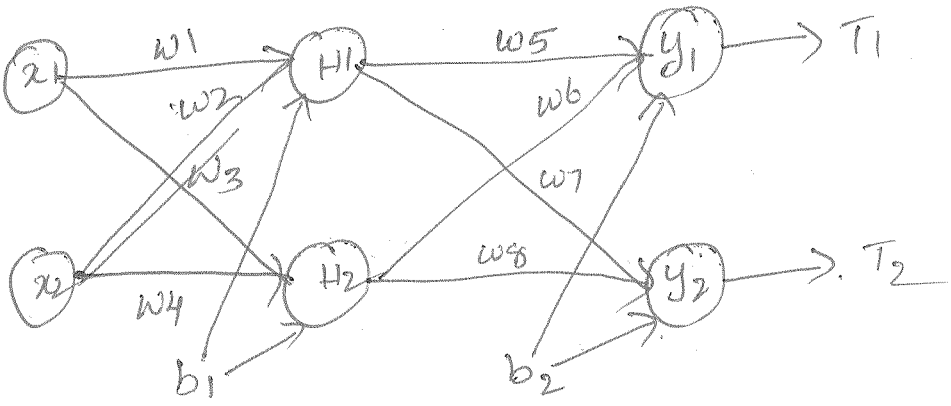

input $H_1 = x_1 * w_1 + x_2 * w_2 + b_1$

output H_1 = Activation function (input H_1)

= sigmoid (input H_1).

$$= \frac{1}{1 + e^{-\text{input } H_1}}$$

Ex:- $x_1 = 0.05$ $x_2 = 0.10$ $T_1 = 0.01$ $T_2 = 0.99$

$b_1 = 0.35$ $b_2 = 0.60$

$w_1 = 0.15$ $w_5 = 0.40$

$w_2 = 0.20$ $w_6 = 0.45$

$w_3 = 0.25$ $w_7 = 0.50$

$w_4 = 0.30$ $w_8 = 0.55$

Forward pass :-

input $H_1 = x_1 * w_1 + x_2 * w_2 + b_1$

$= 0.05 * 0.15 + 0.10 * 0.20 + 0.35$

$= 0.3775$

out $H_1 = \frac{1}{1 + e^{-0.3775}} = 0.5932699921$

similarly.

out $H_2 = 0.596884378$

Now calculating for (y_1) and (y_2) :

input y_1 = out $H_1 * w_5 +$ out $H_2 * w_6 + b_2$

$= 0.4 * 0.5932699 2 + 0.596884378 * 0.45 + 0.6$

$= 1.105905967$

out $y_1 = \frac{1}{1+e^{-\text{input}y_1}} = \frac{1}{1+e^{-1.105905967}}$

$= 0.75136507$

Similarly.

out $y_2 = 0.772928465$

NOT matched with the target $T_1 = 0.01$
$T_2 = 0.99$

So calculate the error

$E_{Total} = \sum \frac{1}{2} (\text{target} - \text{output})^2$

$= \frac{1}{2}(T_1 - \text{out}y_1)^2 + \frac{1}{2}(T_2 - \text{output}y_2)^2$

$= \frac{1}{2}(0.01 - 0.75136507)^2 + \frac{1}{2}(0.99 - 0.772928465)^2$

$= 0.274811083 + 0.023560026$

$E_{total} = 0.298371109$

Backward pass or Backpropagate the error: (P3)

consider w_5:

update afor w_5: $\frac{\partial E_{total}}{\partial w_5}$

$$\frac{\partial E_{total}}{\partial w_5} = \frac{\partial E_{total}}{\partial out_{y_1}} * \frac{\partial out_{y_1}}{\partial y_1} * \frac{\partial y_1}{\partial w_5}$$

(1) (2) (3)

$$E_{total} = \frac{1}{2}(T_1 - out_{y_1})^2 + \frac{1}{2}(T_2 - out_{y_2})^2$$

$$\frac{\partial E_{total}}{\partial out_{y_1}} = \frac{1}{2} \cdot 2 (T_1 - out_{y_1}) * -1 + 0.$$

$$= -(T_1 - out_{y_1}).$$

$$= -(0.01 - 0.75136507) =$$

$$\frac{\partial E_{total}}{\partial out_{y_1}} = 0.74136507 \quad \text{---} \quad (1)$$

$$\frac{\partial out_{y_1}}{\partial y_1} = ?$$

$$out\ y_1 = sigmoid(input\ y_1).$$

$$= \frac{1}{1 + e^{-(input\ y_1)}}$$

$$\frac{S\left(\frac{1}{1+e^{-x}}\right)}{\partial x} = \frac{1}{1+e^{-x}} * \left[1 - \frac{1}{1+e^{-x}}\right]$$

$$= \qquad = out_{y_1} * (1 - out_{y_1})$$

$$\frac{\partial out\ y_1}{y_1} = out_{y_1} * (1 - out\ y_1)$$

$$= 0.75136507 (1 - 0.75136507).$$

$$= 0.18681560 \quad \text{---} \quad (2)$$

$$\frac{\partial y_1}{\partial w_5} = ?$$

$$y_1 = out\,H_1 * w_5 + out\,H_2 * w_6 + b_2.$$

$$\frac{\partial y_1}{\partial w_5} = 1 * out\,H_1$$

$$= 0.59326992 \quad -(3)$$

Now calculate the update for w_5

$$\frac{\partial E_{total}}{\partial w_5} = \frac{\partial E_{total}}{\partial out_{y_1}} * \frac{\partial out_{y_1}}{\partial y_1} * \frac{\partial y_1}{\partial w_5}.$$

$$= 0.74136507 * 0.186815602 * 0.59326992$$

$$= 0.082167041.$$

updated w_5 is:

$$w_5 = w_5 - \eta \Delta w_5 \qquad \left[\Delta w_5 = \frac{\partial E_{total}}{\partial w_5}\right]$$

$$= 0.4 - 05 \times 0.082167041$$

$$\boxed{w_5 = 0.35891648}$$

similarly

$$w_6 = 0.408666186$$
$$w_7 = 0.511301270$$
$$w_8 = 0.56137021$$

} updated weights.

Updating the Hidden layer and input layer

i.e w_1, w_2, w_3, w_4.

$$\frac{\partial E_{total}}{\partial w_1} = \frac{\partial E_{total}}{\partial out_{H1}} * \frac{\partial out_{H1}}{\partial H_1} * \frac{\partial H_1}{\partial w_1}$$

(1) (2) (3)

$$\frac{\partial E_{total}}{\partial out_{H1}} = \frac{\partial E_1}{\partial out_{H1}} + \frac{\partial E_2}{\partial out_{H1}}$$

0.055399425 −0.019049119 = 0.036635

(1) (11) (12)

$$\frac{\partial E_1}{\partial out_{H1}} = \frac{\partial E_1}{\partial out_{y_1}} * \frac{\partial out_{y_1}}{\partial y_1} * \frac{\partial y_1}{\partial out_{H1}}$$

0.741365074 0.821670411 w5

(11)

$$\frac{\partial E_2}{\partial out_{H1}} = \frac{\partial E_2}{\partial out_{y_2}} * \frac{\partial out_{y_2}}{\partial y_2} * \frac{\partial y_2}{\partial out_{H1}}$$

(12)

(2) $\frac{\partial out_{H1}}{\partial H_1} = ?$

$$out_{H1} = \frac{1}{1+e^{-H_1}}$$

$$\frac{\partial out_{H1}}{\partial H_1} = out_{H1}(1 - out_{H1})$$

$$= 0.59326992 (1 - 0.59326992)$$

$$= 0.241300709$$

(3) $\frac{\partial H_1}{\partial w_1} = ?$

$$H_1 = x_1 * w_1 + x_2 * w_2 + b_1$$

$$\frac{\partial H_1}{\partial w_1} = x_1 = 0.05$$

$$\frac{\partial E_{total}}{\partial w_1} = 0.03635 * 0.241300 * 0.05$$

$$= 0.000438568.$$

Now update weight w_1

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

$$= 0.15 - 0.5 * 0.000438568.$$

$$w_1 = 0.149780716.$$

Similarly update w_2, w_3, w_4.

$$w_2 = 0.19956143$$

$$w_3 = 0.24975114$$

$$w_4 = 0.29950229.$$

similarly update the bias also.

$$\frac{\partial E_{total}}{\partial b_2} = \frac{\partial E_{total}}{\partial out_{y_1}} * \frac{\partial out_{y_1}}{y_1} * \frac{\partial y_1}{b_2}$$

$$= * 1$$

$$\frac{\partial E_{total}}{\partial b_1} = \frac{\partial E_{total}}{\partial out_{H_1}} * \frac{\partial out_{H_1}}{\partial H_1} * \frac{\partial H_1}{\partial b_1} * 1$$

(P7)

Finally update b_1 and b_2 as

$$b_1 = b_1 - \eta \frac{\partial E_{total}}{\partial b_1}$$

$$b_2 = b_2 - \eta \frac{\partial E_{total}}{\partial b_2}$$

with this all weights and biases are updated. Hence one epoch or iteration completed.

⇒ Repeat the process of forward pass and Backpropagation until any one of the following Termination conditions are satisfied:

(1) E_{total} is 0 [Prediction = Actual].

(2) E_{total} is < Threshold.

(3) Maximum specified number of iterations.