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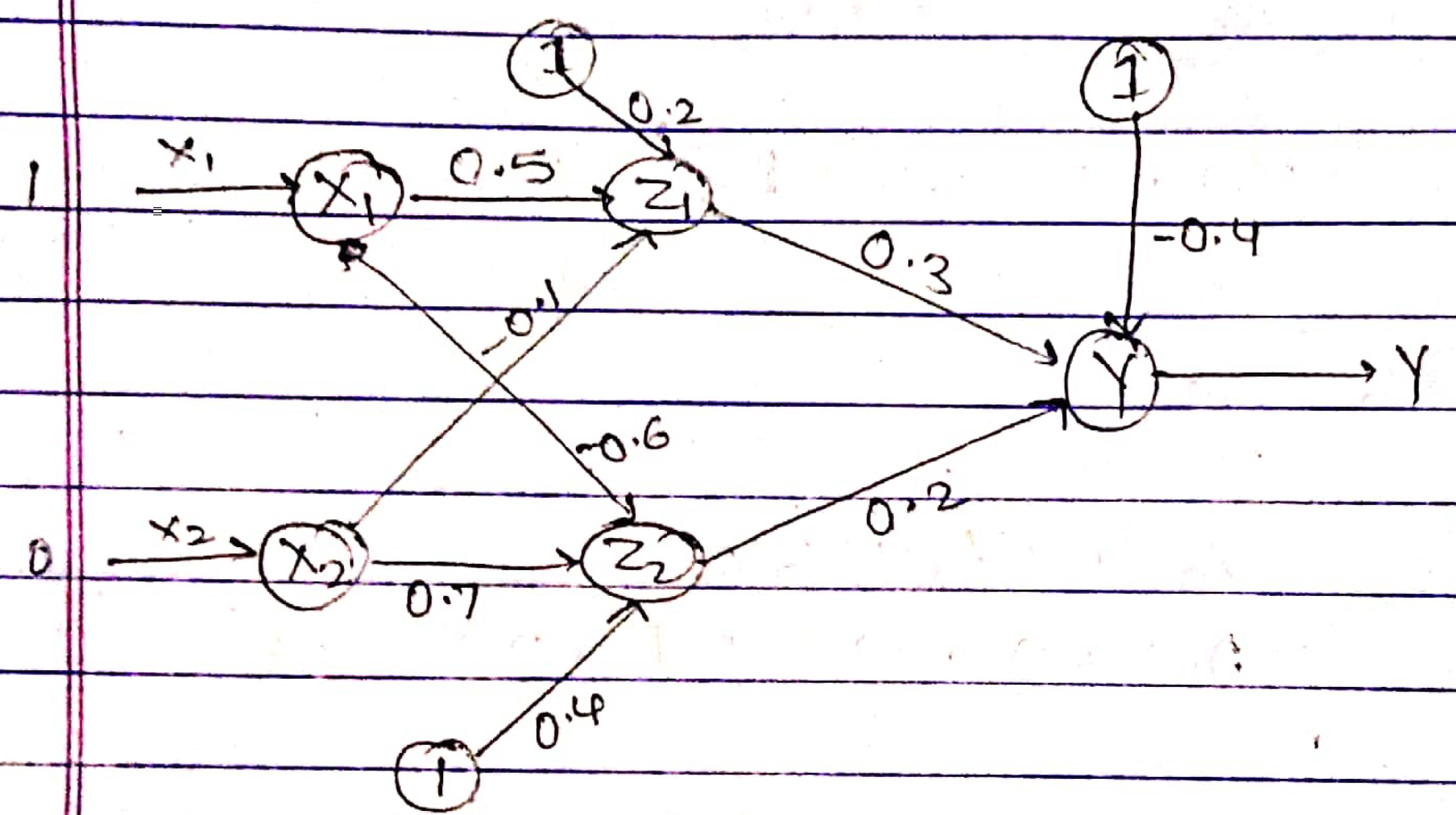
Q) Using back-propagation network, find the new weights for the network shown in the figure. The network is presented with the input pattern [1,0] and target output 1. Use learning rate of $\alpha = 0.3$ and binary sigmoidal activation function



Sol: The initial weights are $[v_{11} \;\; v_{21} \;\; v_{01}] = [0.5 \;\; -0.1 \;\; 0.2]$

$[v_{12} \;\; v_{22} \;\; v_{02}] = [-0.6 \;\; 0.7 \;\; 0.4]$

and $[w_1 \;\; w_2 \;\; w_0] = [0.3 \;\; 0.2 \;\; -0.4]$

- $\alpha = 0.3$
- Activation function used is binary sigmoidal activation function and is given by —

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

Given the output sample $= [x_1, x_2] = [1 \cdot 0]$
and target $t = 1$.

- Calculate the net input:

For z_1 layer.

$$z_{in1} = v_{01} + x_1 v_{11} + x_2 v_{21}$$

$$= 0.2 + 1 * 0.5 + 0 * (-0.1)$$
$$= 0.2 + 0.5 + 0$$
$$= 0.7$$

For z_2 layer

$$z_{in2} = v_{02} + x_1 v_{12} + x_2 v_{22}$$

$$= 0.4 + 1 * -0.6 + 0 * 0.7$$
$$= 0.4 - 0.6$$
$$= -0.2$$

- Applying activation to calculate the output, we obtain:

$$z_1 = f(z_{in1}) = \frac{1}{1+e^{-z_{in1}}} = \frac{1}{1+e^{-0.7}} = \frac{1}{1+0.497} = 0.668$$

$$z_2 = f(z_{in2}) = \frac{1}{1+e^{-z_{in2}}} = \frac{1}{1+e^{0.2}} = \frac{1}{1+1.221} = 0.450$$

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- Calculate the net input entering the output layer.

For y layer,

$$y_{in} = w_0 + z_1 w_1 + z_2 w_2$$

$$= -0.4 + 0.668 * 0.3 + 0.45 * 0.2$$

$$= -0.4 + 0.2004 + 0.09$$
$$= -0.1096$$

Applying activations to calculate the output, we obtain-

$$y = f(y_{in}) = \frac{1}{1+e^{-y_{in}}} = \frac{1}{1+e^{0.1096}} = \frac{1}{1+1.116} = 0.4725$$

- Compute the error portion δ_K:

$$\delta_K = (t_K - y_K) f'(y_{inK})$$

Now,

$$f'(y_{in}) = f(y_{in})[1 - f(y_{in})] = 0.4725[1 - 0.4725]$$

$$f'(y_{in}) = 0.2492$$

This implies,

$$\delta_1 = (1 - 0.4725)(0.2492) = 0.1314$$

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Find the changes in weights b/w hidden and output layer:

$\Delta w_1 = \alpha \delta_1 z_1 = 0.3 * 0.1314 * 0.668 =$
$= 0.0263$

$\Delta w_2 = \alpha \delta_1 z_2 = 0.3 * 0.1314 * 0.450 =$
$= 0.0177$

$\Delta w_0 = \alpha \delta_1 = 0.3 * 0.1314 = 0.0394$

- Compute the error portion δ_j b/w input and hidden layer ($j = 1$ to 2)

$$\boxed{\delta_j = \delta_{inj} f'(z_{inj})}$$

$$\delta_{inj} = \sum_{K=1}^{m} \delta_K w_{jK}$$

$\delta_{inj} = \delta_1 w_{j1}$ [$\because$ only one output neuron]

$\Rightarrow \delta_{in1} = \delta_1 w_{11} = 0.1314 * 0.3 = 0.03942$

$\Rightarrow \delta_{in2} = \delta_1 w_{21} = 0.1314 * 0.2 = 0.02628$

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Error, $\delta_1 = \delta_{in1} f'(z_{in1})$

$f'(z_{in1}) = f(z_{in1})[1 - f(z_{in1})]$

$= 0.668[1 - 0.668]$

$= 0.221776$

$\delta_1 = \delta_{in1} f'(z_{in1})$

$= 0.03942 * 0.221776$

$= 0.008742$

Error, $\delta_2 = \delta_{in2} f'(z_{in2})$

$f'(z_{in2}) = f(z_{in2})[1 - f(z_{in2})]$

$= 0.45[1 - 0.45] = 0.2475$

$\delta_2 = \delta_{in2} f'(z_{in2})$

$= 0.02628 * 0.2475$

$= 0.0065043$

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Now, find the changes in weights b/w input & hidden layer

$\Delta V_{11} = \alpha \delta_1 x_1 = 0.3 * 0.0087 * 1 = 0.00261$

$\Delta V_{21} = \alpha \delta_1 x_2 = 0.3 * 0.0087 * 0 = 0$

$\Delta V_{01} = \alpha \delta_1 = 0.3 * 0.0087 = 0.00261$

$\Delta V_{12} = \alpha \delta_2 x_1 = 0.3 * 0.0065 * 1 = 0.00195$

$\Delta V_{22} = \alpha \delta_2 x_2 = 0.3 * 0.0065 * 0 = 0$

$\Delta V_{02} = \alpha \delta_2 = 0.3 * 0.0065 = 0.00195$

- Compute the final weights of the network:

$V_{11}(new) = V_{11}(old) + \Delta V_{11} = 0.5 + 0.00261 = 0.50261$

$V_{12}(new) = V_{12}(old) + \Delta V_{12} = -0.6 + 0.00195 = -0.59805$

$V_{21}(new) = V_{21}(old) + \Delta V_{21} = -0.1 + 0 = -0.1$

$V_{22}(new) = V_{22}(old) + \Delta V_{22} = 0.7 + 0 = 0.7$

$W_1(new) = W_1(old) + \Delta W_1 = 0.3 + 0.0263 = 0.3263$

$W_2(new) = W_2(new) + \Delta W_2 = 0.2 + 0.0177 = 0.2177$

$V_{01}(new) = V_{01}(old) + \Delta V_{01} = 0.2 + 0.00261$
$= 0.20261$

$V_{02}(new) = V_{02}(old) + \Delta V_{02} = 0.4 + 0.00195$
$= 0.40195$

$W_0(new) = W_0(old) + \Delta W_0 = -0.4 + 0.0394$
$= -0.3606$

Thus, the final weights have been computed.

$\Rightarrow$ **Final:**