Q The following data pairs are applied to a single perceptron ANN assume bipolar binary activation function is used and initial weights = [0.4 -0.1 0.6]; $\alpha = 0.2$, $X_1 = [5\ -2\ -3]$, $d_1 = -1$, $X_2 = [4\ 2\ 1]$ $d_2 = 1$ after two steps of perceptron learning rule the weights will be equal to

(a) [0 1.5 2.2]
(b) [0.8 2.1 -0.2]
(c) [1.7 -1.1 0.4]
(d) [-0.6 2.5 3.1]

ans
= ∵ bipolar binary

$$f(net) = \begin{cases} 1 & net \geq 0 \\ -1 & net < 0 \end{cases}$$

Step 1 $\quad w^{1t} = [0.4\ -0.1\ 0.6] \quad X_1 = \begin{bmatrix} 5 \\ -2 \\ -3 \end{bmatrix} \quad d_1 = -1$

$$net^1 = w^{1t} X_1 = [0.4\ -0.1\ 0.6]\begin{bmatrix} 5 \\ -2 \\ -3 \end{bmatrix} = 0.4 \geq 0$$

$$\therefore f(net^1) = 1$$

$$w^2 = w^1 + \alpha(d_1 - f(net^1))X_1$$

$$= \begin{bmatrix} 0.4 \\ -0.1 \\ 0.6 \end{bmatrix} + 0.2(-1-1)\begin{bmatrix} 5 \\ -2 \\ -3 \end{bmatrix} = \begin{bmatrix} 0.4 \\ -0.1 \\ 0.6 \end{bmatrix} - 0.4\begin{bmatrix} 5 \\ -2 \\ -3 \end{bmatrix}$$

$$= \begin{bmatrix} 0.4 \\ -0.1 \\ 0.6 \end{bmatrix} - \begin{bmatrix} 2 \\ -0.8 \\ -1.2 \end{bmatrix} = \begin{bmatrix} -1.6 \\ 0.7 \\ 1.8 \end{bmatrix}$$

step₂ $W^2 = \begin{bmatrix} -1.6 \\ 0.7 \\ 1.8 \end{bmatrix}$ $X_2 = \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix}$ $d_2 = 1$

$$net^2 = \begin{bmatrix} -1.6 & 0.7 & 1.8 \end{bmatrix} \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix} = -3.2 < 0$$

$$f(net^2) = -1$$

$$W^3 = W^2 + \alpha(d_2 - f(net^2))X_2$$

$$= \begin{bmatrix} -1.6 \\ 0.7 \\ 1.8 \end{bmatrix} + 0.2(1-(-1)) \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} -1.6 \\ 0.7 \\ 1.8 \end{bmatrix} + 0.4 \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} -1.6 \\ 0.7 \\ 1.8 \end{bmatrix} + \begin{bmatrix} 1.6 \\ 0.8 \\ 0.4 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 1.5 \\ 2.2 \end{bmatrix}$$

$\therefore$ a

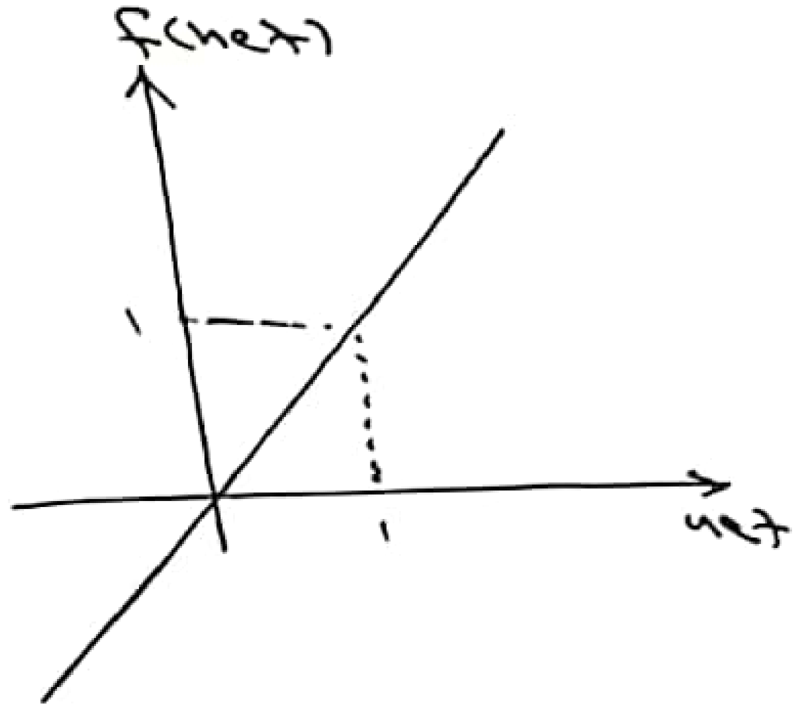
$$\therefore W = \begin{bmatrix} 0 & 1.5 & 2.2 \end{bmatrix}$$

* linear activation function

$f(net) \propto net$

if linear

$f(net) = net$



or

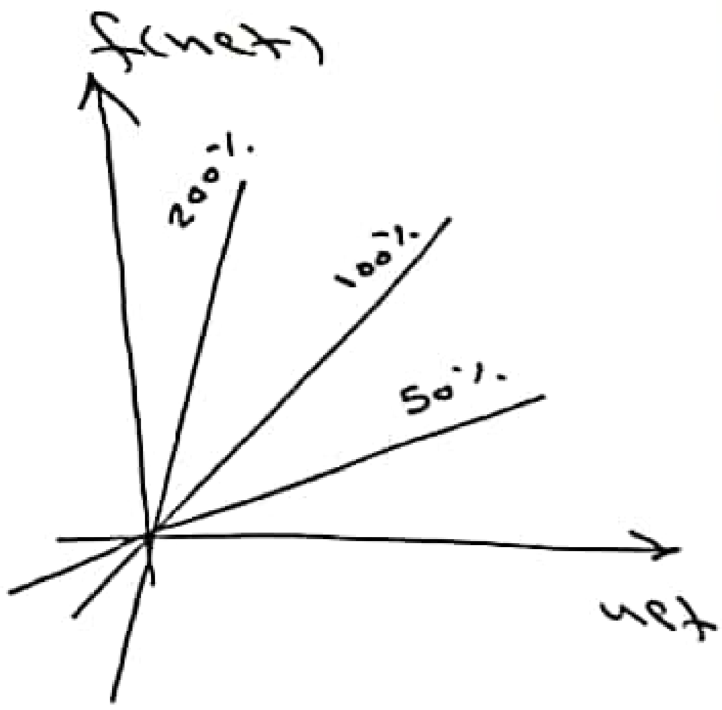
$$\boxed{f(net) = K\,(net)}$$

proportionality constant

→ if slope of linear is 50%

$f(net) = \frac{50}{100}\, net$

$f(net) = 0.5\, net$



→ if slope is 200%

$f(net) = \frac{200}{100}\, net$

$f(net) = 2\, net$

→ if constant of proportionality is 5

$f(net) = 5\, net$

ADLINE leaning Rules

- use linear activation function
- update for wieght

$$\boxed{W^2 = W^1 + \alpha (d_1 - f(net)) X_1}$$

$f(net) = K\, net$ linear activation function

ثابت التناسب

Q ADLINE leaning rule with linear activation function with

$W^1 = [0.5 \ -0.2 \ 0.4]$

$X_1 = [3 \ -2 \ 1]$ $d_1 = -1$

$X_2 = [1 \ -2 \ -1]$ $d_2 = 1$

use four steps to update the weights use leaning rate $\alpha = 0.8$

ans $f(net) = net$

$$W^2 = W^1 + \alpha (d_1 - net) X_1$$

$$net_1 = [0.5 \ -0.2 \ 0.4] \begin{bmatrix} 3 \\ -2 \\ 1 \end{bmatrix} = 2.3$$

$$W^2 = \begin{bmatrix}0.5\\-0.2\\0.4\end{bmatrix} + 0.8(-1-2.3)\begin{bmatrix}3\\-2\\1\end{bmatrix} = \begin{bmatrix}-7.42\\5.08\\-2.24\end{bmatrix}$$

Step2

$$W^3 = W^2 + \alpha(d_2 - net^2)X_2$$

$$net^2 = \begin{bmatrix}-7.42 & 5.08 & -2.24\end{bmatrix}\begin{bmatrix}1\\-2\\-1\end{bmatrix} = -15.34$$

$$W^3 = \begin{bmatrix}-7.42\\5.08\\-2.24\end{bmatrix} + 0.8(1-(-15.34))\begin{bmatrix}1\\-2\\1\end{bmatrix} = \begin{bmatrix}5.65\\-21.06\\-15.31\end{bmatrix}$$

Step3

$$W^4 = W^3 + \alpha(d_3 - net_3)X_3$$

when $X_3 = X_1$ $\quad d_3 = d_1$

$$net_3 = \begin{bmatrix}5.65 & -21.06 & -15.31\end{bmatrix}\begin{bmatrix}3\\-2\\1\end{bmatrix} = 43.76$$

$$W^4 = \begin{bmatrix}5.65\\-21.06\\-15.31\end{bmatrix} + 0.8(-1-43.76)\begin{bmatrix}3\\-2\\1\end{bmatrix} = \begin{bmatrix}-101\\50\\-51\end{bmatrix}$$

Step4 عليكم $\quad X_4 = X_2$

$d_4 = d_2$

⑥ a neuron learned with ADALINE learning rule and has the weight vector [1.5 0.5 2 3] the activation function is linear, where the constant of proportional equal 3. if The input vector is $x = [4\ 8\ 5\ 6]$ then the output of The neuron of The neuron will be

ⓐ 37
ⓑ 114
ⓒ 59
ⓓ 1
ⓔ 118

ans

$$W = [1.5\ \ 0.5\ \ 2\ \ 3]$$

$$f(net) = 3net$$

$$X = [4\ \ 8\ \ 5\ \ 6]$$

$$f(net) = ?$$

$$net = W^t X = [1.5\ \ 0.5\ \ 2\ \ 3] \begin{bmatrix} 4 \\ 8 \\ 5 \\ 6 \end{bmatrix}$$

$$= 6 + 4 + 10 + 18$$

$$= 38$$

$$f(net) = 3(38)$$

$$= 114 \qquad \therefore \text{ⓑ}$$

* continous unipolar sigmoid

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

$$f'(net) = f(net)(1-f(net))$$

* continous bipolar

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

$$f'(net) = \frac{1}{2}(1-f^2(net))$$

Note

$O \equiv output \equiv f(net)$

Q The drevative of sigmoid function $f(x)$ is

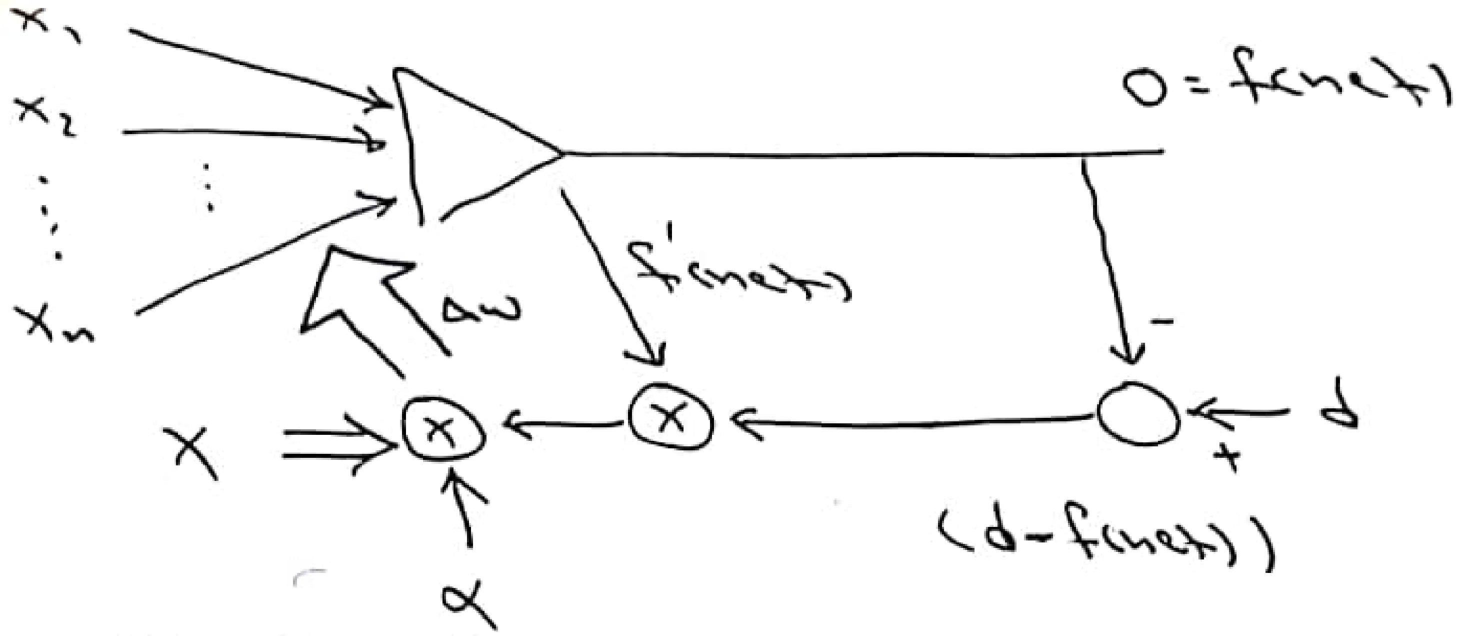
ⓐ $f(x)(f(x)-1)$

ⓑ $f(x)(-f(x)+1) \Rightarrow f(x)(1-f(x))$ ✓

ⓒ $-f(x)(1+f(x))$

ⓓ $f(x)(1+f(x))$

Delta leaving Rule



$$\boxed{W^{new} = W^{old} + \alpha\,(d^{old} - O^{old})\,f'(net)_{old}\,X_{old}}$$

$\alpha = \eta \Rightarrow$ leaving rate.

$$f'(net) = f(net)(1 - f(net)) \qquad \text{continuous unipolar}$$
$$= O\,(1 - O)$$

$$f'(net) = \frac{1}{2}(1 - f^2(net)) \qquad \text{continuous bipolar}$$
$$= \frac{1}{2}(1 - O^2)$$

Ex for the network use Delta learning rule with <u>bipolar continous</u> activation function, assume $\eta = 0.1$ $\lambda = 1$ initial value for weight vector

$W = [1 \ -1 \ 0 \ 0.5]$ $d_1 = -1, d_2 = -1, d_3 = 1$

$$X_1 = \begin{bmatrix} 1 \\ -2 \\ 0 \\ -1 \end{bmatrix}, \quad X_2 = \begin{bmatrix} 0 \\ 1.5 \\ -0.5 \\ -1 \end{bmatrix}, \quad X_3 = \begin{bmatrix} -1 \\ 1 \\ 0.5 \\ -1 \end{bmatrix}$$

ans

$$f'(net) = \frac{1}{2}(1 - f^2(net_1))$$

step 1

$$net_1 = [1 \ -1 \ 0 \ 0.5]\begin{bmatrix} 1 \\ -2 \\ 0 \\ -1 \end{bmatrix} = 2.5$$

$$f(net_1) = \frac{2}{1+e^{-2.5}} - 1 = 0.848$$

$$f'(net_1) = \frac{1}{2}(1 - 0.848^2) = 0.14$$

$$W^2 = W^1 + \eta(d_1 - f(net^1))f'(net^1)X_1$$

$$= \begin{bmatrix} 1 \\ -1 \\ 0 \\ 0.5 \end{bmatrix} + 0.1(-1 - 0.848)(0.14)\begin{bmatrix} 1 \\ -2 \\ 0 \\ -1 \end{bmatrix}$$

$$W^2 = \begin{bmatrix} 0.974 \\ -0.948 \\ 0 \\ 0.526 \end{bmatrix}$$

Step2

$$net_2 = [0.974 \quad -0.948 \quad 0 \quad 0.526] \begin{bmatrix} 0 \\ 1.5 \\ -0.5 \\ -1 \end{bmatrix} = -1.948$$

$$f(net_2) = \frac{2}{1 + e^{-(-1.948)}} - 1 = -0.75$$

$$f'(net_2) = \frac{1}{2}\left(1 - (-0.75)^2\right) = 0.21$$

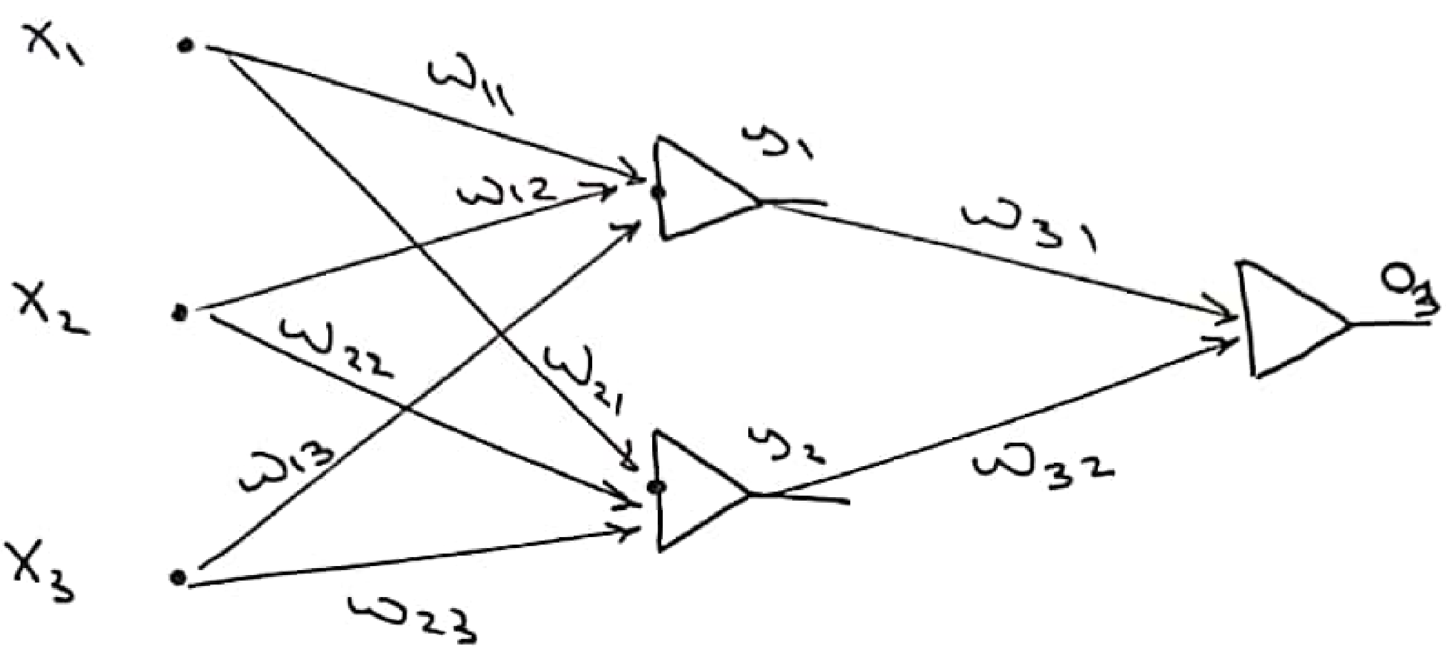
$$w^3 = w^2 + \eta\left(d_2 - f(net^2)\right) f'(net_2)\, X_2$$

$$= \begin{bmatrix} 0.979 \\ -0.948 \\ 0 \\ 0.526 \end{bmatrix} + 0.1\left(-1 - (-0.75)\right)(0.21) \begin{bmatrix} 0 \\ 1.5 \\ -0.5 \\ -1 \end{bmatrix}$$

$$= \begin{bmatrix} 0.975 \\ -0.956 \\ 0.002 \\ 0.531 \end{bmatrix}$$

Step3 عليكم

Back Propagation Training "EBPT" or BP



$$w_{new} = w_{old} + \eta \, \delta_{y_j} x_i$$

$$w_{new} = w_{old} + \eta \, \delta_{oK} y_j$$

$$net\ y_j \Rightarrow y_j = f(net_j)$$

$$net\ o_K \Rightarrow O_K = f(net_K)$$

$$\delta_{oK} = (d_K - O_K) \, f'(net_K)$$

$$\delta_{y_j} = f'(net_y) \sum_{K=1}^{K} \delta_{oK} \, w_{Kj}$$

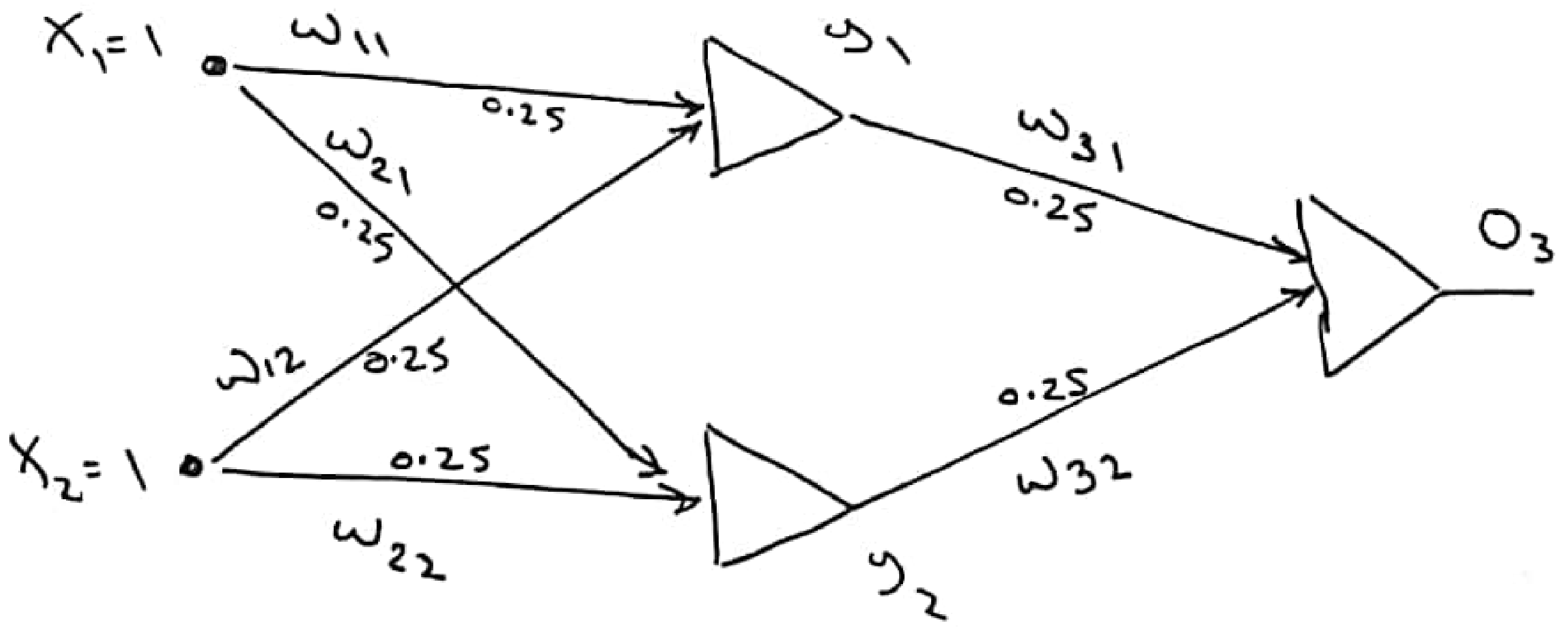
after applying Back Propagation algorithm to find the new weight of feed forward neural assume input pattern [1, 1] and desired output $O_3 = 0.85$. assume network has single hidden layer with 2 neurons and single output neuron. and all weight are initially to (0.25). All neurons use bipolar continous activition function $\lambda = 1$, $\eta = 0.5$ find new weights

ans

∵ input pattern [1,1] ∴ 2 input

single hidden layer 2 neroun

single output 1 output



$net_1 = X_1 \omega_{11} + X_2 \omega_{12} = 1 \times 0.25 + 1 \times 0.25 = 0.5$

$y_1 = f(net_1) = \dfrac{2}{1 + e^{-0.5}} - 1 = \underline{\underline{0.245}}$

$net_2 = X_1 \omega_{21} + X_2 \omega_{22} = 0.5$ $\qquad y_2 = \underline{\underline{0.245}}$

$$net_3 = y_1 w_{31} + y_2 w_{32}$$
$$= 0.245 \times 0.25 + 0.245 \times 0.25$$
$$= 0.1225$$

$$O_3 = f(net_3) = \frac{2}{1 + e^{-0.1225}} - 1 = 0.061$$

$$\delta_{O_3} = (d_3 - O_3) \overbrace{\frac{1}{2}(1 - O_3^2)}^{f'(net_3)}$$

$$= (0.85 - 0.061) \frac{1}{2}(1 - (0.061)^2)$$

$$= 0.393$$

$$\delta y_1 = f'(net_{y_1}) \delta_{O_3} w_{31}$$
$$= \frac{1}{2}(1 - y_1^2) \delta_{O_3} w_{31}$$
$$= \frac{1}{2}(1 - 0.245^2)(0.393)(0.25)$$
$$= 0.0461$$

$$\delta y_2 = f'(net_{y_2}) \delta_{O_3} w_{32}$$
$$= \frac{1}{2}(1 - 0.245^2)(0.393)(0.25)$$
$$= 0.0461$$

$$w_{11}^{new} = w_{11}^{old} + \eta \delta y_1 x_1$$
$$= 0.25 + 0.5(0.0461)(1)$$
$$w_{11}^{new} = 0.273$$

$$w_{21}^{new} = w_{21}^{old} + \eta \delta y_2 x_1 = 0.273$$

$$w_{21} = w_{22} = 0.273$$

$$w_{31}^{new} = w_{31}^{old} + \eta \delta_{o3} y_1$$

$$= 0.25 + 0.5(0.393)(0.245)$$

$$w_{31}^{new} = 0.298$$

$$w_{32}^{new} = w_{32}^{old} + \eta \delta_{o3} y_2$$

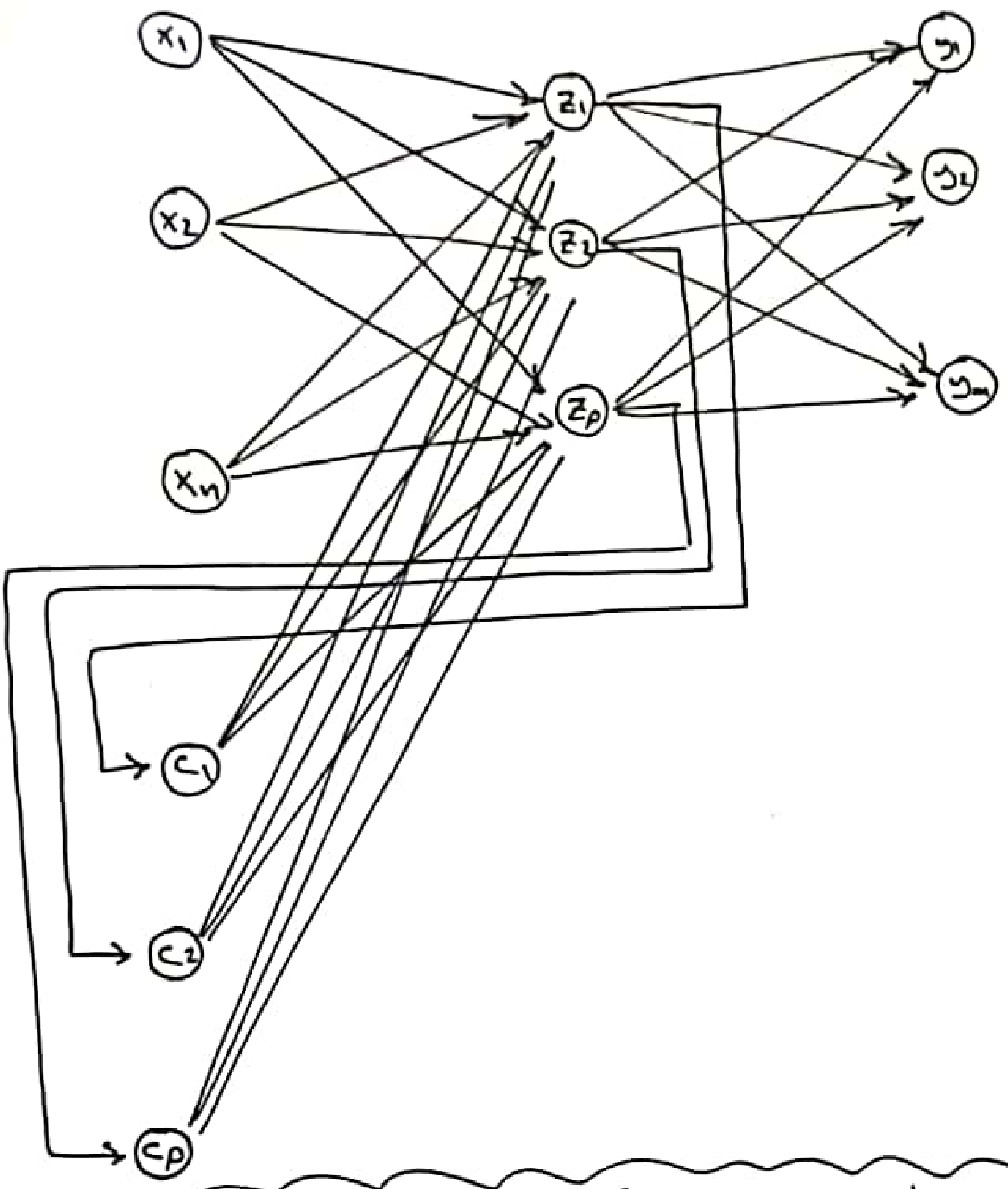
$$= 0.25 + 0.5(0.393)(0.245)$$

$$= 0.298$$

$$w_{11} = w_{12} = w_{21} = w_{22} = 0.273$$

$$w_{31} = w_{32} = 0.298$$

Elman Neural network



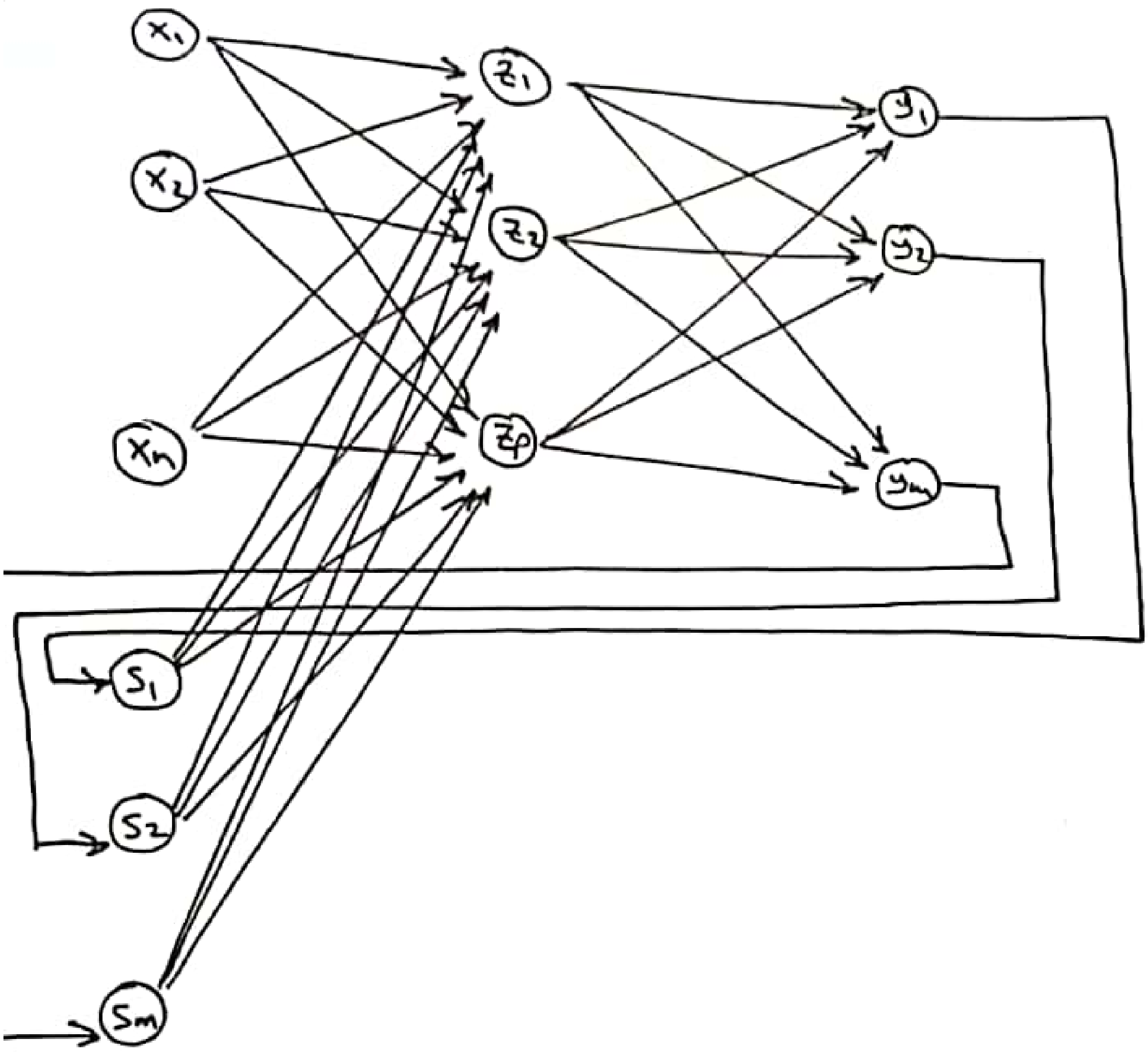
context unit = no. of neroun in hidden layer

ex input 5 hidden neroun 4 output 3
Elman

ans: total no. of weight $= 5\times4 + 4\times3 + 4\times4$
$= 20 + 12 + 16$
$= 48$

no. of context unit = 4

Jordan Neural network



State unit = no. of neuron in output

Q in a jordan network with (5) input neurons 4 hidden layer neurons and (3) output neurons Then the number of neurons will there be in the state vector is

a) 5
b) 15
c) 20
d) 3

ans: input 5 4 hidden 3 output

∴ no. of neuron in state vector = output = 3 ∴ d

note total no. of wieght $= 5\times4 + 4\times3 + 3\times4$
$= 20 + 12 + 12 = 44$