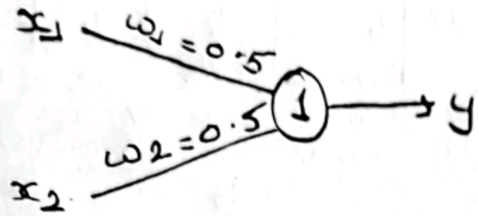
2078 NN

1. Consider following ANN with logistic activation function Calculate weights update for the training sample (0.7, 0.3, 0.6) using momentum Assume $\alpha = 1$, $\beta = 0.8$



Logistic function

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

$x_1 = 0.7$, $x_2 = 0.3$, $t = 0.6$.

$$y_{in} = x_1 \cdot w_1 + x_2 \cdot w_2$$
$$= 0.7 \times 0.5 + 0.8 \times 0.5$$
$$= 0.35 + 0.15$$
$$= 0.5$$

For training example

$$y = \frac{1}{1+e^{(-y_{in})}}$$
$$= \frac{1}{1+e^{(-0.5)}}$$
$$= \frac{1}{1+0.606} = \frac{1}{1.606} = 0.6227$$

$$dw_1 = (y-t) \times y(1-y) \cdot x_1$$
$$= (0.6227 - 0.6) \times 0.6227(1-0.6227) \cdot 0.7$$
$$= 0.0227 \times 0.1644$$
$$= 0.00373$$

$$dw_2 = (y-t) \times y(1-y) \cdot x_2$$
$$= (0.6227 - 0.6) \times 0.6227(1-0.6227) \cdot 0.3$$
$$= 0.0227 \times 0.0704$$
$$= 0.00159$$

Now,

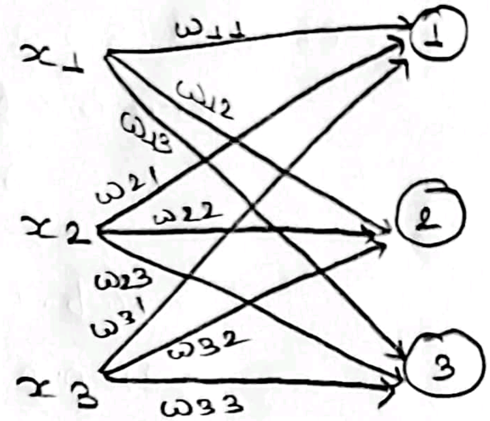
$$V_1 = \beta \cdot V_0 + (1-\beta) \cdot dw_1$$
$$= 0.8 \times 0 + (1-0.8) \times 0.00373$$
$$= 0 + 0.2 \times 0.00373$$
$$= 0.000746$$

$$V_2 = \beta \cdot V_0 + (1-\beta) \cdot dw_2$$
$$= 0 + 0.2 \times 0.00159$$
$$= 0.000318$$

$$w_1(new) = w_1 old - \alpha \cdot V_1$$
$$= 0.5 - 1 \times 0.000746$$
$$= 0.4992$$

$$w_2(\cancel{old}) = w_2 old - \alpha \cdot V_2$$
$$= 0.5 - 1 \times 0.000318$$
$$= 0.5 - 0.000318$$
$$= 0.4996$$

2. Consider following 1-D SOM and initial weight Matrix. Show, the working of SOM for the input (0·2, 0·1, 0·3)



Initial weight Matrix

0·1	0·2	0·3
0·2	0·4	0·5
0·3	0·6	0·4

Solution:-

Input (0·2, 0·1, 0·3)

Euclidean distance between the input and weight vector of each output neuron.

$$d_1 = d(x, w_1) = \sqrt{(0.2-0.1)^2+(0.1-0.2)^2+(0.3-0.3)^2}$$
$$= \sqrt{(0.1)^2+(-0.1)^2+0}$$
$$= \sqrt{0.01+0.01}$$
$$= \sqrt{0.02} = 0.14$$

$$d_2 = d(x, w_2) = \sqrt{(0.2-0.2)^2+(0.1-0.4)^2+(0.3-0.6)^2}$$
$$= \sqrt{0+(-0.3)^2+(-0.3)^2}$$
$$= \sqrt{0.09+0.09} = \sqrt{0.18} = 0.42$$

$$d_3 = d(x, w_3) = \sqrt{(0.2-0.3)^2+(0.1-0.5)^2+(0.3-0.4)^2}$$
$$= \sqrt{(-0.1)^2+(-0.4)^2+(-0.1)^2}$$
$$= \sqrt{0.01+0.16+0.01}$$
$$= \sqrt{0.18} = 0.42$$

Clearly neuron 1 is winner.

Now,

Updating weights assuming $\alpha = 1$ $\sigma = 1$

We know,

$$w_j(n+1) = w_j(n) + \alpha . h_{ji}(x - w_j(n))$$

$$h_{ji(\vec{x})} = \exp\left(-\frac{d_{ji}^2}{2\sigma^2}\right)$$

Now,

$$h_{11} = \exp\left(-\frac{(1-1)^2}{2 . 1^2}\right) = \exp\left(0/2\right)$$
$$= \exp(0)$$
$$= 1$$

Now,

$$w_{11} = w_{11} + 1 . 1 (0.2 - 0.1)$$
$$= 0.1 + 0.1$$
$$= 0.2$$

$$w_{21} = w_{21} + 1 . 1 (0.1 - 0.2)$$
$$= 0.2 + 1(-0.1)$$
$$= 0.2 - 0.1$$
$$= 0.1$$

$$w_{31} = 0.3 + 1 \times 1 (0.3 - 0.3)$$
$$= 0.3 + 0$$
$$= 0.3 .$$

Similarly,

$$h_{21} = \exp\left(-\frac{(2-1)^2}{2}\right) = \exp\left(-\frac{1}{2}\right) = 0.6$$

Now,

$$w_{12} = 0.2 + 1 \times 0.6 (0.2 - 0.2)$$
$$= 0.2 + 0 = 0.2$$

$$w_{22} = 0.4 + 1 \times 0.6 (0.1 - 0.4)$$
$$= 0.4 + 0.6(-0.3)$$
$$= 0.4 - 0.18$$
$$= 0.22$$

$$w_{32} = 0.6 + 1 \times 0.6(0.3 - 0.6)$$
$$= 0.6 + 0.6(-0.3)$$
$$= 0.6 - 0.18$$
$$= 0.22.$$

also,

$$h_{31} = \exp\left(-\frac{(3-1)^2}{2 \cdot 1^2}\right) = \exp\left(-\frac{4}{2}\right) = 0.135$$

$$w_{13} = 0.3 + 1 \times 0.135(0.2 - 0.3)$$
$$= 0.3 + 0.135(-0.1)$$
$$= 0.3 - 0.0135$$
$$= 0.2865$$

$$w_{23} = 0.5 + 1 \times 0.135(0.1 - 0.5)$$
$$= 0.5 + 0.135(-0.4)$$
$$= 0.5 - 0.054$$
$$= 0.446.$$

$$w_{33} = 0.4 + 1 \times 0.135(0.3 - 0.4)$$
$$= 0.4 + 0.135(-0.1)$$
$$= 0.4 - 0.0135$$
$$= 0.3865$$

3. Fit the quadratic curve through the following data using gradient descent. Show one epoch of training

x	1	2	3	4
$y=f(x)$	1	1	4	9

Solution:-

General form of quardatic equation is

$$y = w_0 + w_1 x + w_2 x^2$$

Assume the initial values of parameters are.

$$w_0 = w_1 = w_2 = 0.$$

Let $\alpha = 0.01$

Iteration 1

$x=1,\ y=f(x)=1,$

$$w_0 = w_0 + \alpha(y - w_0 - w_1 x - w_2 x^2$$

$$= 0 + 0.01(1 \cancel{-0})$$

$$= 0 + 0.01$$

$$= 0.01$$

$$w_1 = w_1 + \alpha(y - w_0 - w_1 x - w_2 x^2)x$$

$$= 0 + 0.01(1)\cdot 1$$

$$= 0.01$$

$$w_2 = w_2 + \alpha(y - w_0 - w_1 x - w_2 x^2)x^2$$

$$= 0 + 0.01(1)\times 1^2$$

$$= 0.01$$

Iteration 2 $x=2,\ \cancel{y}=fx=1$

$$w_0 = w_0 + \alpha(y - w_0 - w_1 x - w_2 x^2)$$

$$= 0.01 + 0.01(1 - 0.01 - 0.01\times 2 - 0.01\times 4)$$

$$= 0.01 + 0.01(1 - 0.01 - 0.02 - 0.04)$$

$$= 0.01 + 0.01(\cancel{0}\ 0.93)$$

$$= 0.01 + \cancel{0.01\times 0.07}\ 0.0093$$

$$= \cancel{0.01 + 0.0007} \quad = 0.0193$$

$$= \cancel{0.0107}$$

$$w_1 = w_1 + \alpha(y - w_0 - w_1 x - w_2 x^2)x$$
$$= 0.01 + 0.01(1 - 0.01 - (0.01\times2) - (0.01\times4))2$$
$$= 0.01 + 0.02(0.93)$$
$$= 0.0286$$

$$w_2 = w_2 + \alpha(y - w_0 - w_1 x - w_2 x^2)x^2$$
$$= 0.01 + 0.01(1 - 0.01 - (0.01\times2) - (0.01\times4))4$$
$$= 0.01 + 0.04(0.93)$$
$$= 0.0472.$$

Iteration 3 $x = 3$ $y = f(n) = 4$

$$w_0 = w_0 + \alpha(y - w_0 - w_1 x - w_2 x^2)$$
$$= 0.0193 + 0.01(4 - 0.0193 - (0.0286\times3) - (0.0472\times9))$$
$$= 0.0193 + 0.01\times3.47$$
$$= 0.054$$

$$w_1 = w_1 + \alpha(y - w_0 - w_1 x - w_2 x^2)\cdot x.$$
$$= 0.0286 + 0.01\times3(4 - 0.0193 - (0.0286\times3) - (0.0472\times9))$$
$$= 0.0286 + 0.03\times3.47$$
$$= 0.1327$$

$$w_2 = w_2 + \alpha(y - w_0 - w_1 x - w_2 x^2)\cdot x^2$$
$$= 0.0472 + 0.01(4 - 0.0193 - (0.0286\times3) - (0.0472\times9))\cdot9$$
$$= 0.0472 + 0.09(3.47)$$
$$= 0.3595$$

Iteration 4 $x = 4$ $y = f(n) = 9$

$$w_0 = w_0 + \alpha(y - w_0 - w_1 x - w_2 x^2)$$
$$= 0.054 + 0.01(9 - 0.054 - (0.1327\times4) - (0.3595\times16))$$
$$= 0.054 + 0.01(2.66)$$
$$= 0.0806$$

$$w_1 = w_1 + \alpha(y - w_0 - w_1 x - w_2 x^2)\cdot x.$$
$$= 0.1327 + 0.01\times4(9 - 0.054 - (0.1327\times4) - (0.3595\times16))$$
$$= 0.1327 + 0.01\times4\times2.66$$
$$= 0.2391$$

$$w_2 = w_2 + \alpha(y - w_0 - w_1 x - w_2 x^2)\cdot x^2$$
$$= 0.3595\times0.01(2.66)\cdot16$$
$$= 0.7851$$

4. Train perceptron up to one epoch using given training set and predict class for input (20, High)

Hair length	Sound pitch	Gender Cclass
18	High	Female
24	High	Female
3	Low	Male
8	Low	Male

Doubtful

Solution:-

Normalize input hair length and encode input sound pitch and target Gender.

Using Min Max scaling.

$$y = \frac{x - Min}{Max - Min}.$$

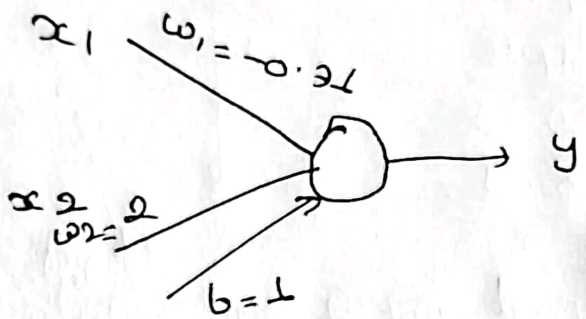
$$\text{Scaling of } 18 = \frac{18-3}{24-3} = 0.71.$$

Similarly normalizing other values.

Hair length x_1	sound pitch x_2	Gender (class)
0.71	-1	-1
1.00	-1	-1
0.00	1	1
0.23	1	1

Input	w_1	w_2	b	v	y	w_1(new)	w_2(new)	b new
0.71,-1,-1	0	0	0	0	0	$0+1\times 0.71(-1-0)$ $= 0+(-0.71$ $=-0.71$	$0+1\times-1(-1-0)$ -1	$0+1(-1-0)$ $=-1$
1,-1,-1	-0.71	1	-1	-2.71	-1	$-0.71+1\times1(-1+1)$ $=-0.71$	$1+1\times-1(-1+1)$ $=1$	$-1+1(-1+1)$ $=-1$
0,1,1	-0.71	1	-1	0	0	$-0.71+1\times0(1-0)$ $=-0.71$	$1+1\times1(1-0)$ $=1+1=2$	$-1+1(1-0)$ $=-1+1$ $=0$
0.23,1,1	-0.71	2	0	1.836	1	$-0.71+0.23(1-1)$ $=-0.71$	$2+1\times1(1-1)$ $=2$	$1+1(1-1)$ $=1$

Thus the final perceptron is as below.



for (20, High)

Normalized $= \frac{20-3}{24-3} = \frac{17}{21} = 0.8095$

Encoded value of High -1

$\therefore V = -0.71 \times 0.8095 + 2 \times -1 + 1$

$= -0.5747 - 2 + 1$

$= -1.5747$.

thus $y = -1$

Hence predicted class for (20, High) is female.

2080 Second terminal

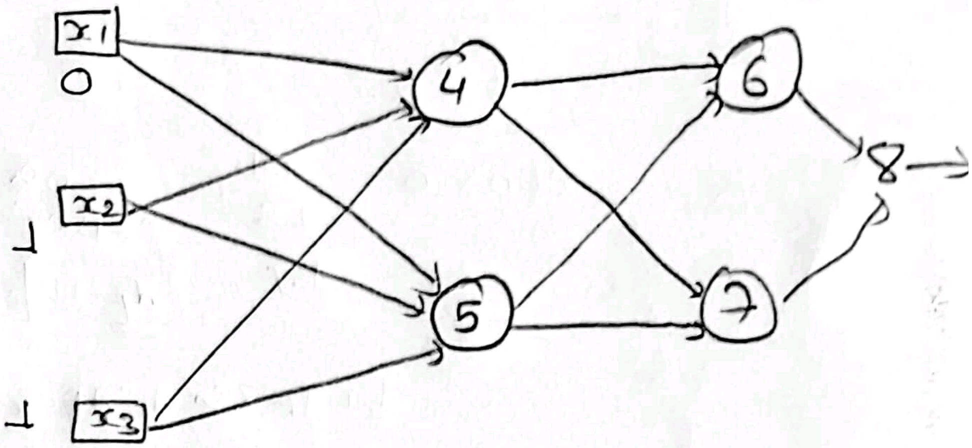
5. Consider MLP given below Let learning rate be 1. The initial weights of a network is given in table below. Assume first training tuple is (0,1,1) and its target output is 1. Calculate weight updates by using back propogation algorithm. Assume logistic activation function.

logistic function

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

$T=1$

$\alpha=1$



w_{14}	w_{15}	w_{24}	w_{25}	w_{34}	w_{35}	w_{46}	w_{47}	w_{56}	w_{57}	w_{68}	w_{78}
0.6	0.4	0.2	-0.3	0.7	-0.6	0.4	0.7	0.1	0.8	0.2	0.5

Solution

For forward pass

$$V_4 = x_1 \cdot w_{14} + x_2 \cdot w_{24} + x_3 \cdot w_{34}$$
$$= 0 * 0.6 + 1 \times 0.2 + 1 \times 0.7$$
$$= 0 + 0.2 + 0.7$$
$$= 0.9$$

$$y_4 = \frac{1}{1+e^{-0.9}} = 0.71$$

$$V_5 = 0 \times 0.4 + 1 \times (-0.3) + 1 \times (-0.6)$$
$$= -0.3 - 0.6$$
$$= -0.9$$

$$y_5 = \frac{1}{1+e^{-(-0.9)}} = \frac{1}{1+e^{0.9}}$$
$$= 0.28$$

$$\delta_4 = y_4(1-y_4)(\delta_7 \times \omega_{74} + \delta_6\, \omega_{64})$$
$$= 0.71(1-0.71)(0.014 \times 0.7 + 0.0059 \times 0.4)$$
$$= 0.0025$$

Now,

updating the weights.

$$\omega_{14} = \omega_{14} + \alpha \cdot \delta_4 \cdot y_1$$
$$= 0.6 + 1 \times 0.0025 \times 0$$
$$= \cancel{0.6025}\ 0.6$$

$$\omega_{15} = \omega_{15} + 1 \times 0.023 \times 0$$
$$= 0.4 + \cancel{0.023}\ 0$$
$$= \cancel{0.423}\ 0.4$$

$$\omega_{24} = \cancel{\omega_{24}}\ 0.2 + 1 \times 0.025 \times 1 =$$
$$= 0.2 + 0.025$$
$$= 0.225$$

$$\omega_{25} = -0.3 + 1 \times 0.0023 \cdot 1$$
$$= -0.3 + 0.0023$$
$$= -0.29$$

$$\omega_{34} = 0.7 + 1 \times 0.0025 \times 1$$
$$= 0.7025$$

$$\omega_{35} = -0.6 + 1 \times 0.0023$$
$$= -0.597$$

$$\omega_{46} = 0.4 + 1 \times \delta_6 \cdot y_4$$
$$= 0.4 + 1 \times 0.0059 \times 0.71$$
$$= 0.4041$$

$$\omega_{47} = 0.7 + 1 \times \delta_7 \cdot y_4$$
$$= 0.7 + 1 \times 0.014 \cdot 0.71$$
$$= 0.7094$$

$$\omega_{56} = 0.1 + 1 \times 0.0059 \times \cancel{0.69}\ 0.28$$
$$= \cancel{0.094}\ 0.1016$$

$$V_6 = 0.9\times0.4 + (-0.9)\times0.1$$
$$= 0.36 - 0.09$$
$$= 0.27$$

$$y_6 = \frac{1}{1+e^{-0.27}} = \cancel{0.43}\ 0.56$$

$$V_7 = 0.9\times0.7 + (-0.9)\cdot0.8$$
$$= 0.63 - 0.72$$
$$= -0.09$$
$$y_7 = \frac{1}{1+e^{0.09}} = 0.47$$

$$V_8 = 0.27\times0.2 + (-0.09)\cdot0.5$$
$$= 0.054 - 0.045$$
$$= 0.009$$
$$y_8 = \frac{1}{1+e^{-0.009}} = 0.502$$

Now,
for Backward pass.

$$\delta_8 = y_8(1-y_8)(d_8 - y_8$$
$$= 0.502(1-0.502)(1-0.502)$$
$$= 0.12$$

$$\delta_7 = y_7(1-y_7)\,\delta_8\cdot w_{87}$$
$$= 0.47(1-0.47)\,0.12\times0.5$$
$$= 0.014$$

$$\delta_6 = y_6(1-y_6)\,\delta_8\cdot w_{86}$$
$$= 0.56(1-0.56)\,0.12\times0.2$$
$$= 0.0059$$

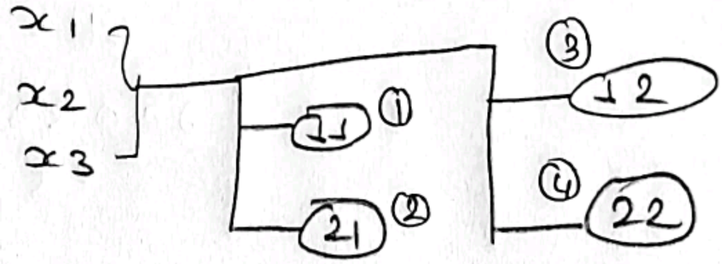
$$\delta_5 = y_5(1-y_5)(\delta_7 w_{75} + \delta_6 w_{65})$$
$$= 0.28(1-0.28)(0.014\times0.8 + 0.0059\times0.1)$$
$$= 0.0023$$

$$w_{57} = 0.8 + 1 \times \cancel{0.02}\ 0.014 \times 0.28$$
$$= 0.803$$

$$w_{68} = w_{68} + 1 \times \delta_8 \cdot y_6$$
$$= 0.2 + 1 \times 0.12 \times 0.56$$
$$= 0.2 + 0.0672$$
$$= 0.2672$$

$$w_{78} = w_{78} + 1 \times \delta_8 \cdot y_7$$
$$= 0.5 + 1 \times 0.12 \times 0.47$$
$$= 0.598$$

6. Consider following 2-D SOM and 3-D inputs. Show the working of SOM for the inputs (0.2, 0.3, 0.6)



0.1	0.2	0.4	0.2
0.4	0.3	0.2	0.5
0.7	0.5	0.6	0.3

Solution:-

Input ~~(0,2)~~ (0,2, 0.3, 0.6).

Euclidean distance between the input and weight vector of each output neuron.

$$d_1 = \sqrt{(0.2-0.1)^2+(0.3-0.4)^2+(0.6-0.7)^2}$$
$$= \sqrt{(0.1)^2+(-0.1)^2+(-0.1)^2}$$
$$= \sqrt{0.01+0.01+0.01} = \sqrt{0.03} = 0.17.$$

$$d_2 = \sqrt{(0.2-0.2)^2+(0.3-0.3)^2+(0.6-0.5)^2}$$
$$= \sqrt{0.01} = 0.1$$

$$d_3 = \sqrt{(0.2-0.4)^2+(0.3-0.2)^2+(0.6-0.6)^2}$$
$$= \sqrt{(0.2^2)+(0.1)^2}$$
$$= \sqrt{0.04+0.01} = 0.22$$

$$d_4 = \sqrt{(0.2-0.2)^2+(0.3-0.5)^2+(0.6-0.3)^2}$$
$$= \sqrt{(-0.2)^2+(0.3)^2}$$
$$= \sqrt{0.04+0.09} = \sqrt{0.13} = 0.36$$

Clearly neuron 2 is winner.

Updating weights assuming $\alpha = 1$ and $\sigma = 1$

$h_{11} = \exp\left(-\frac{(2-1)^2}{2\times 1^2}\right) = \exp\left(-\frac{1}{2}\right) = 0.60$

$\omega_{11} = 0.1 + 1\times 0.6\,(0.2-0.1)$
$= 0.1 + 0.06$
$= 0.16$

$\omega_{21} = 0.4 + 1\times 0.6\,(0.3-0.4)$
$= 0.4 + 0.6(-0.1)$
$= 0.34$

$\omega_{31} = 0.7 + 1\times 0.6\,(0.6-0.7)$
$= 0.7 + 0.6\times(-0.1)$
$= 0.64$

$h_{21} = \exp\left(-\frac{(2-2)^2}{2\times 1^2}\right) = \exp(0) = 1$

$\omega_{21} = 0.2 + 1\times 1\,(0.2-0.2)$
$= 0.2$

$\omega_{22} = 0.3 + 1\times 1\,(0.3-0.3)$
$= 0.3$

$\omega_{23} = 0.5 + 1\times 1\,(0.6-0.5)$
$= 0.5 + 0.1$
$= 0.6$

$h_{31} = \exp - \left(\frac{3-2}{2\sigma^2}\right) \quad \exp\left(-\frac{1}{2}\right) = 0.60$

$\omega_{31} = 0.4 + 1\times 0.6\,(0.2-0.4)$
$= 0.4 - 0.12$
$= 0.28$

$\omega_{32} = 0.2 + 1\times 0.6\,(0.3-0.2)$
$= 0.2 + 0.6\times 0.1$
$= 0.26$

~~w_{33}~~ =

$w_{33} = 0.6 + 1 \times 0.6 (0.6 - 0.6)$

$= 0.6$

$h_{41} = \exp\left(-\frac{(4-2)^2}{2}\right)$

$= \exp\left(-4/2\right)$

$= 0.135$

$w_{41} = 0.2 + 1 \times 0.135 (0.2 - 0.2)$

$= 0.2$

$w_{42} = 0.5 + 1 \times 0.135 (0.3 - 0.5)$

$= 0.5 - 0.027$

$= 0.473$

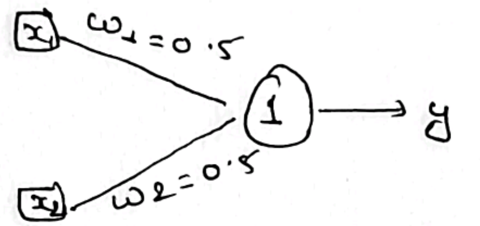
$w_{43} = 0.3 + 1 \times 0.135 (0.6 - 0.3)$

$= 0.3 + 0.0405$

$= 0.3405$.

2080

7. Consider following ANN with logistic activation function. Calculate weight updates for a training sample (0.1, 0.4, 0.5) using RMS prop. Assume $\alpha = 0.2$, $\beta = 0.9$



Soln

Logistic function $y = \frac{1}{1+e^{-x}}$.

$x_1 = 0.1 \quad x_2 = 0.4, \; t = 0.5$

$$y_{in} = x_1 \cdot w_1 + x_2 \cdot w_2$$
$$= 0.1 \times 0.5 + 0.4 \times 0.5$$
$$= 0.25$$

For training. $y = \frac{1}{1+e^{(-y_{in})}} = \frac{1}{1+e^{-0.25}} = 0.56$

$$dw_1 = (y-t) \cdot y(1-y) \cdot x_1$$
$$= (0.56 - 0.5) \cdot 0.56(1-0.56) \cdot 0.1$$
$$= 0.06 \times 0.56 \times 0.44 \times 0.1$$
$$= 0.00147$$

$$dw_2 = (y-t) \, y(1-y) \cdot x_2$$
$$= (0.56-0.5) \, 0.56(1-0.56) \times 0.4$$
$$= 0.06 \times 0.56 \times 0.44 \times 0.4$$
$$= 0.00591$$

Now,

$$V_t = \beta V_{t-1} + (1-\beta) \cdot dw_t^2$$

$$V_1 = \beta \cdot V_0 + (1-\beta) \cdot dw_1^2$$
$$= 0.9 \times 0 + (1-0.9) \times (0.00147)^2$$
$$= 0.1 \times 0.00000216$$
$$= 0.000000216$$

$$V_2 = 0.9 \times 0 + (1-0.9) \times (0.00591)^2$$
$$= 0 + 0.1 \times 0.0000349$$
$$= 0.00000349$$

Now,

updating weights.

$$\omega_{t+1} = \omega_t - \frac{\alpha}{\sqrt{V_t + \epsilon}} \cdot d\omega_t$$

$$\omega_1 = \omega_1 - \frac{\alpha}{\sqrt{V_t}} \cdot d\omega_t$$
$$= 0.5 - \frac{0.2}{\sqrt{0.000000216}} \times 0.00147$$
$$= 0.5 - \frac{0.2}{0.000464} \times 0.00147$$
$$= 0.5 - 0.2 \times 3.168$$
$$= 0.5 - 0.633$$
$$= -0.133.$$

$$\omega_2 = 0.5 - \frac{0.2}{\sqrt{0.00000349}} \times 0.00591$$
$$= 0.5 - \frac{0.2}{0.00186} \times 0.00591$$
$$= 0.5 - 0.2 \times 3.1774$$
$$= 0.5 - 0.635$$
$$= -0.135$$

2080

2 no question similar to q no 6.

2080

Q no 6 part 2:

Store the pattern [1, 1, 1, -1] in an autoassociative neural network. Find weight Matrix and test input vector [-1, 1, 1, -1]

Soln

here pattern to be stored (s) = [1, 1 1 -1]

Now,

$$W = \sum s^T(p) \cdot s(p)$$

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

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

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

Now,

Test input (x) = [-1, 1, 1 -1]

$$y = x \cdot W$$

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

$$= [-1\times1 + 1\times1 + 1\times1 + (-1)\times(-1) \quad -1\times1 + 1\times1 + 1\times1 \times (-1)\times(-1) \quad -1\times1 + 1\times1 + \rightarrow$$

$$\rightarrow 1\times1 + \cancel{1\times1} + (-1)\times(-1) \quad -1\times1 + 1\times1 + 1\times1 + -1\times1]$$

$$= [\cancel{-1} + \cancel{1} + 1 + 1 \quad \cancel{1} + \cancel{1} + 1 + 1 \quad \cancel{-1} + \cancel{1} + 1 + 1 \quad \cancel{-1} + \cancel{1} + \cancel{1} \cancel{-1}]$$

$$= [2, 2\ 2\ 0]$$

Applying the activation to calculate output we get y = [1 1 1 0]