Numerical on Hetro-Associative Memory

Q For the given input vector $S = (s_1, s_2, s_3, s_4)$ and output vector $T = (T_1, T_2)$, find the weight matrix using hetro associative training algo.

$S = (s_1, s_2, s_3, s_4)$	$T = (T_1, T_2)$
I = (1, 1, 0, 0)	(0, 1)
II = (1, 0, 0, 1)	(1, 1)
III = (1, 1, 0, 0)	(1, 0)
IV = (0, 1, 0, 1)	(0, 0)

Solⁿ

weight matrix $= S^T . T$

$$S = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$$

$$S^T = \begin{bmatrix} 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$$

$$W = \Sigma hro\ S^T T = \begin{bmatrix} 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 \\ 1 & 1 \\ 1 & 0 \\ 0 & 0 \end{bmatrix}$$

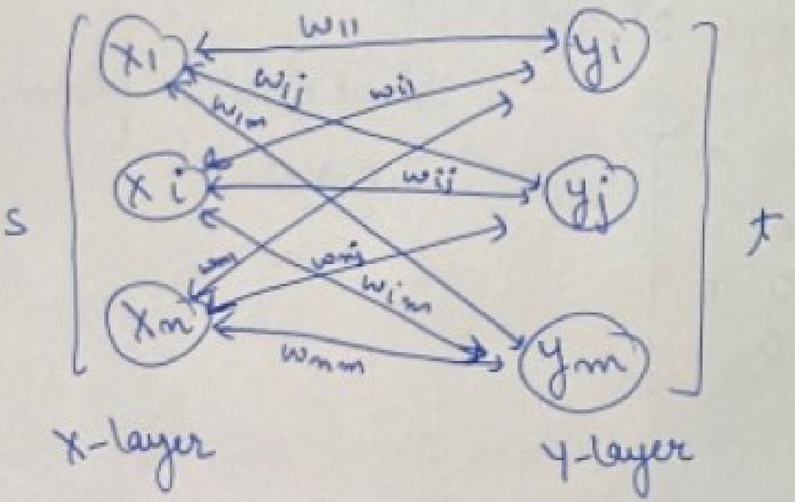
$$w = \begin{bmatrix} 2 & 2 \\ 1 & 1 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}$$ Ans

Bi-Directional Associative Memory (BAM)

It is a hetero associative recurrent neural network consisting of two layers:

i) X-layer   ii) Y-layer

which are connected by means of directional weighted connection paths.



BAM Architecture

→ The network iterates by sending a signal back and forth between the two layers until all neurons reach equilibrium.

→ The network can respond to input on ~~after~~ either layer.

If the weight matrix for signal sent from the x-layer to Y-layer is W, then weight matrix for signal sent from Y-layer to X-layer is W^T.

Types of BAM

→ Discrete BAM → Binary form (0,1)
→ Bipolar form (-1,+1)

→ Continuous BAM

for the set of input & output vector

$s(p) : t(p)$, $p = 1, 2, 3, --- P$

using Hebb's rule

$$\text{weight } (w_{ij}) = \sum_{p=1}^{P} [2 s_i(p) - 1] [2 t_j(p) - 1]$$

$$= [2s^T - 1][2t - 1]$$

for Bipolar input vector

$$w_j = \sum_{p=1}^{P} s_i(p)\, t_j(p) = S^T . t$$

→ Activation function for Binary form (step function)

for X-layer

$$x_i = \begin{cases} 1, & \text{if } x_{ini} > 0 \\ x_i, & \text{if } x_{ini} = 0 \\ 0, & \text{if } x_{ini} < 0 \end{cases}$$

for y-layer

$$y_j = \begin{cases} 1, & \text{if } y_{in} > 0 \\ y_j, & \text{if } y_{in} = 0 \\ 0, & \text{if } y_{in} < 0 \end{cases}$$

Activation function for Bipolar form

for X-layer $$x_i = \begin{cases} 1, & \text{if } x_{ini} > \theta \\ x_i & \text{if } x_{ini} = \theta \\ -1 & x_{ini} < \theta \end{cases}$$

for Y-layer $$y_i = \begin{cases} 1, & \text{if } y_{ini} > \theta \\ y_i & y_{inj} = \theta \\ -1 & y_{in} < \theta \end{cases}$$

Continuous BAM

A continuous BAM has the capability to transfer the input smoothly & continuously into the respective output.

→ The Continous BAM uses logistic sigmoid activation function for all the limits.

For binary input vector

weights are determined using Hebb's rule

$$w_{ij} = \sum_{P=1}^{1} [2 s_i(P) - 1][2 t_j(P) - 1]$$

Activation function

- for binary "logistic function"

$$f(y_{inj}) = \left(\frac{1}{1+e^{-y_{in}}} \right)$$

for Bipolar logistic function

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

- these activation function are applied over the input to calculate the output

$$\boxed{\underbrace{y_{inj}}_{\text{output}} = \underbrace{b_j}_{\text{bias}} + \Sigma \underbrace{x_i}_{\text{input}} w_{ij} \rightarrow \text{weight}}$$

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