

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

5x5 input

$w_1$	$w_2$	$w_3$
0	1	2
2	$2^{w_4}$	$2^{w_5}$
0	$1^{w_7}$	$2^{w_8}$

3x3

$$Z_1 = 0 \times 3 + 1 \times 3 + 2 \times 2 + 2 \times 0 + 2 \times 0 + 0 \times 1 - \\ 0 \times 3 + 1 \times 1 + 2 \times 2$$

$$Z_1 = 0 + 3 + 4 + 0 + 0 + 0 + 0 + 1 + 4$$

$$Z_1 = 12$$

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

0	1	2
2	2	0
0	1	2

$$Z_2 = 0 \times 2 + 1 \times 1 + 2 \times 0 + 2 \times 1 + 2 \times 3 + 0 \times 1 + \\ 0 \times 2 + 1 \times 2 + 2 \times 3$$

$$Z_2 = 0 + 1 + 0 + 2 + 6 + 0 + 0 + 2 + 6$$

$$Z_2 = 17$$

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

0	1	2
2	2	0
0	1	2

$$Z_3 = 0 \times 3 + 1 \times 1 + 2 \times 2 + 2 \times 2 + 2 \times 0 + 0 \times 0 + \\ 0 \times 2 + 1 \times 0 + 2 \times 0$$

$$Z_3 = 0 + 1 + 4 + 4 + 0 + 0 + 0 + 0 + 0$$

$$Z_3 = 9$$

3	3	2	1	0
0	0	1	3	1
3	1	2	2	3
2	0	0	2	2
2	0	0	0	1

0	1	2
2	2	0
0	1	2

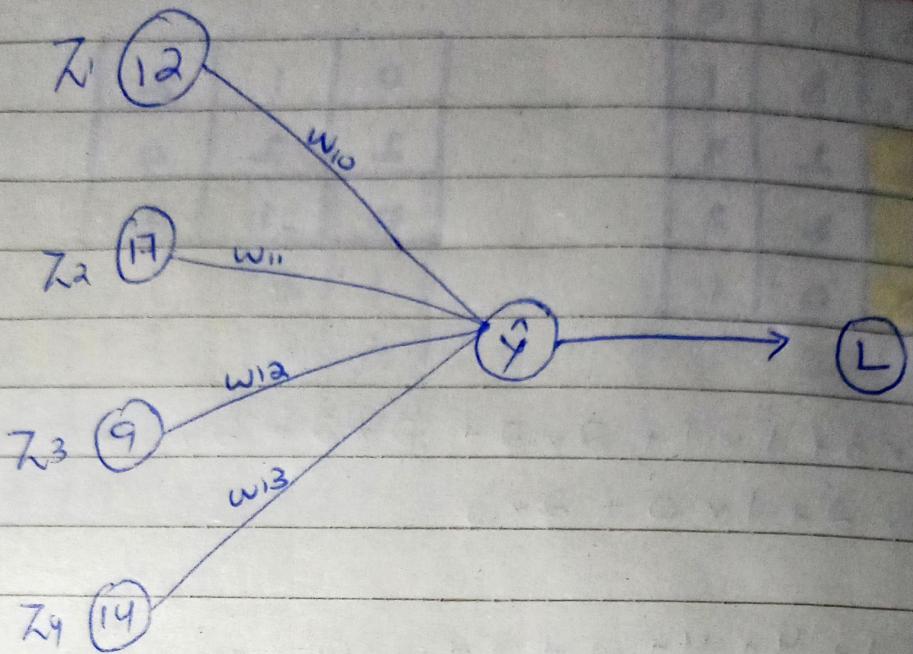
$$Z_4 = 0 \times 2 + 1 \times 2 + 2 \times 3 + 2 \times 0 + 2 \times 2 + 0 \times 2 + \\ 0 \times 0 + 1 \times 0 + 2 \times 1$$

$$Z_4 = 0 + 2 + 6 + 0 + 4 + 0 + 0 + 0 + 2$$

$$Z_4 = 14$$

$Z_1$	$Z_2$
12	17
9	14

$Z_3 \quad Z_4$



$w_1$	$w_2$	$w_3$
0	1	2
2	2	0
0	1	2

$z_1$	$z_2$
12	17
9	14

$w_{10}$	$w_{11}$
2	4
3	1

$$w_i^* = w_i - \alpha \times \frac{\partial L}{\partial w_i}$$

$$Y = z_1 \times w_{10} + z_2 \times w_{11} + z_3 \times w_{12} + z_4 \times w_{13}$$

$$Y = 12 \times 2 + 17 \times 4 + 9 \times 3 + 14 \times 1$$

$$Y = 24 + 68 + 27 + 14$$

$$Y = 133$$

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

$$\text{Sigmoid} = \frac{1}{1 + e^{-133}}$$

$$\text{Sigmoid} = 1$$

$$\frac{\partial L}{\partial w_1} = \frac{\partial z_1}{\partial w_1} \cdot \frac{\partial y}{\partial z_1} \cdot \frac{\partial L}{\partial y}$$

$$\rightarrow \frac{\partial L}{\partial w_1} = \frac{\partial z_1}{\partial w_1} \cdot \frac{\partial L}{\partial z_1} -$$

$$\frac{\partial L}{\partial w_1} = \frac{\partial z_1}{\partial w_1} \cdot \frac{\partial L}{\partial z_1} + \frac{\partial z_2}{\partial w_1} \cdot \frac{\partial y}{\partial z_2} \cdot \frac{\partial L}{\partial y}$$

$$\rightarrow \frac{\partial L}{\partial w_1} = \frac{\partial z_1}{\partial w_1} \cdot \frac{\partial L}{\partial z_1} + \frac{\partial z_2}{\partial w_1} \cdot \frac{\partial L}{\partial z_2}$$

$$\frac{\partial L}{\partial w_1} = \frac{\partial z_1}{\partial w_1} \cdot \frac{\partial L}{\partial z_1} + \frac{\partial z_2}{\partial w_2} \cdot \frac{\partial L}{\partial z_2} + \frac{\partial z_3}{\partial w_3} \cdot \frac{\partial y}{\partial z_3} \cdot \frac{\partial L}{\partial y}$$

$$\rightarrow \frac{\partial L}{\partial w_1} = \frac{\partial z_1}{\partial w_1} \cdot \frac{\partial L}{\partial z_1} + \frac{\partial z_2}{\partial w_2} \cdot \frac{\partial L}{\partial z_2} + \frac{\partial z_3}{\partial w_3} \cdot \frac{\partial L}{\partial z_3}$$

$$\frac{\partial L}{\partial w_1} = \frac{\partial z_{21}}{\partial w_1} \cdot \frac{\partial L}{\partial z_{21}} + \frac{\partial z_{22}}{\partial w_1} \cdot \frac{\partial L}{\partial z_{22}} + \frac{\partial z_{23}}{\partial w_1} \cdot \frac{\partial L}{\partial z_{23}} + \frac{\partial z_{24}}{\partial w_1} \cdot \frac{\partial L}{\partial z_{24}}$$

$$\rightarrow \frac{\partial L}{\partial w_1} = \frac{\partial z_{21}}{\partial w_1} \cdot \frac{\partial L}{\partial z_{21}} + \frac{\partial z_{22}}{\partial w_2} \cdot \frac{\partial L}{\partial z_{22}} + \frac{\partial z_{23}}{\partial w_3} \cdot \frac{\partial L}{\partial z_{23}} + \frac{\partial z_{24}}{\partial w_4} \cdot \frac{\partial L}{\partial z_{24}}$$

$\downarrow$                    $\downarrow$                    $\downarrow$                    $\downarrow$   
 $a_1$                    $a_3$                    $a_4$                    $a_{13}$

$$\frac{\partial L}{\partial w_1} = a_1 \frac{\partial L}{\partial z_{21}} + a_3 \frac{\partial L}{\partial z_{22}} + a_4 \frac{\partial L}{\partial z_{23}} + a_{13} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_2} = a_2 \frac{\partial L}{\partial z_{21}} + a_4 \frac{\partial L}{\partial z_{22}} + a_{12} \frac{\partial L}{\partial z_{23}} + a_{14} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_3} = a_3 \frac{\partial L}{\partial z_{21}} + a_5 \frac{\partial L}{\partial z_{22}} + a_{13} \frac{\partial L}{\partial z_{23}} + a_{15} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_4} = a_6 \frac{\partial L}{\partial z_{21}} + a_8 \frac{\partial L}{\partial z_{22}} + a_{16} \frac{\partial L}{\partial z_{23}} + a_{18} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_5} = a_7 \frac{\partial L}{\partial z_{21}} + a_9 \frac{\partial L}{\partial z_{22}} + a_{17} \frac{\partial L}{\partial z_{23}} + a_{19} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_6} = a_8 \frac{\partial L}{\partial z_{21}} + a_{10} \frac{\partial L}{\partial z_{22}} + a_{18} \frac{\partial L}{\partial z_{23}} + a_{20} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_7} = a_{11} \frac{\partial L}{\partial z_{21}} + a_{13} \frac{\partial L}{\partial z_{22}} + a_{21} \frac{\partial L}{\partial z_{23}} + a_{23} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_8} = a_{12} \frac{\partial L}{\partial z_1} + a_{14} \frac{\partial L}{\partial z_2} + a_{22} \frac{\partial L}{\partial z_3} + a_{24} \frac{\partial L}{\partial z_4}$$

$$\frac{\partial L}{\partial w_9} = a_{13} \frac{\partial L}{\partial z_1} + a_{15} \frac{\partial L}{\partial z_2} + a_{23} \frac{\partial L}{\partial z_3} + a_{25} \frac{\partial L}{\partial z_4}$$

$$\begin{array}{|c|c|c|} \hline 3 & 3 & 2 \\ \hline 0 & 0 & 1 \\ \hline 3 & 1 & 2 \\ \hline \end{array} \times 12 + \begin{array}{|c|c|c|} \hline 2 & 1 & 0 \\ \hline 1 & 3 & 1 \\ \hline 2 & 2 & 3 \\ \hline \end{array} \times 17 +$$

$$\begin{array}{|c|c|c|} \hline 3 & 1 & 2 \\ \hline 2 & 0 & 0 \\ \hline 2 & 0 & 0 \\ \hline \end{array} \times 9 + \begin{array}{|c|c|c|} \hline 2 & 2 & 3 \\ \hline 0 & 2 & 2 \\ \hline 0 & 0 & 1 \\ \hline \end{array} \times 14$$

$$\frac{\partial L}{\partial w_1} = a_1 \frac{\partial L}{\partial z_{21}} + a_3 \frac{\partial L}{\partial z_{22}} + a_4 \frac{\partial L}{\partial z_{23}} + a_{13} \frac{\partial L}{\partial z_{24}}$$

$$\frac{\partial L}{\partial w_1} = 3 \times 12 + 2 \times 17 + 3 \times 9 + 2 \times 14$$

$$\frac{\partial L}{\partial w_1} = 36 + 34 + 27 + 28$$

$$\boxed{\frac{\partial L}{\partial w_1} = 125}$$

$$\frac{\partial L}{\partial w_2} = a_2 \frac{\partial L}{\partial z_{21}} + a_4 \frac{\partial L}{\partial z_{22}} + a_{12} \frac{\partial L}{\partial z_{23}} + a_{14} \frac{\partial L}{\partial z_{24}}$$

$$= 3 \times 12 + 1 \times 17 + 1 \times 9 + 2 \times 14 \\ = 36 + 17 + 9 + 28$$

$$\boxed{\frac{\partial L}{\partial w_2} = 90}$$

$$\frac{\partial L}{\partial w_3} = a_3 \frac{\partial L}{\partial z_1} + a_5 \frac{\partial L}{\partial z_2} + a_{13} \frac{\partial L}{\partial z_3} + a_{15} \frac{\partial L}{\partial z_4}$$

$$\begin{aligned}\frac{\partial L}{\partial w_3} &= 2 \times 12 + 0 \times 17 + 2 \times 9 + 3 \times 14 \\ &= 24 + 0 + 18 + 42\end{aligned}$$

$$\boxed{\frac{\partial L}{\partial w_3} = 84}$$

$$\frac{\partial L}{\partial w_4} = a_6 \frac{\partial L}{\partial z_1} + a_8 \frac{\partial L}{\partial z_2} + a_{16} \frac{\partial L}{\partial z_3} + a_{18} \frac{\partial L}{\partial z_4}$$

$$\begin{aligned}&= 0 \times 12 + 1 \times 17 + 2 \times 9 + 0 \times 14 \\ &= 0 + 17 + 18 + 0\end{aligned}$$

$$\boxed{\frac{\partial L}{\partial w_4} = 35}$$

$$\frac{\partial L}{\partial w_5} = a_7 \frac{\partial L}{\partial z_1} + a_9 \frac{\partial L}{\partial z_2} + a_{17} \frac{\partial L}{\partial z_3} + a_{19} \frac{\partial L}{\partial z_4}$$

$$\begin{aligned}&= 0 \times 12 + 3 \times 17 + 0 \times 9 + 2 \times 14 \\ &= 0 + 51 + 0 + 28\end{aligned}$$

$$\boxed{\frac{\partial L}{\partial w_5} = 79}$$

$$\frac{\partial L}{\partial w_6} = a_8 \frac{\partial L}{\partial z_1} + a_{10} \frac{\partial L}{\partial z_2} + a_{18} \frac{\partial L}{\partial z_3} + a_{20} \frac{\partial L}{\partial z_4}$$

$$= 1 \times 12 + 1 \times 17 + 0 \times 9 + 2 \times 14$$

$$= 12 + 17 + 0 + 28$$

$$\boxed{\frac{\partial L}{\partial w_7} = 57}$$

$$\frac{\partial L}{\partial w_7} = a_{11} \frac{\partial L}{\partial z_1} + a_{13} \frac{\partial L}{\partial z_2} + a_{21} \frac{\partial L}{\partial z_3} + a_{23} \frac{\partial L}{\partial z_4}$$

$$= 3 \times 12 + 2 \times 17 + 2 \times 9 + 0 \times 14$$

$$= 36 + 34 + 18 + 0$$

$$\boxed{\frac{\partial L}{\partial w_7} = 88}$$

$$\frac{\partial L}{\partial w_8} = a_{12} \frac{\partial L}{\partial z_1} + a_{14} \frac{\partial L}{\partial z_2} + a_{22} \frac{\partial L}{\partial z_3} + a_{24} \frac{\partial L}{\partial z_4}$$

$$= 1 \times 12 + 2 \times 17 + 0 \times 9 + 0 \times 14$$

$$= 12 + 34 + 0 + 0$$

$$\boxed{\frac{\partial L}{\partial w_8} = 46}$$

$$\frac{\partial L}{\partial w_9} = a_{13} \frac{\partial L}{\partial z_1} + a_{15} \frac{\partial L}{\partial z_2} + a_{23} \frac{\partial L}{\partial z_3} + a_{25} \frac{\partial L}{\partial z_4}$$

$$= 2 \times 12 + 3 \times 17 + 0 \times 9 + 1 \times 14$$

$$= 24 + 51 + 0 + 14$$

$$\boxed{\frac{\partial L}{\partial w_9} = 89}$$

125	90	84
35	79	57
88	46	89

$$w_i^* = w_i - \alpha \times \frac{\partial L}{\partial w_i}$$

$$w_i^* =$$

0	1	2
2	2	0
0	1	2

$$- \alpha \times$$

125	90	84
35	79	57
88	46	89