
I	1	1	1	-1	1	-1	1	1	1	1	+1
O	1	1	1	1	-1	1	1	1	1	1	-1

$(\alpha=1)$

Set 1

$\Delta w_1 = 1$	$w_1 \text{ new} = 1$
$\Delta w_2 = 1$	$w_2 = 1$
$\Delta w_3 = 1$	$w_3 = 1$
$\Delta w_4 = -1$	$w_4 = -1$
$\Delta w_5 = 1$	$w_5 = 1$
$\Delta w_6 = -1$	$w_6 = -1$
$\Delta w_7 = 1$	$w_7 = 1$
$\Delta w_8 = 1$	$w_8 = 1$
$\Delta w_9 = 1$	$w_9 = 1$
$\Delta b = 1$	$b = 1$

Set 2

$1(-1) = -1$

$\Delta w_1 = -1$	$w_1 = 0$	$b = 0$
$\Delta w_2 = -1$	$w_2 = 0$	
$\Delta w_3 = -1$	$w_3 = 0$	
$\Delta w_4 = -1$	$w_4 = -2$	
$\Delta w_5 = 1$	$w_5 = 2$	
$\Delta w_6 = -1$	$w_6 = -2$	
$\Delta w_7 = -1$	$w_7 = 0$	
$\Delta w_8 = -1$	$w_8 = 0$	
$\Delta w_9 = -1$	$w_9 = 0$	
$\Delta b = -1$		

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epoch 2

set 1		set 2
	$w_1 = 1$	$w_1 = 0$
	$w_2 = 1$	$w_2 = 0$
	$w_3 = 1$	$w_3 = 0$
	$w_4 = -3$	$w_4 = -4$
	$w_5 = 3$	$w_5 = 4$
	$w_6 = -3$	$w_6 = -4$
	$w_7 = 1$	$w_7 = 0$
	$w_8 = 1$	$w_8 = 0$
	$w_9 = 1$	$w_9 = 0$
	$b = 1$	$b = 0$

SUPERVISED LEARNING

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1. Perceptron Algorithm

$$W_{new} = W_{old} + \Delta W$$

$$\Delta W = \alpha t x$$

calculate

$y \neq t \rightarrow$ target o/p

actual o/p we are getting

- ✓ This W_{new} can be calculated for more than one epoch.
- ✓ Irrespective of I/P, we assume target o/p t in bi-polar form
- ✓ activation f^n taken $\longrightarrow$ step activation f^n.

$$y = \begin{cases} 1 & \text{if } y_{in} > \theta \\ 0 & \text{if } y_{in} = \theta \\ -1 & \text{if } y_{in} < \theta \end{cases}$$

- ✓ if, θ is not given assume it to be 0

Eg AND Gate

x_1	x_2	x_0	t
1	1	1	1
1	-1	1	-1
-1	1	1	-1
-1	-1	1	-1

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if, not given, we take, them to be '0' initially

$$\begin{cases} w_1 = w_2 = b = 0 \\ \alpha = 1 \\ \theta = 0 \end{cases}$$

Now,

$$y = \begin{cases} 1 & ; y_{in} > 0 \\ 0 & ; y_{in} = 0 \\ -1 & ; y_{in} < 0 \end{cases}$$

1. $[1 \quad 1 \quad 1] : 1$

$y_{in} =$ ~~[illegible]~~ $1(0) + 1(0) + 1(0) = 0$

$y = 0$

$\Rightarrow y \neq t$

$\Rightarrow$ training needs to be done.

$\Delta w_1 = \alpha . t_i . x_i$
$= 1(1)(1) = 1$

$\Delta w_2 = 1(1)(1) = 1$

$\Delta b = 1(1) = 1$

$w_{1N} = 0 + 1 = 1$

$w_{2N} = 0 + 1 = 1$

$b_N = 0 + 1 = 1$

Correct set of w for Ist set.

2. $[1 \quad -1 \quad 1] : -1$

$y_{in} = 1(1) + (-1)(1) + 1(1)$
$= 1$

$y = 1$

$y \neq t$

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$\downarrow$ train.

$\Delta w_1 = 1(-1)(1) = -1$ | $w_{1N} = 1-1 = 0$

$\Delta w_2 = 1(-1)(-1) = 1$ | $w_{2N} = 1+1 = 2$

$\Delta b = 1(-1)(1) = -1$ | $b_N = 1-1 = 0$

3. $[-1 \quad 1 \quad 1] : -1$

$y_{in} = -1(0) + 1(2) + 1(0) = 2.$

$y = 1$

$y \neq t$

$\downarrow$ train

$\Delta w_1 = 1(-1)(-1) = 1$ | $w_{1N} = 0+1 = 1$

$\Delta w_2 = 1(-1)(1) = -1$ | $w_{2N} = 2-1 = 1$

$\Delta b = 1(-1)(1) = -1$ | $b_N = 0-1 = -1$

4. $[-1 \quad -1 \quad 1] : -1$

$y_{in} = -1(1) + (-1)(1) + 1(-1) = -3$

$y = -1$

~~$\Delta w_1 = 1(-1)(-1) = 1$~~

$\Delta w_2 = 1(-1)(-1) = 1$

$\Delta b = 1(-1)(1) = -1$

$y = t$

$\therefore$ No training is requ.

* After 1^{st} epoch :-

$\boxed{w_1 = 1, \quad w_2 = 1, \quad b = -1}$

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{ if not given, assume, $\theta = 0$
{ & make step activation fn.

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Q. Use a perceptron network to find the final weights of the given data with $\alpha = 1$, initial wt. as 0 after 2 epochs.

x_1	x_2	x_3	x_4	b	t
1	1	1	1	8	1
-1	1	-1	-1	8	1
1	1	1	-1	8	-1
1	-1	-1	1	8	-1

(don't assume bias if not IMP mentioned.)
IMP
= only assume if in Gates by default

$$y = \begin{cases} 1 & ; \ y_{in} > 0.2 \\ 0 & ; \ -0.2 \leq y_{in} \leq 0.2 \\ -1 & ; \ y_{in} < -0.2 \end{cases}$$

1. [1 1 1 1] : 1

$y_{in} = 1(0) + 1(0) + 1(0) + 1(0) = 0$

$y = 0$

$y \neq t$

↓ train

$\Delta w_1 = 1(1)(1) = 1$	$w_1' = 1$
$\Delta w_2 = 1(1)(1) = 1$	$w_2' = 1$
$\Delta w_3 = 1(1)(1) = 1$	$w_3' = 1$
$\Delta w_4 = (1)(1)(1) = 1$	$w_4' = 1$

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2 $[-1 \quad 1 \quad -1 \quad -1] : 1$

$y_{in} = -1(1) + 1(1) + -1(1) + (-1)(1)$

$= \cancel{-1} \cancel{+1} \cancel{-1} \cancel{-1} = 0$

$y = 0$

$y \neq t$

$\downarrow$ train

$\Delta w_1 = 1(1)(-1) = -1$	$w_1' = 0$
$\Delta w_2 = 1(1)(1) = 1$	$w_2' = 2$
$\Delta w_3 = 1(1)(-1) = -1$	$w_3' = 0$
$\Delta w_4 = 1(1)(-1) = -1$	$w_4' = 0$

3 $[1 \quad 1 \quad 1 \quad -1] : -1$

$y_{in} = 1(0) + 1(2) + 1(0) + (-1)(0) = 2$

$y = 1$

$y \neq t$

$\downarrow$ train.

$\Delta w_1 = -1(1) = -1$	$w_1' = -1$
$\Delta w_2 = -1(1) = -1$	$w_2' = 1$
$\Delta w_3 = -1(1) = -1$	$w_3' = -1$
$\Delta w_4 = -1(-1) = 1$	$w_4' = 1$

y [1 -1 -1 1] : -1

$y_{in} = -1(1) + 1(-1) + (-1)(-1) + 1(1)$
$= -1 -1 +1 +1 = 0$

$y = 0$

$y \neq t$

$\downarrow$ train

$\Delta w_1 = (-1)(1) = -1$	$w_1' = -2$
$\Delta w_2 = (-1)(-1) = 1$	$w_2' = 2$
$\Delta w_3 = (-1)(-1) = 1$	$w_3' = 0$
$\Delta w_4 = (-1)(1) = -1$	$w_4' = 0$

2nd epoch

1 [1 1 1 1] : 1

$y_{in} = -2(1) + 2(1) + 0 + 0 = 0$

$y = 0$

$y \neq t$

$\downarrow$ train

$\Delta w_1 = 1(1) = 1$	$w_1' = -1$
$\Delta w_2 = 1(1) = 1$	$w_2' = 3$
$\Delta w_3 = 1(1) = 1$	$w_3' = 1$
$\Delta w_4 = 1(1) = 1$	$w_4' = 1$

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2. [-1 1 -1 -1] : 1

$y_{in} = -1(-1) + 3(1) + 1(-1) + 1(-1)$
$= 1 + 3 - 2 = 2$

$y = 1$

$y = t$

⇒ wt remains same.

$w_1' = -1$
$w_2' = 3$
$w_3' = 1$
$w_4' = 1$

3. [1 1 1 -1] : -1

$y_{in} = -1(1) + 3(1) + 1(1) + (-1)(1)$
$= -1 + 3 + 1 - 1 = 2$

$y = 1$

$y \neq t$

↓ train

$\Delta w_1 = -1$	$w_1' = -2$
$\Delta w_2 = -1$	$w_2' = 2$
$\Delta w_3 = -1$	$w_3' = 0$
$\Delta w_4 = 1$	$w_4' = 2$

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4 [1 -1 -1 1] : -1

$y_{in} = 1(-2) + (-1)(2) + (-1)(0) + 1(2)$
$= -2 - 2 + 0 + 2 = -2$

$\boxed{y = -1}$

$y = t$

⇒ final wt. are,

$$\left\{ \begin{aligned} w_1 &= -2 \\ w_2 &= 2 \\ w_3 &= 0 \\ w_4 &= 2 \end{aligned} \right\}$$

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