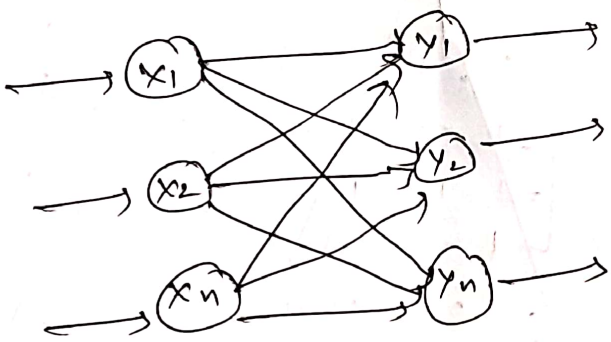
Associative Memory Network

These kinds of neural networks work on the basis of pattern association, which means they can store different patterns and at the time of giving an output they can produce one of the stored patterns.

Following are the two types of associative memories.

Auto Associative Memory

This is a single layer neural network in which the input training vector and the output target vectors are the same.



Train Auto association Memory Network using outer product rule to store input row vector [1 1 1 1] [-1 1 1 -1] to output row vector.

Outer product rule to determine the weight matrix in Auto Associative Memory

$$W = \sum_{P=1}^{r} s^T(P)\, s(P)$$

Auto Associative

Sol:- To initialise the weight using outer product Hebb's rule.

$$W = S^T(P)\, S(P) \qquad SP = [-1 \;\; 1 \;\; 1 \;\; -1]$$

$$W = \begin{bmatrix} -1 \\ 1 \\ 1 \\ -1 \end{bmatrix} [-1 \;\; 1 \;\; 1 \;\; -1]$$

$$= \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

I/p data = $[-1 \;\; 1 \;\; 1 \;\; -1] \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$

$$= [-4 \;\; 4 \;\; 4 \;\; -4] = [-1 \;\; 1 \;\; 1 \;\; -1]$$

Mistake data :- $[1 \;\; 1 \;\; 1 \;\; -1]$

$$[+1 \;\; 1 \;\; 1 \;\; -1] \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$= [-2 \;\; 4 \;\; +2 \;\; -2]$$

$$= [-1 \;\; 1 \;\; 1 \;\; -1].$$

$$[-1 \ -1 \ 1 \ -1] \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$= [-2 \ 2 \ 2 \ -2] = [-1 \ 1 \ 1 \ -1]$$

Missing data :-

$$[0 \ 1 \ 1 \ -1] \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$= [-3 \ 3 \ 3 \ -3] = [-1 \ 1 \ 1 \ -1]$$

Hetero Association :-

s_1	s_2	s_3	s_4	t_1	t_2
1	-1	-1	-1	-1	1
1	1	-1	-1	-1	1
-1	-1	-1	1	1	-1
-1	-1	1	1	1	-1.

Similar to Auto Associative Memory network, this is also a single layer neural network. In this network the input training vector and the output target vectors are not the same.

$$[-1 \ -1 \ 1 \ -1] \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \quad (3)$$

$$= [-2 \ 2 \ 2 \ -2] = [-1 \ 1 \ 1 \ -1]$$

Missing data :-

$$[0 \ 1 \ 1 \ -1] \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$= [-3 \ 3 \ 3 \ -3] = [-1 \ 1 \ 1 \ -1]$$

Hetero Association :-

s_1	s_2	s_3	s_4	t_1	t_2
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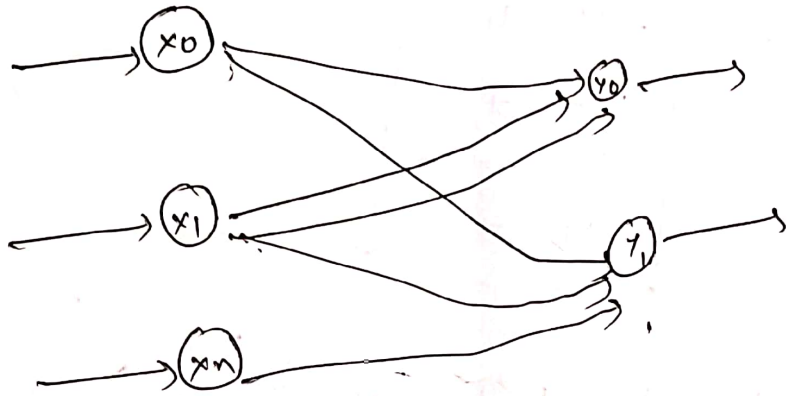
The architecture of Hetero Associative memory has 'n' number of inputs and m number of output target vectors.



W_1 = [ ] (Input)^T × output

$$W_1 = \begin{bmatrix} 1 \\ -1 \\ -1 \\ -1 \end{bmatrix}_{4\times 1} [-1 \;\; 1]_{1\times 2} = \begin{bmatrix} -1 & 1 \\ 1 & -1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix}$$

$$W_2 = \begin{bmatrix} 1 \\ 1 \\ -1 \\ -1 \end{bmatrix} [-1 \;\; 1] = \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix}$$

$$W_3 = \begin{bmatrix} -1 \\ -1 \\ -1 \\ 1 \end{bmatrix} [1 \;\; -1] = \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ -1 & 1 \\ +1 & -1 \end{bmatrix}$$

$$W_4 = \begin{bmatrix} -1 \\ -1 \\ 1 \\ 1 \end{bmatrix} [1 \;\; -1] = \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix}$$

$$W = w_1 + w_2 + w_3 + w_4$$

$$= \begin{bmatrix} -1 & 1 \\ 1 & -1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix} + \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix} + \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ -1 & 1 \\ 1 & -1 \end{bmatrix} + \begin{bmatrix} -1 & 1 \\ -1 & 1 \\ 1 & -1 \\ 1 & -1 \end{bmatrix}$$

$$= \begin{bmatrix} -4 & 4 \\ -2 & +2 \\ 2 & -2 \\ 4 & -4 \end{bmatrix}$$

$$O/P = [-1 \quad -1 \quad 1 \quad 1] \times \begin{bmatrix} -4 & 4 \\ -2 & +2 \\ 2 & -2 \\ 4 & -4 \end{bmatrix}$$

$$= [12 \quad -12] = [1 \quad -1]$$

$$\text{Mixing data} = [0 \quad -1 \quad 1 \quad 1] \begin{bmatrix} -4 & 4 \\ -2 & 2 \\ 2 & -2 \\ 4 & -4 \end{bmatrix}$$

$$= [4 \quad -8] = [1 \quad -1].$$

$$\text{Mistake data} = [1 \quad -1 \quad 1 \quad 1] \times \begin{bmatrix} -4 & 4 \\ -2 & 2 \\ 2 & -2 \\ 4 & -4 \end{bmatrix}$$

$$= [4 \quad -4] = [1 \quad -1]$$