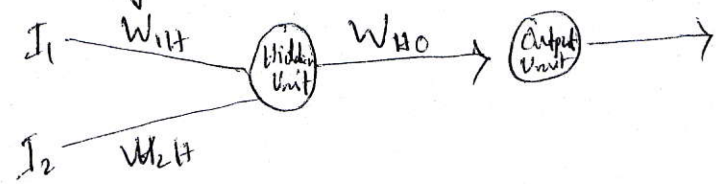
1. Find an input-output mapping using the following multilayer neural network (MLN) for each of the following activation function using the bias value 0.2 for every neuron.

Assume $I_1 = 1$ and $I_2 = 1$

a) Heaviside func

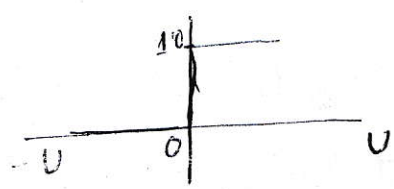
b) Piecewise-Liner function

c) Logistic function with $a = 2$

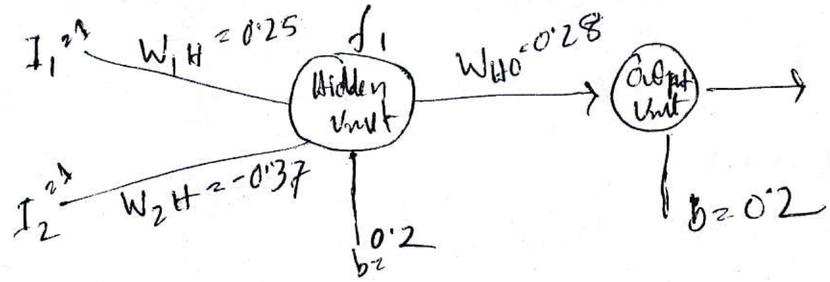


Initial weight vector, $(W_{1H}, W_{2H}, W_{HO}) = (0.25\ -0.37, 0.28)$

Ans: a) Heaviside function



$$f(x) = \begin{cases} 1.0 & \text{where } v \geq 0 \\ 0.0 & \text{where } v < 0 \end{cases}$$



For Hidden Unit

$U = I_1 * W_1 H + I_2 * W_2 H + b = 1 * 0.25 + 1 * (-0.37) + 0.2 = 0.08$

$\therefore$ U value 0.8 and Grater than 0

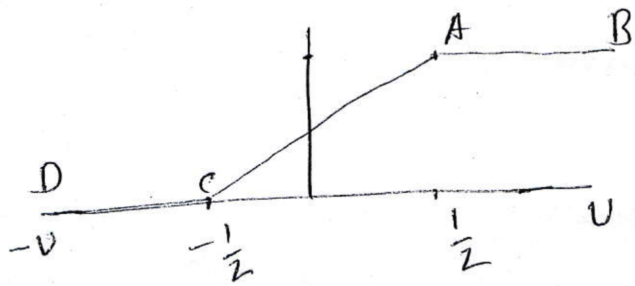
$f(1) = 1$

For Output Unit

$U = f_1 * W_{HO} + b = \cancel{0.08}^{1} * 0.28 + 0.2 = 0\cancel{.48}\ 0.48$

$\therefore f(U) = 1$

b) Piece wise - Liner function



We know

$$f(U)\begin{cases} AB \text{ equation } & U \geq \frac{1}{2} \\ AC \text{ equation } & -\frac{1}{2} < U < \frac{1}{2} \\ CD \text{ equation } & U \leq -\frac{1}{2} \end{cases}$$

$$f(U)\begin{cases} 1 \text{ equation } & U \geq \frac{1}{2} \\ U + \frac{1}{2} \text{ equation } & \frac{1}{2} < U < \frac{1}{2} \\ 0 \text{ equation } & U \leq -\frac{1}{2} \end{cases}$$

From Hidden Unit

$U = I_1 W_{1H} * I_2 W_2 H + b = 0.08$

$f(1) = U + \frac{1}{2} = 0.08 + 0.5 = 0.58$

For Output Unit:

$U = f_1 * W_{HO} + b = (0.58 * 0.28) + 0.2 = 0.3625$

$f_{(1)} = U + \frac{1}{2} = 0.3624 + 0.5 = 0.8625$

c) Logistic function with $a = 2$

Hidden Unit

$$U = I_1 W_{1H} + I_2 W_{2H} + b = 1 * 0.25 + 1 * (-0.37) + 0.2 = 0.08$$

Here $a = 2$

$$\therefore f_1 = \frac{1}{1 + e^{-aU}} = \frac{1}{1 + e^{-2 * 0.08}} = 0.5399$$

For Output Unit

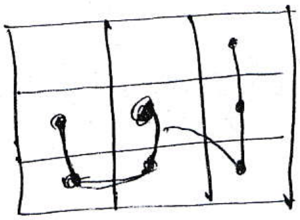
$$U = f_1 * W_{1H0} + b = 0.5399 * 0.28 + 0.2 = 0.3512$$

$$\therefore f(U) = \frac{1}{1 + e^{-aU}} = \frac{1}{1 + e^{-2 * 0.3512}} = 0.6687$$

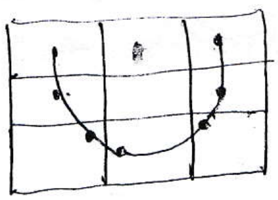
2.b Show MLN (Multilayer Nural Network) Architecture for Bengali chracter recognition. Show Input-output patterns for traing and Testing.

Ans. Problem Bengali chracter recognition

Input: অ আ ই ঈ উ ঊ ঋ এ ঐ ও ... ঁ
ক খ গ ঘ ঙ ...

অ:  ⇒

I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9
0	0	1	1	1	1	1	1	1	1

ঁ  ⇒

I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8
1	1	1	1	0	1	1	1	1

Input pattern Dimention = 9 ($I_0 \ldots I_8$)

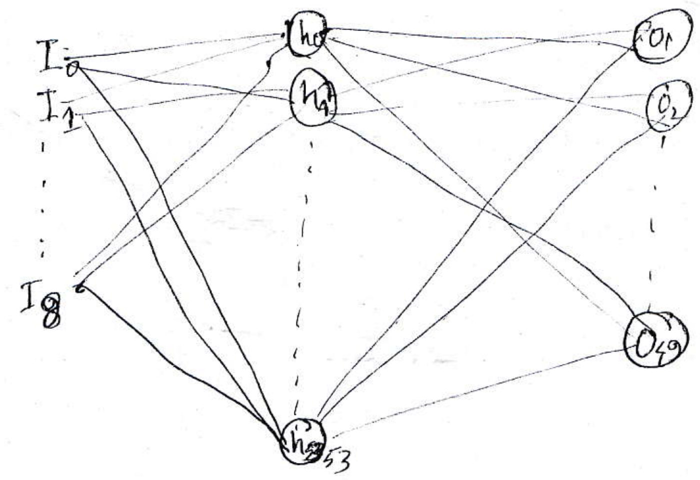
Output Pattern Dimention = 50 ($O_{অ} \ldots O_{ঁ}$)

Neural Network Architecture:

Input layer = 9

~~Output~~ Hidden layer = 9 × 6 = 54

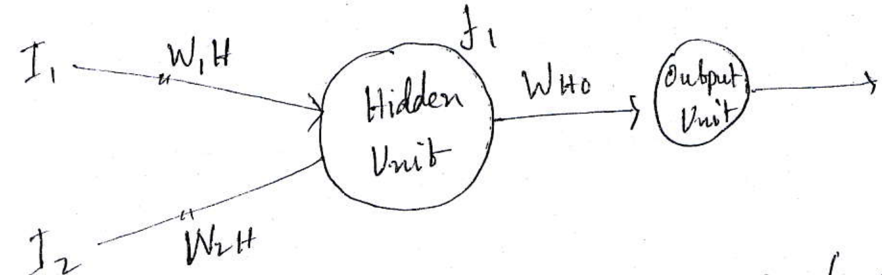
Output layer = 50



9 - 54 - 50

Neural Network Architecture

3. a) Find output of the following neuron using the different types of neuron models. Assume bias and Pseudo-temperature for each neuron are 0.25 and 10000, respectively, Use sigmoid as an activation function. Assume, $I_1 = 1$ and $I_2 = 1$



Initial Weight Vector, $(W_1H, H_{2H}, W_{HO}) = (0.25, -0.37, 0.28)$

Ans: There are three type of model

i) Neural model without bias

ii) Neural model with bias

iii) stochastic model of a neuron

i)

$$v = I_1 W_1 + I_2 W_2 = 1 * 0.25 + 1 * (-0.37) = -0.17$$

$$f(v) = \frac{1}{1+e^{-v}} = \frac{1}{1+e^{-0.17}} = 0.5923$$

$$v = f_1 * W_{HO} = 0.5923 * 0.28 = 0.1518$$

$$f(v) = \frac{1}{1+e^{-v}} = \frac{1}{1+e^{-0.1518}} = 0.5338$$

ii) Neural Model with Bias

$$v = I_1 W_{1H} + I_2 H_{2H} + b = 1 * 0.25 + 1 * (-0.37) + 0.25 = 0.13$$

$$f_1 = \frac{1}{1+e^{-v}} = \frac{1}{1+e^{-0.13}} = 0.5324$$

$$v = f_1 * W_{HO} + b = 0.5324 * 0.28 + 0.25 = 0.4291$$

$$f(v) = \frac{1}{1+e^{-v}} = \frac{1}{1+e^{-0.4291}} = 0.6057$$

iii) Stochastic Model of a Neuron

$$v = I_1 W_{1H} + I_2 H_{2H} + b = 0.13$$

$$f_1 = \frac{1}{1+e^{\frac{-v}{T}}} = \frac{1}{1+e^{\frac{-0.13}{100000}}} = 0.500000325$$

$$v = f_1 * W_{HO} + b = 0.500000325 * 0.28 + 0.25 = 0.39000009$$

$$f_{(v)} = \frac{1}{1+e^{-\frac{v}{T}}} = \frac{1}{1+e^{-\frac{0.39000009}{100000}}}$$

$$= 0.500000975$$

$$n = \begin{cases} +1 & \text{with probability } P(v) \\ -1 & \text{with probability } 1-P(v) \end{cases}$$

$$n = \begin{cases} +1 & \text{with probability } 0.500000975 \\ -1 & \text{" " } 1 - 0.50000975 = 0.49999025 \end{cases}$$

4) a) Discuss the different type of memory-based learning for the test data, (2, 4, 1) using the following input-output patterns.

((4,5,6) A), ((2,1,5) B), ((1,4,3) C), ((1,2,4) A) ((4,3,5) B) ((2,4,5),C), ((1,2,3),B), ((2,3,1),C) and ((2,1,3),B)

Ans: Memory Based Learning : Nearest Neibourn Algorithm & K Nearest Neibourn Algorithum

((4,5,6),A)
((2,1,5) B)
((1,4,3) C)
((1,2,4) A)
((4,3,5) B)
((2,4,5) C)
((1,2,3),B)
((2,3,1) C)
((2,1,3) B

Nearest Neibourn Algorithum:

A
4 5 6
1 2 4

Average $\frac{4+1}{2}$ $\frac{5+2}{2}$ $\frac{6+4}{2}$

= 2.5 3.5 5

B
2 1 5
4 3 5
1 2 3
2 1 3

Average = $\frac{2+4+1+2}{4}$ $\frac{1+3+2+1}{4}$ $\frac{5+5+3+3}{4}$

= 2.25 1.75 4

C
1 4 3
2 4 5
2 3 1

Average $\frac{1+2+2}{3}$ $\frac{4+4+3}{3}$ $\frac{3+5+1}{3}$

= 1.67 3.67 3

Classify test Data (2, 4, 1)

$d_1^2 = (2.5-2)^2 + (3.5-4)^2 + (5-1)^2 = 16.5$

$d_2^2 = (2.25-2)^2 + (1.75-4)^2 + (4-1)^2 = 14.125$

$d_3^2 = (1.67-2)^2 + (3.67-4)^2 + (3-1)^2 = 4.23$

$\therefore d_1^2 > d_2^2 > d_3^2$ Output class C

K nearest Neiboun Algorithom

$d_1^2 = (4-2)^2 + (5-4)^2 + (6-1)^2 = 30$ Class A

$d_2^2 = (2-2)^2 + (1-4)^2 + (5-1)^2 = 25$ Class B

$d_3^2 = (1-2)^2 + (4-4)^2 + (3-1)^2 = 5$ Class C

$d_4^2 = (1-2)^2 + (2-4)^2 + (4-1)^2 = 14$ Class A

$d_5^2 = (4-2)^2 + (3-4)^2 + (5-1)^2 = 21$ Class B

Class - C

$d_6^2 = (2-2)^2 + (4-4)^2 + (5-1)^2 = 16$

$d_7^2 = (1-2)^2 + (2-4)^2 + (3-1)^2 = 9$ Class B

$d_8^2 = (2-2)^2 + (3-4)^2 + (1-1)^2 = 1$ Class C

Class B

$d_9^2 = (2-2) + (1-4)^2 + (3-1)^2 = 13$

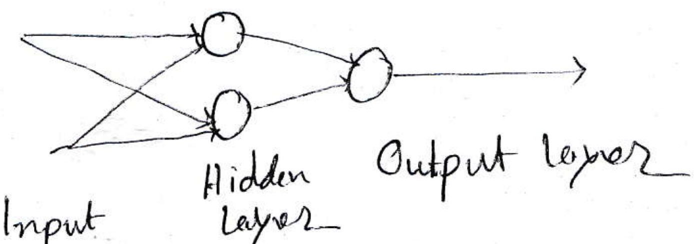
K = 3 ~~3 Neiboun~~
3 Nearest Neiboun Algorithm

C B C

Output Class = C (Majority.

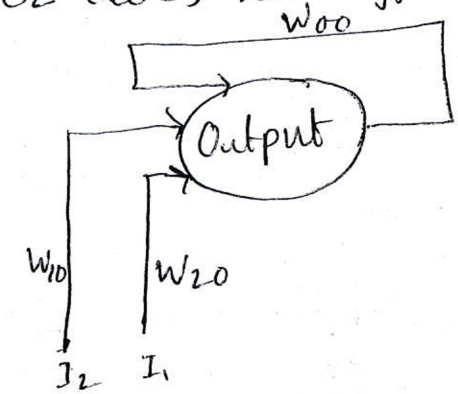
4.6. What are the differences between RNN and MLN

MLN:



From input to Output there are no feedback (loop). Here one or mor Hidden layer. The output of any layer does not affect that same layer.

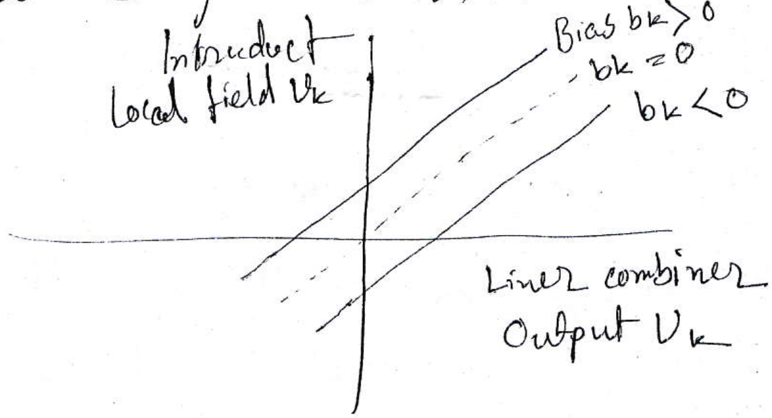
RNN:



A recurrent neural Network consists of a single layer of neuron with each neuron feeding its output signal back to the inputs of all the other. neurons.

Net

3.5 Figure Affine tronsaction processed by the presence of a bias; Note that $v = b_k$ at $u_k = 0$



#1 We know output signal $y_k(n)$ as an infinite weighted summation of present and past samples of the input signal $x_j(n)$ as shown is

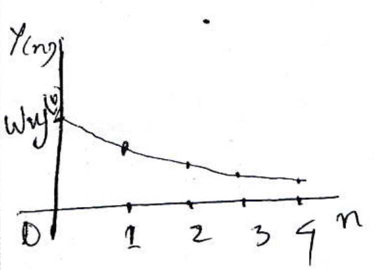
$$y_k(n) = \sum_{l=0}^{\infty} w^{l+1} x_j(n-l)$$

We now see clearly that the dynamic behaviour of a feedback system represented by the system is suitable.

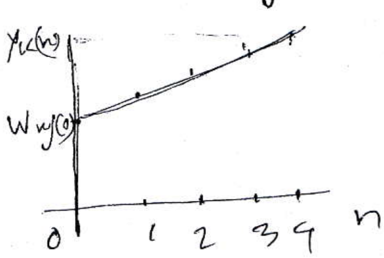
1. $|w| < 1$ for which the output signal $y_k(n)$ is exponentially coverage. That is, the system is stable. This case is illustrated in a positive w.

2. $|w| \geq 1$ for which the output signal $y_k(n)$ is disvergent. that is the system unsuitable.

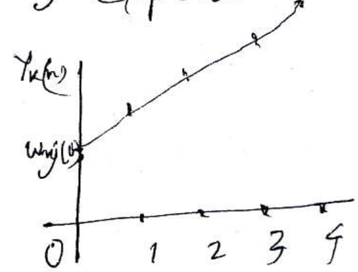
If $|w| = 1$ the divergence in liner Then $|w| > 1$ also the divergence is exponential.



(a)



(b)



(c)

The case of $|w| < 1$ correspond to a system with infinite memory in the sense that the output of the system depends on sample of the input extending into the infinite past.

Moreover, the memory is fading in that the influence of a past sample is reduced exponentially with time n. Suppose that for some power 'N': $|w|$ is small enough relative to unity such that w^N is negligible for all practical purpose. In such situation, we may approximate the output y_k by the finite sum.

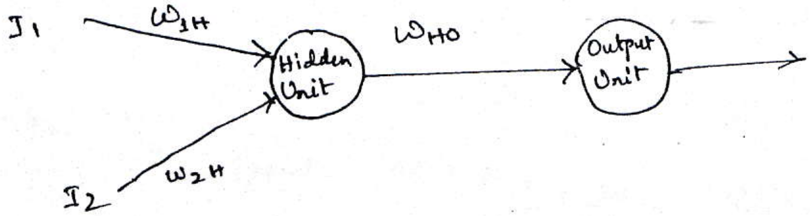
$$y_n(n) \approx \sum_{l=0}^{N-1} w^{l+1} x_j(n-1)$$

$$= w x_j(n) + w^2 x_j(n-1) + w^3 x_j(n-2) + \cdots + w^N x_j(n-N+1)$$

In a corresponding way, we may use the feed-forword single-flow graph.

Find output of the following

neuron models. Assume bias and Pseudo-Temperature for each neuron are 0·25 and 100000, respectively. Use sigmoid ~~function~~ as an activation function. Assume, $I_1 = 1$, $I_2 = 1$.



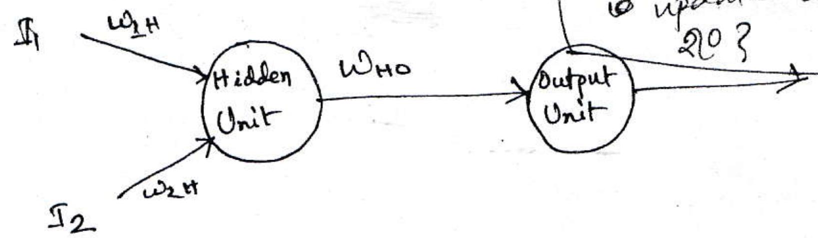
Initial weight vector, $(W_{1H}, W_{2H}, W_{HO}) = (0.25, -0.37, 0.28)$

Without bias Model

$u = I_1 W_{1H} + I_2 \cdot W_{2H}$

given below find the output for the test data, (1,0). Assume, $I_1 = 1$, and $I_2 = 1$.

যদি bias ~~updat~~ করতে বললে, bias কি ও update করতে হবে? কেমনে হলে কি ভাবে করতে হবে? (10)



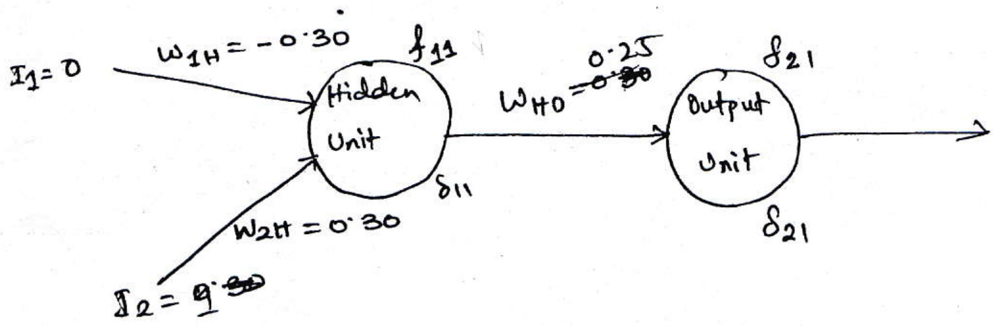
Initial Weight; $w_{1H} = -0.30$ $\quad W_{2H} = +0.30$ $\quad W_{HO} = +0.25$

Learning rate, $\eta = 0.1$

Training Samples,

Input (I_1)	Input (I_2)	Output
0	1	1.0
1	1	1.0

Use sigmoid as an activation function.



(1)

ns:

Initialization

$w_{1H} = -0.30$ $\qquad \eta = 0.1$

$w_{2H} = +0.30$

$w_{HO} = +0.25$

Training / Learning Phase :-

Foreward Pass : $I_1 = 0$, $I_2 = 1$, $d_1 = 1.0$

For Hidden ~~layer~~ Unit:

$u = I_1 W_{1H} + I_2 W_{2H} = 0 * (-0.30) + 1 * 0.30 = 0.30$

$$f_{11} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.30}} = 0.57444$$

For output Unit :

$u = f_{11} * w_{HO} = 0.57444 * 0.25 = 0.14361$

$$f_{21} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.14361}} = 0.53584$$

Backpropagation

For Output Unit

δ_{21} Calculation :

$$\delta_{21} = f_{21}' (d_1 - f_{21})$$
$$= f_{21}(1 - f_{21})(d_1 - f_{21})$$
$$= 0.53584(1 - 0.53584)(1.0 - 0.53584) =$$
$$= 0.53584 * 0.46416 * 0.46416 = 0.11544$$

②

$$\delta_{11} = f_{11}'(\delta_{21} * w_{HO}) = f_{21}(1 - f_{21})(\delta_{21} * w_{HO})$$

$$= \cancel{0.11544(1-0.11544)}$$

$$= 0.53584\,(1 - 0.53584)\,(0.11544 * 0.25)$$

$$= 0.24872 * 0.02886$$

$$= 0.007178$$

Weight Update

$$\Delta w_{1H} = \eta * \delta_{11} * I_1 = 0.1 * 0.007178 * 0 = 0$$

$$w_{1H} = w_{1H} + \Delta w_{1H} = -0.30 + 0 = -0.30$$

$$\Delta w_{2H} = \eta * \delta_{11} * I_2 = 0.1 * 0.007178 * 1 = 0.0007178$$

$$w_{2H} = w_{2H} + \Delta w_{2H} = 0.30 + 0.0007178 = 0.3007178$$

$$\cong 0.301$$

$$\Delta w_{HO} = \eta * \delta_{21} * \cancel{w_{HO}} = 0.1 * 0.11544 * 0.25$$

$$= 0.002886$$

$$w_{HO} = w_{HO} + \Delta w_{HO} = 0.25 + 0.002886$$

$$= 0.252886$$

$$\cong 0.259$$

For Hidden Unit

$$u = I_1 W_{1H} + I_2 W_{2H} = 1 * (-0.30) + 1 * 0.301$$

$$= 0.001$$

$$f_{11} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.001}} = 0.50025$$

For Output Unit

$$u = f_{11} * W_{HO} = 0.50025 * 0.253 = \cancel{0.1266}\ 0.12656$$

$$f_{21} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.12656}} = \cancel{0.532}\ 0.5316$$

Backpropagation

For Output Unit

δ_{21} Calculation

$$\delta_{21} = f'_{21}(d_2 - f_{21})$$

$$= f_{21}(1-f_{21})(d_2 - f_{21})$$

$$= 0.5316\,(1-0.5316)\,(1.0 - 0.5316)$$

$$= 0.5316 * 0.4684 * 0.4684$$

$$= 0.1166$$

$$\delta_{11} = f_{11}(\delta_{21} * \omega_{HO})$$

$$= f_{11}(1 - f_{11})(\delta_{21} * \omega_{HO})$$

$$= 0.50025 * (1 - 0.50025)(0.1166 * 0.253)$$

$$= 0.00737$$

Weight Update

$$\Delta\omega_{1H} = \eta * \delta_{11} * I_1 = 0.1 * 0.00737 * 1 = 0.0007.$$

$$\omega_{1H} = \omega_{1H} + \Delta\omega_{1H} = -0.30 + 0.0007 = -0.2993$$

$$\Delta\omega_{2H} = \eta * \delta_{11} * I_2 = 0.1 * 0.00737 * 1 = 0.0007.$$

$$\omega_{2H} = \omega_{2H} + \Delta\omega_{2H} = 0.301 + 0.0007 = 0.3017$$

$$\Delta\omega_{HO} = \eta * \delta_{21} * \omega_{HO} = 0.1 * 0.1166 * 0.253$$

$$= 0.00295$$

$$\omega_{HO} = \omega_{HO} + \Delta\omega_{HO} = 0.253 + 0.00295$$

$$= 0.256.$$

One epoch completed.

Testing:

Forward Pass : $I_1 = 1$, $I_2 = 0$.

For Hidden Unit

$$u = I_1 \, w_{1H} + I_2 \, w_{2H} = 1 * (-0.2993) + 0 * 0.3017$$
$$= -0.2993$$

$$f_{11} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.2993}} = 0.5743$$

For Output Unit

$$u = f_{11} * w_{HO} = 0.5743 * 0.256 = 0.1470$$

$$f_{21} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.1470}} = 0.5367$$

learning in the self organizing map (SOM). Use the initial weight matrix and ~~lar~~ learning rate given below.

Input pattern:

i1: (1, 1, 0)
i2: (1, 0, 0)
i3: (1, 0, 1)
i4: (1, 1, 1)

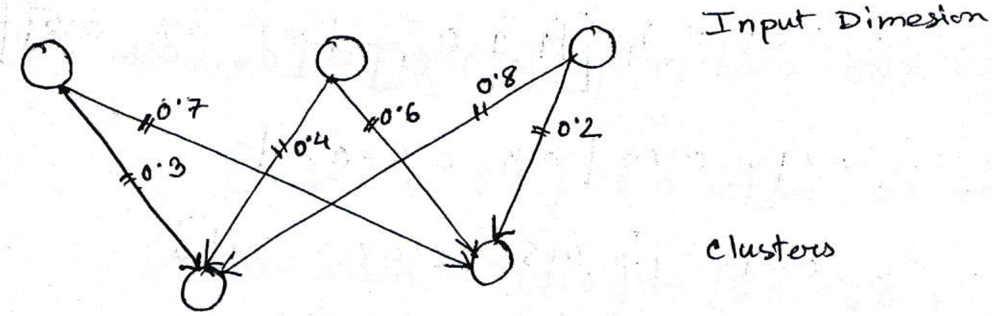
Initial weight matrix, W =
$$\begin{matrix} 0.3 & 0.4 & 0.8 \\ 0.7 & 0.6 & 0.2 \end{matrix}$$

Learning rate, η = 0.05

Complete one epoch. Does which cluster contain the pattern, $(\cancel{0,0,1})$ 1, 0, 1?

Ans:-

Neural Network Architecture:-



Step 0: Initialization:

$$\text{Weight} = \begin{bmatrix} 0.3 & 0.4 & 0.8 \\ 0.7 & 0.6 & 0.2 \end{bmatrix} \begin{matrix} \leftarrow c_1 \\ \leftarrow c_2 \end{matrix}$$

Training Phase:

i1 training:

For C_1 cluster

$$d_1^2 = (1-0.3)^2 + (1-0.4)^2 + (0-0.8)^2$$

$$= \cancel{0.89}\ 1.49$$

For C_2 cluster

$$d_2^2 = (1-0.7)^2 + (1-0.6)^2 + (0-0.2)^2$$

$$= 0.29.$$

Since $d_1^2 > d_2^2$, C_2 is winner

Weight update for C_2

$\cancel{[0.7\ \ 0.6\ \ 0.2] + \eta[[0.7\ \ 0.6\ \ 0.2] - [}$

$$[0.7\ \ 0.6\ \ 0.2] + \eta\,[[1\ \ 1\ \ 0] - [0.7\ \ 0.6\ \ 0.2]]$$

$$\Rightarrow [0.7\ \ 0.6\ \ 0.2] + 0.05\,[0.3\ \ 0.4\ \ -0.2]$$

$$= [0.7\ \ 0.6\ \ 0.2] + [0.015\ \ 0.02\ \ -0.01]$$

$$= [0.725\ \ 0.62\ \ 0.19]$$

$$\text{weight} = \begin{array}{cc} \begin{bmatrix} 0.3 & 0.4 & 0.8 \\ 0.72 & 0.62 & 0.19 \end{bmatrix} & \begin{array}{l} \leftarrow c_1 \\ \leftarrow c_2 \end{array} \end{array}$$

For c_1 cluster

$$d_1^2 = (1-0.3)^2 + (0-0.4) + (0-0.8)^2$$

$$= 1.29$$

For C_2 cluster

$$d_2^2 = (1-0.72)^2 + (0-0.62)^2 + (0-0.19)^2$$

$$= 0.4989$$

Since $d_1^2 > d_2^2$, C_2 is winner.

Weight update for C_2

$$[0.72 \;\; 0.62 \;\; 0.19] + \eta\,[[1 \;\; 0 \;\; 0] - [0.72 \;\; 0.62 \;\; 0.19]]$$

$$= [0.72 \;\; 0.62 \;\; 0.19] + 0.05\,[0.28 \;\; -0.62 \;\; -0.19]$$

$$= [0.72 \;\; 0.62 \;\; 0.19] + [0.014 \;\; -0.031 \;\; -0.0095]$$

$$= [0.734 \;\; 0.589 \;\; 0.1805]$$

$$\text{Weight} = \begin{bmatrix} 0.3 & 0.4 & 0.8 \\ 0.734 & 0.589 & 0.1805 \end{bmatrix} \begin{array}{l} \leftarrow c_1 \\ \leftarrow c_2 \end{array}$$

i3 training

For C_1 cluster

$$d_1^2 = (1-0.3)^2 + (0-0.4)^2 + (1-0.8)^2$$

$$= 0.69$$

For C_2 cluster

$$d_2^2 = (1-0.734)^2 + (0-0.589)^2 + (1-0.1805)^2$$

$$= 1.089$$

Since, $d_1^2 < d_2^2$, C_1 is winner.

$$= [0.3 \quad 0.4 \quad 0.8] + \eta \big[[1 \quad 0 \quad 1] - [0.3 \quad 0.4 \quad 0.8]\big]$$

$$= [0.3 \quad 0.4 \quad 0.8] + 0.05 [0.7 \quad -0.4 \quad 0.2]$$

$$= [0.3 \quad 0.4 \quad 0.8] + [0.035 \quad -0.02 \quad 0.01]$$

$$= [0.335 \quad 0.38 \quad 0.81]$$

$$\text{Weight} = \begin{array}{cc} \begin{bmatrix} 0.335 & 0.38 & 0.81 \\ 0.734 & 0.589 & 0.1805 \end{bmatrix} & \begin{array}{l} \leftarrow c_1 \\ \leftarrow c_2 \end{array} \end{array}$$

<u>i4 training</u>

For c_1 cluster	For c_2 cluster
$d_1^2 = (1-0.335)^2 + (1-0.38)^2 + (1-0.81)^2$	$d_2^2 = (1-0.734)^2 + (1-0.589)^2 + (1-0.1805)^2$
$= 0.863$	$= 0.911$

Since $\cancel{d_2}$ $d_1^2 < d_2^2$, c_1 is winner

<u>weight update for c_1</u>

$$= [0.335 \quad 0.38 \quad 0.81] + \eta \big[[1 \quad 1 \quad 1] - [0.335 \quad 0.38 \quad 0.81]\big]$$

$$= [0.335 \quad 0.38 \quad 0.81] + 0.05 [0.665 \quad 0.62 \quad 0.19]$$

$$= [0.335 \quad 0.38 \quad 0.81] + [0.03325 \quad 0.031 \quad 0.0095]$$

$$= \cancel{[0.302}$$

$$= [0.368 \quad 0.411 \quad 0.819]$$

$$\text{Weight} = \begin{array}{cc} \begin{bmatrix} 0.368 & 0.411 & 0.819 \\ 0.734 & 0.589 & 0.1805 \end{bmatrix} & \begin{array}{l} \leftarrow c_1 \\ \leftarrow c_2 \end{array} \end{array}$$

One epoch completed.

For c_1 cluster

$$d_1^2 = (1-0.368)^2 + (1-0.411)^2 + (0-0.819)^2$$

$$= 1.42$$

For c_2 cluster

$$d_2^2 = (1-0.734)^2 + (1-0.589)^2 + (0-0.1805)^2$$

$$= 0.27$$

Since $d_1^2 > d_2^2$, C_2 cluster wins. So

$\therefore$ i1 data is in C_2 cluster

For i2 data

For C_1 cluster

$$d_1^2 = (1-0.368)^2 + (0-0.411)^2 + (0-0.819)^2$$

$$= 1.24$$

For C_2 cluster

$$d_2^2 = (1-0.734)^2 + (0-0.589)^2 + (0-0.1805)^2$$

$$= 0.45$$

Since, $d_1^2 > d_2$, C_2 cluster wins.

$\therefore$ i2 data is in C_2 cluster.

For c_1 cluster

$$d_1^2 = (1-0.368)^2 + (0-0.411)^2 + (1-0.819)^2$$
$$= 0.60$$

For c_2 cluster

$$d_2^2 = (1-0.734)^2 + (0-0.589)^2 + (1-0.1805)^2$$
$$= 1.089$$

Since $d_1^2 < d_2^2$, c_1 wins.

$\therefore$ i3 data is in cluster c_1.

For i4 data

For c_1 cluster

$$d_1^2 = (1-0.368)^2 + (1-0.411)^2 + (1-0.819)^2$$
$$= 0.78$$

For c_2 cluster

$$d_2^2 = (1-0.734)^2 + (1-0.589)^2 + (1-0.1805)^2$$
$$= 0.91$$

Since, $d_1^2 < d_2^2$, c_1 cluster wins.

$\therefore$ i4 data is in c_1 cluster.

Pattern	Cluster
~~i3 i4~~, i3, i4	C_1
~~i1, i2~~ i1, i2	C_2

~~Dat~~ New data pattern (0, 0, 1).

<u>For C_1 cluster</u>

$d_1^2 = (0-0.368)^2 + (0-0.411)^2 + (1-0.819)^2$

$= 0.34$

<u>For C_2 cluster</u>

$d_2^2 = (0-0.734)^2 + (0-0.589)^2 + (1-0.1805)^2$

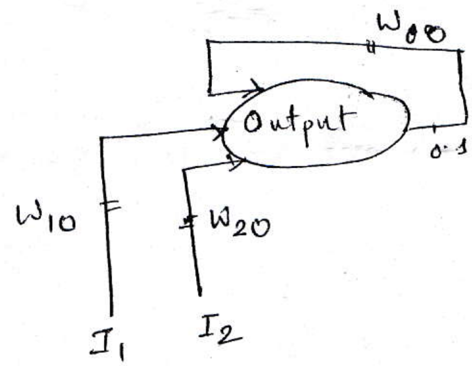
$= \cancel{0.34}\ 1.56$

Since, $d_1^2 < d_2^2$, C_1 is winner.

$\therefore$ New data pattern (0, 0, 1) is in C_1 cluster.

———— X ————

below. Using the RNN given below find the output for the test data (1, 1)



Initial weight vector : $(W_{10}, W_{20}, W_{00}) = (0.95, -0.43, 0.47)$

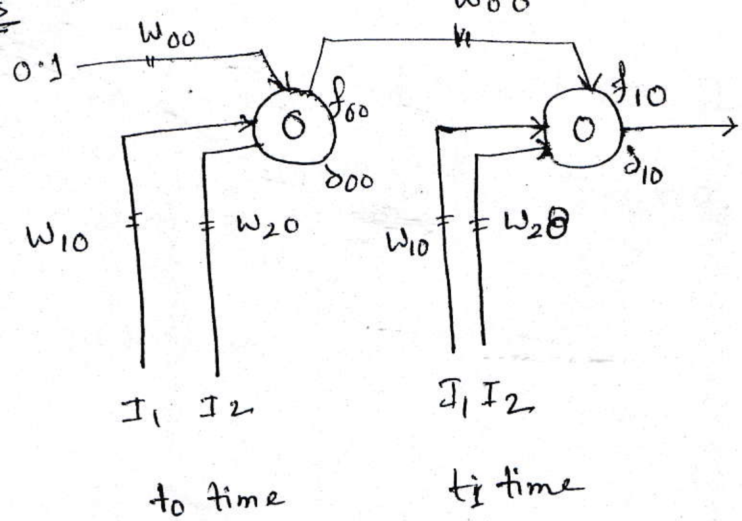
Learning rate, $\eta = 0.01$.

Training samples,

I_1	I_2	Output
0	1	1
1	0	1

Use sigmoid as an activation function.

Ans



Step 0 : Initialization

$W_{10} = 0{\cdot}95$ $\quad W_{20} = -0{\cdot}43, \quad W_{00} = 0{\cdot}47 \quad \eta = 0{\cdot}01$

Forward Pass:

to time: $(I_1 = 0, \; I_2 = 1, \; d_o = 1)$

For O:

$u = 0{\cdot}1 * W_{00} + I_1 * W_{10} + I_2 * W_{20}$

$= 0{\cdot}1 * 0{\cdot}47 + 0 * (0{\cdot}95 + 1 * (-0{\cdot}43)$

$= 0{\cdot}047 + 0 - 0{\cdot}43$

$= -0{\cdot}383$

$f_{00} = \dfrac{1}{1+e^{-u}} = \dfrac{1}{1+e^{(0{\cdot}383)}} = 0{\cdot}405$

P.T.O.

For O:

$u = f_{00} * w_{00} + I_1 w_{10} + I_2 w_{20}$

$= 0.405 * 0.47 + 1 * 0.95 + 0 * (-0.43)$

$= 0.19035 + 0.95$

$= 1.14$

$f_{10} = \frac{1}{1+e^{-1.14}} = 0.758$

Back propagation through time:

For t_1 time

δ_{10} Calculation:

$\delta_{10} = f_{10}' (d_1 - f_{10})$

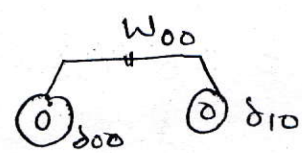
$= f_{10}(1 - f_{10})(d_1 - f_{10})$

$= 0.758(1 - 0.758)(1 - 0.758)$

$= 0.044$

For t_0 time:

δ_{00} Calculation



$\delta_{00} = f_{00}' (d_0 - f_{00} + sum)$

$= \cancel{0.405 (1 - 0.7}$

$= f_{00}(1 - f_{00})(d_0 - f_{00} + sum)$

where $sum = w_{00} * \delta_{00}$

$= 0.405 (1 - 0.405)(1 - 0.405 + (0.47 * 0.044))$

$= 0.405 * 0.595 * 0.62 = \cancel{0.149}\ 0.15$

$\boxed{PTO}$

t_0 time

$$\Delta W_{00} = \eta * 0.1 * \delta_{00} = 0.01 * 0.1 * 0.15 = 0.00015$$

$$W_{00} = W_{00} + \Delta W_{00} = 0.47 + 0.00015 = 0.47015$$

$$\Delta W_{10} = \eta * I_1 * \delta_{00} = 0.01 * 0 * 0.15 = 0$$

$$W_{10} = W_{10} + \Delta W_{10} = 0.95 + 0 = 0.95$$

$$\Delta W_{20} = \eta * I_2 * \delta_{00} = 0.01 * 1 * 0.15 = 0.0015$$

$$W_{20} = W_{20} + \Delta W_{20} = -0.43 + 0.0015 = -0.4285$$

t_1 time

$$\Delta W_{00} = \eta * f_{00} * \delta_{10} = 0.01 * 0.405 * 0.044 = 0.00018$$

$$W_{00} = W_{00} + \Delta W_{00} = 0.47015 + 0.00018 = 0.47033$$

$$\Delta W_{10} = \eta * I_1 * \delta_{10} = 0.01 * 1 * 0.044 = 0.00044$$

$$W_{10} = W_{10} + \Delta W_{10} = 0.95 + 0.00044 = 0.95044$$

$$\Delta W_{20} = \eta * I_2 * \delta_{10} = 0.01 * 0 * 0.044 = 0$$

$$W_{20} = W_{20} + \Delta W_{20} = -0.4285 + 0 = -0.4285$$

P.T.O.

Forward Pass : $(I_1 = 1, I_2 = 1)$

For 0:

~~u = 0.1 * 0.47033~~

$u = 0.1 * w_{00} + I_1 * w_{10} + I_2 * w_{20}$

$= 0.1 * 0.47033 + 1 * 0.95044 + 1 * (-0.4285)$

$= 0.047033 + 0.95044 - 0.4285$

$= 0.568973$

$f_{00} = \frac{1}{1+e^{-u}} = \frac{1}{1+e^{-0.568973}} = 0.6385$