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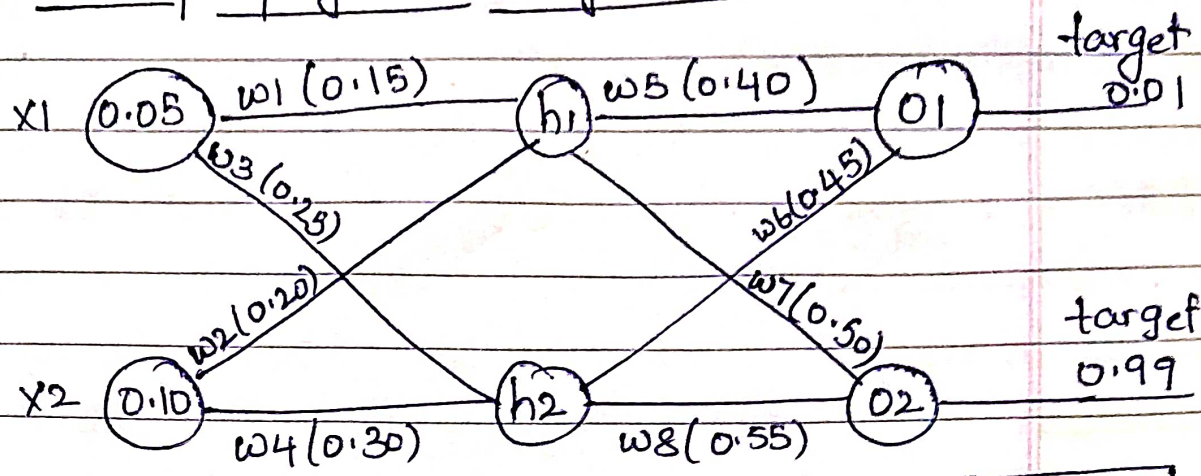
# Back Propagation algorithm:




$b1 = 0.35$ $b2 = 0.60$. $\eta = 0.6$

I Calculate forward propagation error

$$h1(in) = W1X1 + W2X2 + b1$$
$$= (0.15 * 0.05) + (0.2 * 0.10) + 0.35$$
$$= 0.377.$$
$$h1(out) = \frac{1}{1+e^{-h1(in)}} = \frac{1}{1+e^{-0.377}} = 0.5932$$

$$h2(in) = W3X1 + W4X2 + b1$$
$$= (0.25 * 0.05) + (0.30 * 0.10) + 0.35$$
$$= 0.3925$$
$$h2(out) = \frac{1}{1+e^{-h2(in)}} = \frac{1}{1+e^{-0.3925}} = 0.5968$$

$$O1(in) = W5\,h1(out) + W6\,h2(out) + b2$$
$$= (0.4 * 0.593) + (0.45 * 0.596) + 0.6$$
$$= 1.105$$
$$O1(out) = \frac{1}{1+e^{-O1(in)}} = \frac{1}{1+e^{-1.105}} = 0.7513$$

$O_2(in) = w_7 h_1(out) + w_8 h_2(out) + b_2$

$= 0.50 * 0.5932 + 0.55 * 0.5968 + 0.6$

$= 1.22484$

$O_2(out) = \frac{1}{1+e^{-O_2(in)}} = \frac{1}{1+e^{-1.22484}} = 0.7729$

$E_{total} = \sum \frac{1}{2}(target - o/p)^2$

$= \frac{1}{2}(0.01 - 0.7513)^2 + \frac{1}{2}(0.99 - 0.7729)^2$

$= 0.2983$

$E_{O_1} = \frac{1}{2}(0.01 - 0.7513)^2$

$= 0.274$

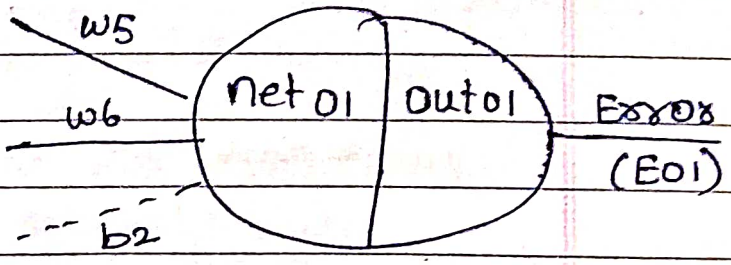
$E_{O2} = \frac{1}{2}(0.99 - 0.7729)^2$

$= 0.0235$

II Calculating backward propagation errors

Output to hidden layer

$w_5, w_6, w_7, w_8$




$\frac{\partial E_{total}}{\partial w_5} = \frac{\partial E_{total}}{\partial out_{o1}} * \frac{\partial out_{o1}}{\partial net_{o1}} * \frac{\partial net_{o1}}{\partial w_5}$

$\frac{\partial E_{total}}{\partial out_{o1}} = (out_{o1} - target_{o1})$

$= 0.7513 - 0.01 = 0.7413$

$$\frac{\partial out_{o1}}{\partial net_{o1}} = out_{o1}(1 - out_{o1})$$

$$= 0.751365\,(1 - 0.751365)$$

$$= 0.186815$$

$$\frac{\partial net_{o1}}{\partial w5} = out_{h1} = 0.59326$$

$$\boxed{\frac{\partial E_{total}}{\partial w5} = 0.08216}$$

$$\boxed{w5^{*} = w5 - \eta * \frac{\partial E_{total}}{\partial w5}}$$

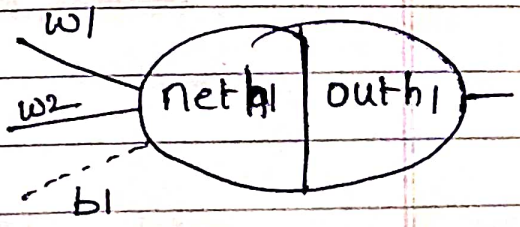
$$= 0.4 - 0.6 * 0.08216$$

$$= 0.3506$$

do the same process for w6, w7, w8

III Calculating backpropagation error hidden to input layer

w1, w2, w3, w4




$$\frac{\partial E_{total}}{\partial w1} = \frac{\partial E_{total}}{\partial out_{h1}} * \frac{\partial out_{h1}}{\partial net_{h1}} * \frac{\partial net_{h1}}{\partial w1}$$

$$\frac{\partial E_{total}}{\partial out_{h1}} = \frac{\partial E_{o1}}{\partial out_{h1}} + \frac{\partial E_{o2}}{\partial out_{h1}}$$

$$\frac{\partial E_{o1}}{\partial net_{o1}} * \frac{\partial net_{o1}}{\partial out_{h1}} + \frac{\partial E_{o2}}{\partial net_{o2}} * \frac{\partial net_{o2}}{\partial out_{h1}}$$

$$\frac{\partial E_{o1}}{\partial out_{o1}} * \frac{\partial out_{o1}}{\partial net_{o1}} * \frac{\partial net_{o1}}{\partial out_{h1}} + \frac{\partial E_{o2}}{\partial out_{o2}} * \frac{\partial out_{o2}}{\partial net_{o2}} * \frac{\partial net_{o2}}{\partial out_{h1}}$$

| | |
|---|---|
| $\frac{\partial E_{o1}}{\partial out_{o1}} = (out_{o1} - target_{o1})$ | $\frac{\partial E_{o2}}{\partial out_{o2}} = (out_{o2} - target_{o2})$ |
| $= 0.7513 - 0.01$ | $= 0.7729 - 0.99$ |
| $= 0.7413$ | $= -0.2171$ |
| $\frac{\partial out_{o1}}{\partial net_{o1}} = out_{o1}(1 - out_{o1})$ | $\frac{\partial out_{o2}}{\partial net_{o2}} = out_{o2}(1 - out_{o2})$ |
| $= 0.7513(1 - 0.7513)$ | $= 0.7729(1 - 0.7729)$ |
| $= 0.1868$ | $= 0.1755$ |
| $\frac{\partial net_{o1}}{\partial out_{h1}} = w_5 = 0.4$ | $\frac{\partial net_{o2}}{\partial out_{h1}} = w_7 = 0.5$ |

$$\frac{\partial E_{o1}}{\partial out_{h1}} = 0.7413 * 0.1868 * 0.4 = 0.055389$$

$$\frac{\partial E_{o2}}{\partial out_{h1}} = -0.2171 * 0.1755 * 0.5 = -0.019050$$

$$\frac{\partial E_{total}}{\partial out_{h1}} = 0.055389 - 0.019050$$

$$= 0.036339$$

$$\frac{\partial out_{h1}}{\partial net_{h1}} = out_{h1}(1 - out_{h1})$$

$$= 0.5932(1 - 0.5932)$$

$$= 0.2413$$

$$\frac{\partial net_{h1}}{\partial w_1} = \frac{\partial}{\partial w_1}(w_1 x_1 + w_2 x_2 + b_1)$$

$$= x_1 = 0.05$$

$$\frac{\partial E_{total}}{\partial w_1} = 0.036339 * 0.2413 * 0.05$$

$$= 0.000438$$

$$w_1^* = w_1 - \eta \frac{\partial E_{total}}{\partial w_1}$$

$$= 0.15 - (0.6 * 0.00438)$$

$$= 0.1497$$

do the same process for $w_2, w_3, w_4$