Date: 5/9/18/

③

Delta Learning Rule

- Adaline N/ws. ⟶ Single layer. (single o/p neuron)
- Supervised learning.
- N/w converging to the o/p. (as close ~~post~~ as possible).
- Cannot be intialized by 0 so take as small as possible.

Adaline N/ws ⟹ Madaline N/w
(No hidden layer). (Multiple o/ps).

$$w_{new} = w_{old} + \Delta w$$

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

$$\Delta w = \underbrace{\alpha}_{\text{learning rate}} \underbrace{(t - y_{in})}_{\text{Learning signal}} \underbrace{x}_{\text{input}}$$

$$\Delta b = \alpha (t - y_{in})$$

Error, $E = (t - y_{in})^2$
(LMS)
↳ (Least Mean Square Error)

Date: / / /

Q Apply delta learning rule to OR gate with bipolar i/p & targets, $\alpha = 0.1$ & initial weights $w_1, w_2, b = 0.1$ for 1 epoch.

x_1	x_2	x_0 (b)	t
1	1	0.1	1
1	-1	1	1
-1	1	1	1
-1	-1	1	-1

① [1 1 1] : [1]

$y_{in} = 1 \times 0.1 + 1 \times 0.1 + 1 \times 0.1$
$= 0.3$

$E = (1 - 0.3)^2 = (0.7)^2 = 0.49.$

$w_{1new} = 0.1 + 0.1 \times (0.7) \times 1$
$= 0.17$

$w_{2new} = 0.1 + 0.1 \times 0.7 \times 1 = 0.17$

$b_{new} = 0.1 + 0.1 \times 0.7 = 0.17$

② [1 -1 1] : [1]

$y_{in} = 0.17 \times 1 + 0.17 \times (-1) + 0.17 \times 1$
$= 0.17$

$E = (1 - 0.17)^2 = (0.83)^2 = 0.6889$

$w_{1new} = 0.17 + 0.1 \times 0.17 \times 1 = 0.187$

$w_{2new} = 0.17 + 0.1 \times 0.17 \times (-1) = 0.153$

MATRIKAS

Date: / / /

$b_{new} = 0.17 + 0.1 \times 0.17 = 0.187$.

(3) [-1 1 1] : [1]

$y_{in} = -1 \times 0.187 + 0.153 \times 1 + 0.187 \times 1$

$= 0.153$

$E = (1 - 0.153)^2$

$w_{1new} = 0.187 + 0.1 \times 0$

(2) [1 -1 1] : [1]

$y_{in} = 0.17 \times 1 + 0.17 \times (-1) + 0.17 \times 1$

$= 0.17$

$E = (1 \times 0.17)^2 = (0.83)^2 = 0.6889$

$w_{1new} = 0.17 + 0.1 \times 0.83 \times 1 = 0.253$

$w_{2new} = 0.17 + 0.1 \times 0.83 \times (-1) = 0.087$

$b_{new} = 0.17 + 0.1 \times 0.83 = 0.253$

(3) [-1 1 1] : [1]

$y_{in} = \cancel{-1 \times 0.253} + 1 \times 0.087 + \cancel{0.253}$

$= 0.087$

$E = (1 - 0.087)^2 = 0.833569 = (0.913)^2$

$w_{1new} = 0.253 + 0.1 \times 0.913 \times (-1) = 0.1617$

$w_{2new} = 0.087 + 0.1 \times 0.913 \times 1 = 0.1783$

$b_{new} = 0.253 + 0.1 \times 0.913 = 0.3443$.

MATRIKAS

Date: / / /

④ [-1 -1 1] : [-1]

$y_{in} = (-1) \times 0.1617 + (-1) \times 0.1783 + 0.3443$

$= \cancel{0.001} \quad 0.0043$

$E = (t - y_{in})^2 = (-1 - 0.0043)^2 = 1.087$

$w_1 new = 0.1617 + (-1)(-1.0043) \times (0.1) = 0.26\cancel{2}1.3$

$w_2 new = 0.1783 + (-1)(-1.0043)(0.1) = 0.27873$

$b_{new} = 0.3443 + 0.1 \times (-1.0043) = 0.24387$

6/9/18

Q Use adaline n/w to train ANDNOT f^n with bipolar i/ps and targets. The intial weights & bias is have value 0.2 and $\alpha = 0.2$. Train the n/w for 2 epochs.

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

$x_1 \bar{x}_2$

① [1 1 1] : [-1]

$y_{in} = 0.2 \times 1 + 0.2 \times 1 + 0.2 \times 1$

$= 0.6$

$E = (-1 - 0.6)^2 = (-1.6)^2 = 2.56$

Date: / / /

$W_1 \text{new} = 0.2 + 0.2 \times (-1 - 0.6) \times 1 = -0.12$

$W_2 \text{new} = 0.2 + 0.2 \times (-1 - 0.6) \times 1 = -0.12$

$b_{new} = 0.2 + 0.2 \times (-1 - 0.6) = -0.12$.

(2) $[1 \ -1 \ 1] : [1]$

$y_{in} = -0.12 \times 1 + (-1)(-0.12) + 1 \times (-0.12)$

$= -0.12$

$E = (1 - (-0.12))^2$

$= (1.12)^2 = 1.2544$.

$W_1 \text{new} = -0.12 + 0.2 \times (1.12)(1) = 0.104$.

$W_2 \text{new} = -0.12 + (0.2)(1.12)(-1) = -0.344$.

$b \text{new} = -0.12 + (0.2)(1.12) = 0.104$.

(3) $[-1 \ 1 \ 1] : [-1]$

$y_{in} = (-1) \cancel{\times (0.104)} + 1 \times (-0.344) + \cancel{1 \times 0.104}$

$= -0.344$.

$E = (-1 - (-0.344))^2$

$= (-0.656)^2 = 0.430336$.

$W_1 \text{new} = 0.104 + (-1)(-0.656)(0.2) = 0.2352$

$W_2 \text{new} = -0.344 + (1)(-0.656)(0.2) = -0.4752$.

$b_{new} = 0.104 + (-0.656)(0.2) = -0.0272$.

MATRIKAS

Scanned with CamScanner

Date: / / /

④ $[-1\ -1\ 1] : [-1]$

$y_{in} = (-1) \times (0.2352) + (-1) \times (-0.4752) + -0.0272$

$= 0.2128$

$E = (t - y_{in})^2$

$= \cancel{0.21}\ (-1 - 0.2128)^2 = (-1.2128)^2 = 1.47088$

$w_1 new = 0.2352 + (-1) \times (-1.2128)(0.2) = 0.47776$

$w_2 new = -0.4752 + (-1)(-1.2128)(0.2) = -0.23264$

$b_{new} = -0.0272 + (-1.2128)(0.2) = -0.26976$

⑤ $[1\ 1\ 1] : [-1]$

$y_{in} = 0.48 + (-0.23) + (-0.27)$

$= -0.02$

$E = (-1 - (-0.02)) = (-0.98)^2 = 0.9604$

$w_1 new = 0.48 + 1 \times (-0.98)(0.2) = 0.28$

$w_2 new = -0.23 + 1 \times (-0.98)(0.2) = -0.43$

$b_{new} = -0.27 + 1 \times (0.98)(0.2) = -0.478$

⑥ $[1\ -1\ 1] : [1]$

$y_{in} = 0.28 + 0.43 - 0.47 = 0.24$

$E = (1 - 0.24)^2 = (0.76)^2 = 0.5776$

$w_1 new = 0.28 + 1 \times (0.76) \times (0.2) = 0.43$

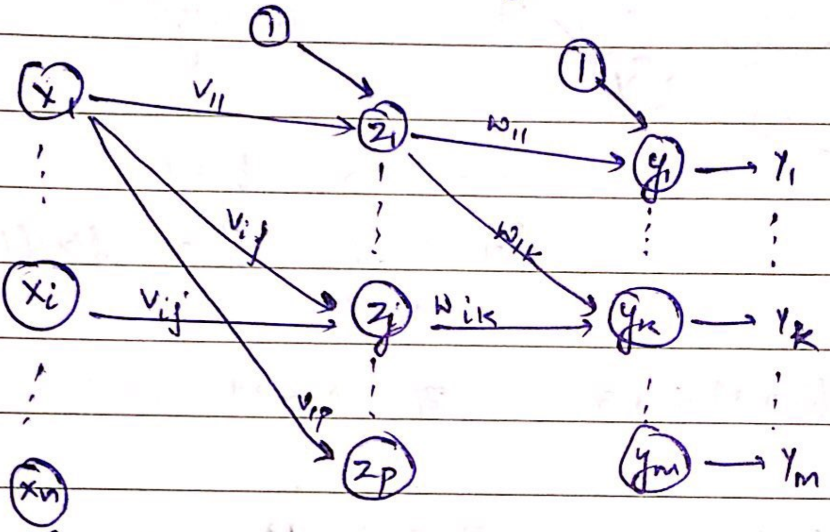
$w_2 new = -0.43 + (-1)(0.76)(0.2) = -0.58$

MATRIKAS

Date: 24 / 9 / 18 /

BPN - Back Propogation N/W.

- Memorization & Generalization
- Multilayer feedfwd n/w
- 3 phases
- During learning all 3
- During testing only feed forward phase.
- Use continuous activation functions.



(feed forward phase)

Phase 1

$$z_{inj} = v_{oj} + \sum_{i=1}^{n} v_{ij} \cdot x_i$$

$$z_j = f(z_{inj})$$

$$y_{ink} = w_{ok} + \sum_{j=1}^{p} w_{jk} z_j$$

$$y_k = f(y_{ink})$$

~~(Back propogation phase)~~

Phase 2

error correction at o/p.

$$\delta_k = (t_k - y_k) f'(y_{in\,k})$$

$$\Delta w_{jk} = \alpha \delta_k z_j$$

$$\Delta w_{ok} = \alpha \delta_k$$

error correction at hidden.

$$\delta_j = \delta_{inj} f'(z_{inj})$$

$$\delta_{inj} = \sum_{k=1}^{m} \delta_k w_{jk}$$

$$\Delta v_{ij} = \alpha \delta_j x_i$$

$$\Delta v_{oj} = \alpha \delta_j$$

$$w_{new} = w_{old} + \Delta w$$

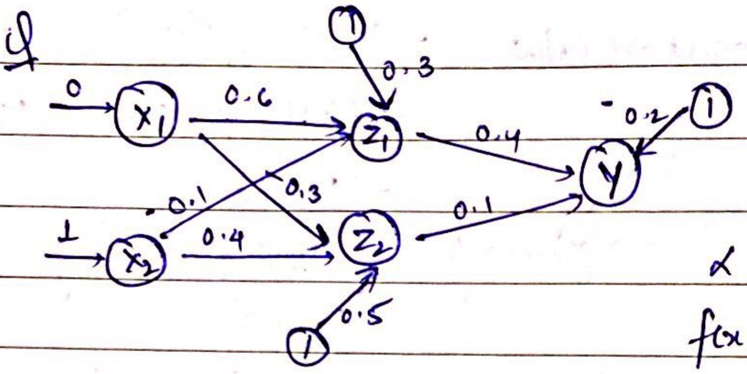
$$v_{new} = v_{old} + \Delta v.$$

Back propogation phase.

MATRIKAS

Date: 25/9/18 /

Q



Find change in weights.

$\alpha = 0.25, \quad t = 1$

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

$z_{in1} = 0 \times 0.6 + 1 \times (-0.1) + 0.3 \qquad z_1 = 0.549$

$= 0.2$

$z_{in2} = 0 \times (-0.3) + 1 \times (0.4) + 0.5 \qquad z_2 = 0.711$

$= 0.9$

$Y_{in} = -0.2 + 0.549 \times 0.4 + 0.711 \times 0.1 \qquad Y = 0.522.$

$= 0.09$

Error Correction at o/p

$\delta_1 = (1 - 0.522)\, f'(0.09)$

$= (1 - 0.522)\, f(0.09)\,(1 - f(0.09))$

$= (1 - 0.522)(0.522)(1 - 0.522)$

$= 0.12$

$\Delta w_{11} = \alpha \delta_1 z_1 = 0.25 \times 0.12 \times 0.55 = 0.0165$

$\Delta w_{12} = \alpha \delta_1 z_2 = 0.25 \times 0.12 \times 0.71 = 0.0213$

$\Delta w_{01} = \alpha \delta_1 = 0.25 \times 0.12 = 0.03$

$w_{11} = 0.4 + 0.0165 = 0.4165$ $\qquad$ w_{01}/ bias $= -0.2 + 0.03$

$w_{21} = 0.1 + 0.0213 = 0.1213$ $\qquad$ $= -0.17$

should be done last step mein.

Date: / / /

Error correction at hidden.

$\delta_1 = \delta_{in_1} f'(z_{in_1}) = 0.048 \times f(0.2) \times (1 - f(0.2)) = 0.012$

$\delta_{in_1} = \delta_1 w_{11} = 0.12 \times 0.4 = 0.048$

$\delta_2 = \delta_{in_2} f'(z_{in_2}) = 0.012 \times f(0.9)(1 - f(0.9)) = 0.002$

$\delta_{in_2} = \delta_1 w_{12} = 0.12 \times 0.1 = 0.012$

~~⇒ Pehle Δw calculate honge~~ yahan.

$\Delta V_{11} = \alpha \delta_1 x_1 = 0.25 \times 0.012 \times 0 = 0$

$\Delta V_{12} = \alpha \delta_2 x_1 = 0.25 \times 0.02 \times 0 = 0$

$\Delta V_{21} = \alpha \delta_1 x_2 = 0.25 \times 0.012 \times 1 = 0.003$

$\Delta V_{22} = \alpha \delta_2 x_2 = 0.25 \times 0.02 \times 1 = 0.0005$

$\Delta V_{01} = \alpha \delta_1 = 0.25 \times 0.012 = 0.003$

$\Delta V_{02} = \alpha \delta_2 = 0.25 \times 0.002 = 0.0005$

⇒ Pehle ~~ka~~ yahan w calculate honge

$V_{11} = 0.6 + 0 = 0.6$

$V_{12} = -0.3 + 0 = -0.3$

$V_{01} = 0.3 + 0.003 = 0.303$

$V_{21} = -0.1 + 0.003 = -0.097$

$V_{22} = 0.4 + 0.0005 = 0.4005$

$V_{02} = 0.5 + 0.0005 = 0.5005$

MATRIKAS

Date: 26/9/18

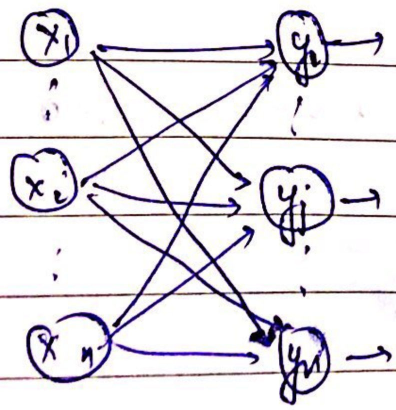
* ASSOCIATIVE MEMORIES.

- Application of NN.
- Memorization - first step of learning & testing.
- Two phases → Memorization - [W] calculation
  ↳ Recall. [Y]. calculation.
- Categories or Addressing mode → CAM → Content addressable Memory
  AAM → Address addressable Memory
- Categories on Association b/w i/p & o/p
  → Autoassociative — n i/p ⇒ n o/ps, $x_n = y_n$.
  ↳ Hetero Associative — n i/ps ⇒ m o/ps, $x_n \neq y_n$.

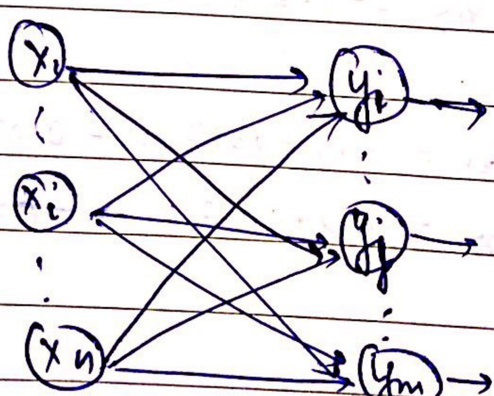
Weight calculation can be done by 2 rules

1. Hebb rule
2. Outer Product rule. $W = S^T t$

Autoassociative (Non-recurrent)



Heteroassociative (Non-recurrent)



MATRIKAS

Scanned with CamScanner

Date: / / /

$W = S^T t$

$y_{in} = xw$

$y = f(y_{in})$

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

$w = S^T t$

$y_{in} = xw$

$y = f(y_{in})$

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

in case of bipolar i/p & o/ps

$= \begin{cases} 1 & y_{in} > 0 \\ 0 & y_{in} \leq 0 \end{cases}$

in case of binary i/p & o/ps.

Q Train the autoassociative n/w for the pattern [-1 1 1 1] and test the n/w with same i/p vector.

$x = [-1\ 1\ 1\ 1] = y.$

$w = S^T t$

$= \begin{bmatrix} -1 \\ 1 \\ 1 \\ 1 \end{bmatrix}_{4\times1} \begin{bmatrix} -1 & 1 & 1 & 1 \end{bmatrix}_{1\times4}$

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

Date: / / /

$y_{in} = xW$

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

$\cancel{= \begin{bmatrix} -2 & 2 & 2 & 2 \end{bmatrix}}$

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

$Y = f(y_{in}) = \begin{bmatrix} -1 & 1 & 1 & 1 \end{bmatrix} = t.$

1/10/18 Missed Class Hetroassociative Memories.

3/10/18 Missed Class. (BAM) Bidirectional Associative Memories.

Date: 4/10/18.

	x_1	x_2	x_3	x_4	y_1	y_2		
S_1	1	0	0	0	1	0	t_1	[1 0 -1 -1]
S_2	1	0	0	1	1	0	t_2	[-1 0 0 -1]
S_3	0	1	0	0	0	1	t_3	[-1 1 0 -1]
S_4	0	1	1	0	0	1	t_4	[1 1 -1 -1]

Find the weight matrix in bipolar form for the given BAM using outer product rule.

Compute the following

(A) Test the response on each i/p data using unit step function.

(B) Test the response on missing & mistaken data.

[First convert S to ~~b~~ bipolar form].

$$w = [s_1^T t_1] + [s_2^T t_2] + [s_3^T t_3] + [s_4^T t_4]$$

$$= \begin{bmatrix} 1 \\ -1 \\ -1 \\ -1 \end{bmatrix} [1\ -1] + \begin{bmatrix} 1 \\ -1 \\ -1 \\ 1 \end{bmatrix} [1\ -1] + \begin{bmatrix} -1 \\ 1 \\ -1 \\ -1 \end{bmatrix} [-1\ 1] + \begin{bmatrix} -1 \\ 1 \\ 1 \\ -1 \end{bmatrix} [-1\ 1]$$

$$= \begin{bmatrix} 1 & -1 \\ -1 & 1 \\ -1 & 1 \\ -1 & 1 \end{bmatrix} + \begin{bmatrix} 1 & -1 \\ -1 & 1 \\ -1 & 1 \\ 1 & -1 \end{bmatrix} + \begin{bmatrix} 1 & -1 \\ -1 & 1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix} + \begin{bmatrix} 1 & -1 \\ -1 & 1 \\ -1 & 1 \\ 1 & -1 \end{bmatrix}$$

Date: / / /

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

$y = xw.$

$$y_1 = x_1 w = \begin{bmatrix} 1 & -1 & -1 & -1 \end{bmatrix} \begin{bmatrix} 4 & -4 \\ -4 & 4 \\ -2 & 2 \\ 2 & -2 \end{bmatrix} = \begin{bmatrix} 8 & -8 \end{bmatrix}$$

$$Y_1 = f(y_1) = \begin{bmatrix} 1 & -1 \end{bmatrix}$$

$$y_2 = x_2 w = \begin{bmatrix} 1 & -1 & -1 & 1 \end{bmatrix} \begin{bmatrix} 4 & -4 \\ -4 & 4 \\ -2 & 2 \\ 2 & -2 \end{bmatrix} = \begin{bmatrix} 12 & -12 \end{bmatrix}$$

$$Y_2 = f(y_2) = \begin{bmatrix} 1 & -1 \end{bmatrix}$$

$$y_3 = x_3 w = \begin{bmatrix} -1 & 1 & -1 & -1 \end{bmatrix} \begin{bmatrix} 4 & -4 \\ -4 & 4 \\ -2 & 2 \\ 2 & -2 \end{bmatrix} = \begin{bmatrix} -8 & 8 \end{bmatrix}$$

$$Y_3 = f(y_3) = \begin{bmatrix} -1 & 1 \end{bmatrix}$$

MATRIKAS

Date: / / /

$$y_4 = x_4 w = \begin{bmatrix} -1 & 1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 4 & -4 \\ -4 & 4 \\ -2 & 2 \\ 2 & -2 \end{bmatrix} = \begin{bmatrix} -12 & 12 \end{bmatrix}$$

$$y_4 = f(y_4) = [-1 \ 1]$$

$$x_1 = y_1 w^T$$
$$= [1 \ -1] \begin{bmatrix} 4 & -4 & -2 & 2 \\ -4 & 4 & 2 & -2 \end{bmatrix} = [8 \ -8 \ -4 \ 4]$$

$$x_1 = f(x_1) = [1 \ -1 \ -1 \ 1]$$ ⇒ Incorrect.

$$x_2 = y_2 w^T$$
$$= [1 \ -1] \begin{bmatrix} 4 & -4 & -2 & 2 \\ -4 & 4 & 2 & -2 \end{bmatrix} = [8 \ -8 \ -4 \ 4]$$

$$x_2 = f(x_2) = [1 \ -1 \ -1 \ 1]$$ ⇒ Correct.

$$x_3 = y_3 w^T$$
$$= [-1 \ 1] \begin{bmatrix} 4 & -4 & -2 & 2 \\ -4 & 4 & 2 & -2 \end{bmatrix} = [-8 \ 8 \ 4 \ -4]$$

$$x_3 = f(x_3) = [-1 \ 1 \ 1 \ -1]$$ ⇒ Incorrect.

$$x_4 = y_4 w^T$$
$$= [-1 \ 1] \begin{bmatrix} 4 & -4 & -2 & 2 \\ -4 & 4 & 2 & -2 \end{bmatrix} = [-8 \ 8 \ 4 \ -4]$$

$$x_4 = f(x_4) = [-1 \ 1 \ 1 \ -1]$$ ⇒ Correct.

Date: / / /

11/10/19 Q Construct ~~and test~~ a BAM n/w to associate letters 'T' & 'O' with simple bipolar i/p ~~to~~ & o/p vectors with matrix of size 4×3. The target o/p for T is [1, -1] and for 'O' is [1, 1].

```
*  *  *          *  *  *
•  *  •          *  •  *
•  *  •          *  •  *
•  *  •          *  *  *
```

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	y_1	y_2
1	1	1	-1	1	-1	-1	1	-1	-1	1	-1	1	-1
1	1	1	1	-1	1	1	-1	1	1	1	1	1	1

$$w = [s_1^T t_1] + [s_2^T t_2]$$

$$= \begin{bmatrix} 1 \\ 1 \\ 1 \\ -1 \\ 1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ 1 \\ -1 \end{bmatrix} [1 \ -1] + \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ 1 \\ 1 \\ -1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} [1 \ 1]$$

Date: / /

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

$$y = xw.$$

$$y_1 = x_1 w = \begin{bmatrix} 1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 2 & 0 \\ 2 & 0 \\ 0 & 2 \\ 0 & -2 \\ 0 & 2 \\ 0 & 2 \\ 0 & -2 \\ 0 & 2 \\ 0 & 2 \\ 2 & 0 \\ 0 & 2 \end{bmatrix}$$

$$= \begin{bmatrix} 8 & -16 \end{bmatrix}$$

$$Y_1 = f(y_1) = \begin{bmatrix} 1 & -1 \end{bmatrix}$$

Mention activation fn's.

Date: / / /

$$y_2 = x_2 w = \begin{bmatrix} 1 & 1 & 1 & 1 & -1 & 1 & 1 & -1 & 1 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 2 & 0 \\ 2 & 0 \\ 0 & 2 \\ 0 & -2 \\ 0 & 2 \\ 0 & 2 \\ 0 & -2 \\ 0 & 2 \\ 0 & 2 \\ 2 & 0 \\ 0 & 2 \end{bmatrix}$$

$$= \begin{bmatrix} 8 & 16 \end{bmatrix}$$

$$Y_2 = f(y_2) = \begin{bmatrix} 1 & 1 \end{bmatrix}.$$

BAM tests correctly for i/p to o/p layer.

$$x = y w^T$$

$$x_1 = y_1 w^T = \begin{bmatrix} 1 & -1 \end{bmatrix} \begin{bmatrix} 2 & 2 & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 2 & -2 & 2 & 2 & -2 & 2 & 2 & 0 & 2 \end{bmatrix}$$

$$= \begin{bmatrix} 2 & 2 & 2 & -2 & 2 & -2 & -2 & 2 & -2 & -2 & 2 & -2 \end{bmatrix}.$$

$$x_1 = f(x_1) = \begin{bmatrix} 1 & 1 & 1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 & -1 \end{bmatrix} = x_1$$

$\Rightarrow$ Correct.

$$x_2 = y_2 w^T = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 2 & 2 & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 2 & -2 & 2 & 2 & -2 & 2 & 2 & 0 & 2 \end{bmatrix}$$

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

$$x_1 = f(x_1) = \begin{bmatrix} 1 & 1 & 1 & 1 & -1 & 1 & 1 & -1 & 1 & 1 & 1 & 1 \end{bmatrix} = x_2$$

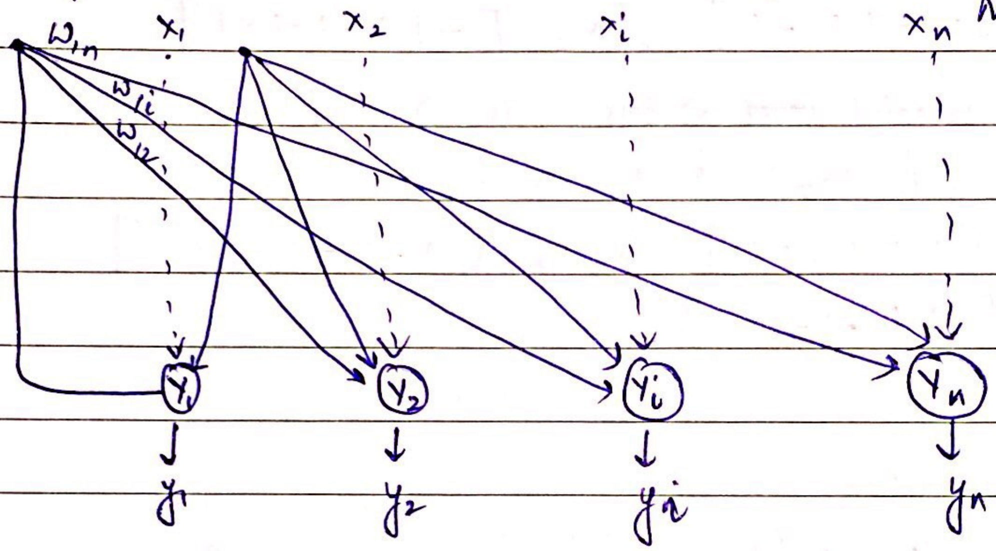
$\Rightarrow$ correct

BAM test correctly for o/p to i/p layer.

Date: 16 / 10 / 18

(Recurrent Autoassociative N/W).

* HOPFIELD NETWORKS. ⇒ Eg:- Content Addressable Memories.



- Discrete Hopfield N/W. & Continuous Hopfield N/W.

$$w_{ij} = \sum_{p=1}^{P} S_i(p) S_j(p) \quad i \neq j \quad \text{[Bipolar i/ps \& targets]}$$

$$w_{ij} = \sum_{p=1}^{P} [2S_i(p) - 1][2S_j(p) - 1] \quad i \neq j$$

[Binary i/ps & targets].

$$Y_i = x_i$$

$$Y_{inj} = x_i = \sum y_j w_{ji}$$

$w_{ii} = 0$ (Because No self loop)

$$y_j = \begin{cases} 1 & y_{in} > \theta \\ y_j & y_{in} = \theta \\ 0 & y_{in} < \theta \end{cases}$$

Lyapinov EF

$$E = -\frac{1}{2} [x_i w^T x_i^T]$$

Date: / / /

Q Construct an auto associative n/w x_1 [1 1 1 1 1] x_2 [1 -1 -1 1 -1], x_3 [-1 1 -1 -1 -1]
Find the weight ~~vect~~ vector with no self connection used discrete hopfield n/w to test the patterns for x_1 [1 1 1 -1 1] for x_2 [1 -1 -1 -1 -1] for x_3 [1 1 -1 -1 -1]

$$W = W_1 + W_2 + W_3$$

$$= s_1^T t_1 + s_2^T t_2 + s_3^T t_3$$

$$= \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \end{bmatrix} + \begin{bmatrix} 1 \\ -1 \\ -1 \\ 1 \\ -1 \end{bmatrix} \begin{bmatrix} 1 & -1 & -1 & 1 & -1 \end{bmatrix} + \begin{bmatrix} -1 \\ 1 \\ -1 \\ -1 \\ -1 \end{bmatrix} \begin{bmatrix} -1 & 1 & -1 & -1 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix} + \begin{bmatrix} 1 & -1 & -1 & 1 & -1 \\ -1 & 1 & 1 & -1 & 1 \\ -1 & 1 & 1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 \\ -1 & 1 & 1 & -1 & 1 \end{bmatrix} + \begin{bmatrix} 1 & -1 & 1 & 1 & 1 \\ -1 & 1 & -1 & -1 & -1 \\ 1 & -1 & 1 & 1 & 1 \\ 1 & -1 & 1 & 1 & 1 \\ 1 & -1 & 1 & 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 3 & -1 & 1 & 3 & 1 \\ -1 & 3 & 1 & -1 & 1 \\ 1 & 1 & 3 & 1 & 3 \\ 3 & -1 & 1 & 3 & 1 \\ 1 & 1 & 3 & 1 & 3 \end{bmatrix}$$

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

$$x_1' = [1 \; 1 \; 1 \; -1 \; 1]$$

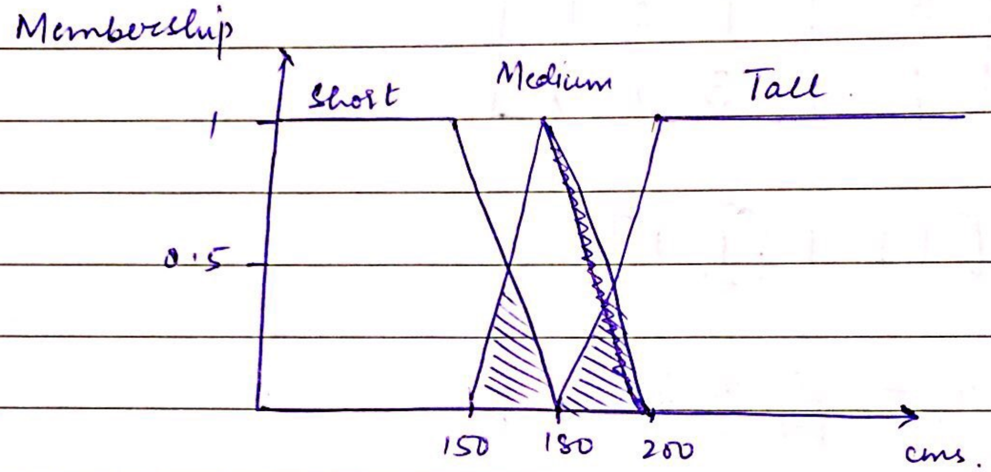
$$y_{in} = x_4 + \sum_{j=1}^{4} y_j \, w_{j4}$$

$$= -1 + [1 \; 1 \; 1 \; -1 \; 1] \begin{bmatrix} 3 \\ -1 \\ -1 \\ 0 \\ 1 \end{bmatrix}$$

Date: 23/10/18

FUZZY LOGIC (FL)

- Lofti A. Zadeh.



$\underbrace{0 \& 1}$ ⇒ Discrete form
Crisp Logic

Degree of Vagueness.

$\tilde{A} = \left\{ \frac{2}{0.5}, \frac{2}{0}, \frac{3}{1} \right\}$

fuzzy set

(degree of Membership). Membership fn.

χ_A

$\mu_A(1) = 0.5$

Knowledge Base used to form different rules ⇒ Rule Base which is then used by inference ~~base~~ system.

Date: / / /

$\boxed{KB} \rightarrow \boxed{RB} \rightarrow \boxed{IS}$

(If then clauses).

↪ required for classification.

Rules can be combined using and & or.

MATRIKAS