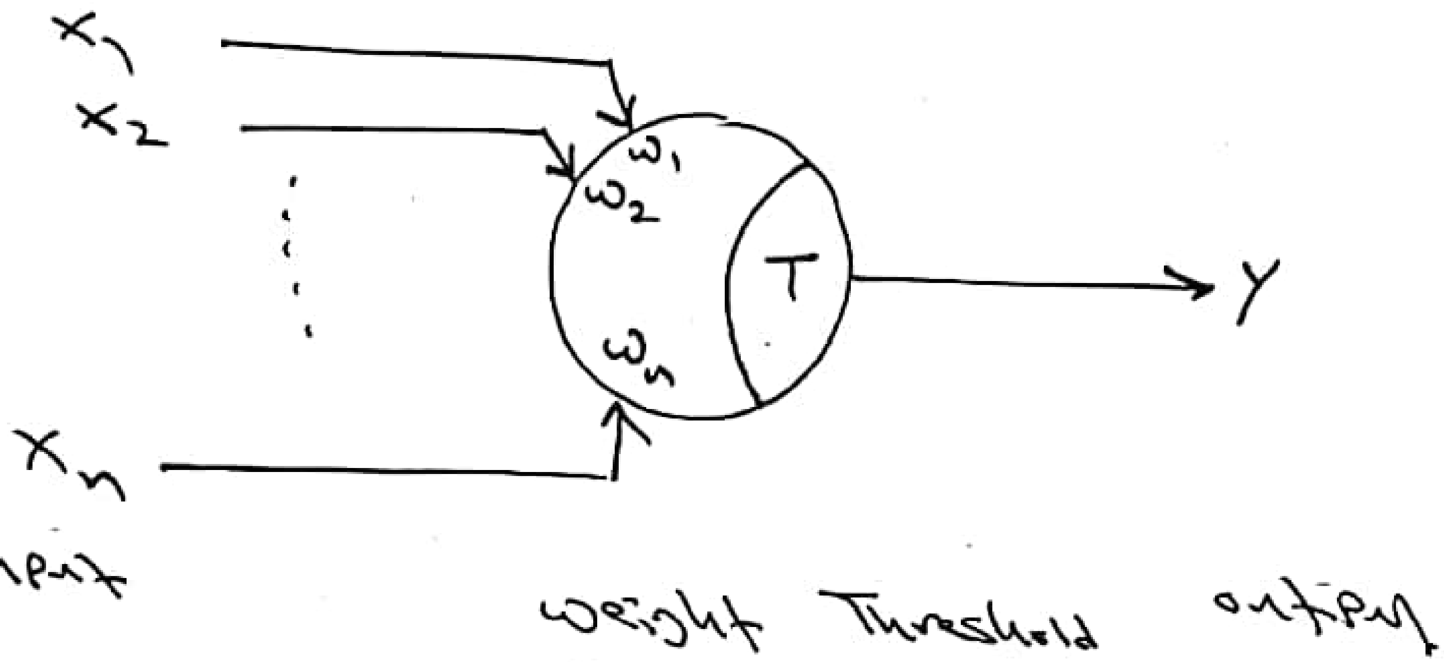
"Soft computing"

* Threshold logic model

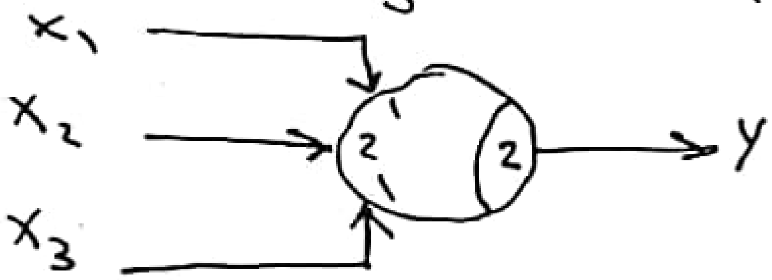


$$x_1 w_1 + x_2 w_2 + \dots x_n w_n = \sum_{i=1}^{n} w_i x_i$$

if $\sum_{i=1}^{n} w_i x_i \geq T$ $\therefore Y = 1$

if $\sum_{i=1}^{n} w_i x_i < T$ $\therefore Y = 0$

Ex: find expression for output y for the following circuit

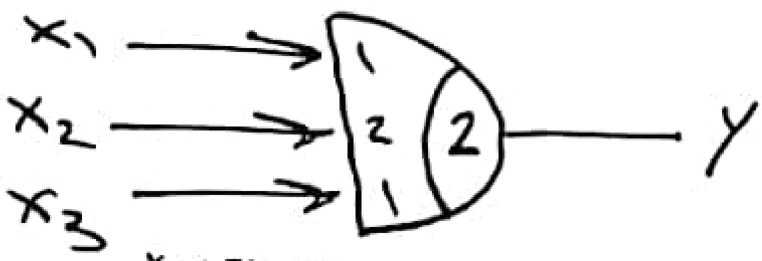


ans: $T = 2$ $\sum_{i=1}^{3} w_i x_i = x_1 + 2x_2 + x_3$

$Y = f(x_1, x_2, x_3)$

$Y = 1$ for $\sum_{i=1}^{3} w_i x_i \geq 2$

$Y = 0$ for $\sum_{i=1}^{3} w_i x_i < 2$



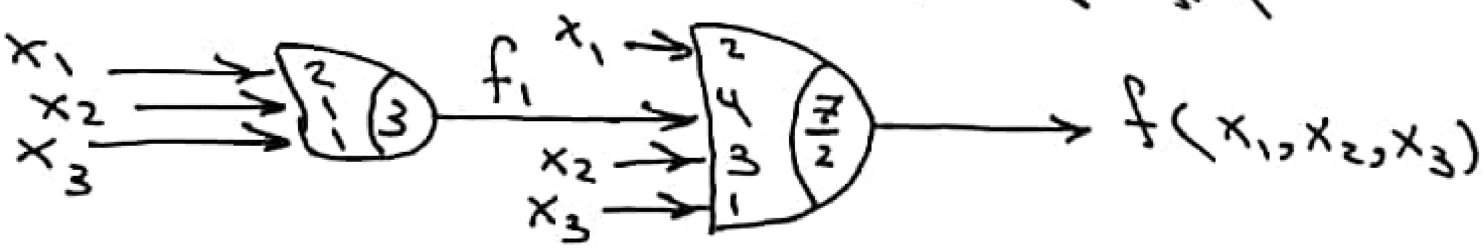
	x_1	x_2	x_3	$\sum w_i x_i$ ($x_1+2x_2+x_3$)	Y
0	0	0	0	0	0
1	0	0	1	1	0
2	0	1	0	2	1
3	0	1	1	3	1
4	1	0	0	1	0
5	1	0	1	2	1
6	1	1	0	3	1
7	1	1	1	4	1

x_3 \ x_1x_2	00	01	11	10
0	0 (0)	1 (2)	1 (6)	0 (4)
1	0 (1)	1 (3)	1 (7)	1 (5)

$$Y = f(x_1, x_2, x_3) = x_2 + x_1 x_3$$

$$Y = f(x_1, x_2, x_3) = \sum m(2, 3, 5, 6, 7)$$

Ex for the switching function $f(x_1, x_2, x_3)$ realize by the two level threshould gat of fig



for $f_1(x_1, x_2, x_3)$ $T = 3$

$$\sum_{i=1}^{3} w_i x_i = 2x_1 + x_2 + x_3 \geq 3 \quad f_1 = 1$$
$$< 3 \quad f_1 = 0$$

for $f(x_1, x_2, x_3)$ $T = 3.5$

$$\sum_{i=1}^{4} w_i x_i = 2x_1 + 4f_1 + 3x_2 + x_3 \geq 3.5 \quad f = 1$$
$$< 3.5 \quad f = 0$$

x_1	x_2	x_3	$2x_1+x_2+x_3$	f_1 ($T=3$)	$2x_1+4f_1+3x_2+x_3$	f ($T=3.5$)
0	0	0	0	0	0	0
0	0	1	1	0	1	0
0	1	0	1	0	3	0
0	1	1	2	0	4	1
1	0	0	2	0	2	0
1	0	1	3	1	7	1
1	1	0	3	1	9	1
1	1	1	4	1	10	1

x_3 \ x_1x_2	00	01	11	10
0	0 (0)	0 (2)	1 (6)	0 (4)
1	0 (1)	1 (3)	1 (7)	1 (5)

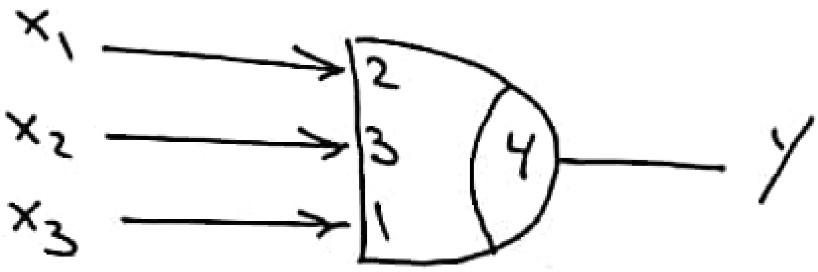
$$f(x_1, x_2, x_3) = x_1x_2 + x_2x_3 + x_1x_3$$

$$f(x_1, x_2, x_3) : \sum m(3, 5, 6, 7)$$

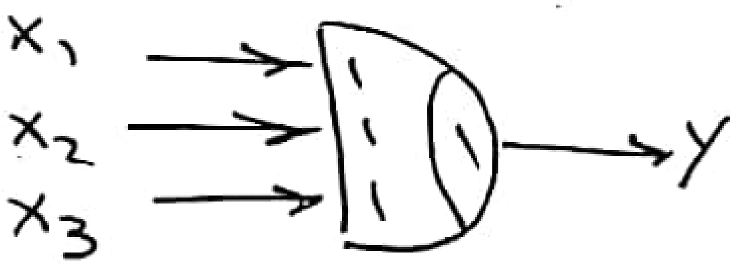
note

$$y = \langle 2x_1 + 3x_2 + x_3 \rangle_4$$

$\Downarrow$

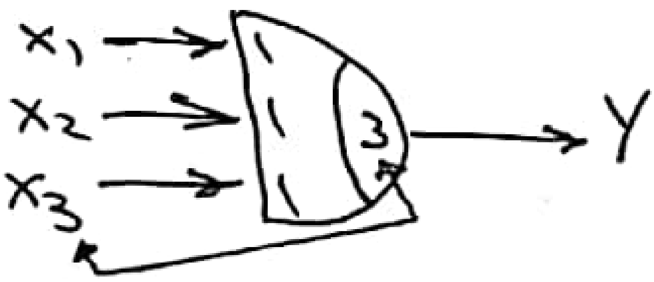


note



OR gate

x_1	x_2	x_3	Σ	Y
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	2	1
1	0	0	1	1
1	0	1	2	1
1	1	0	2	1
1	1	1	3	1



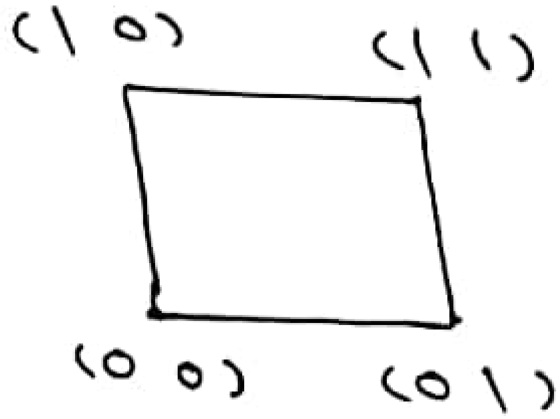
AND gate

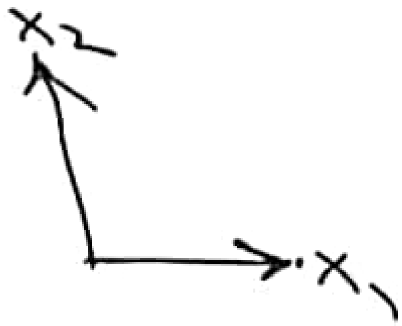
x_1	x_2	x_3	Σ	Y
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	2	0
1	0	0	1	0
1	0	1	2	0
1	1	0	2	0
1	1	1	3	1

* function can be linear seprable or not

$x_1, x_2 \rightarrow$ 2 dimation

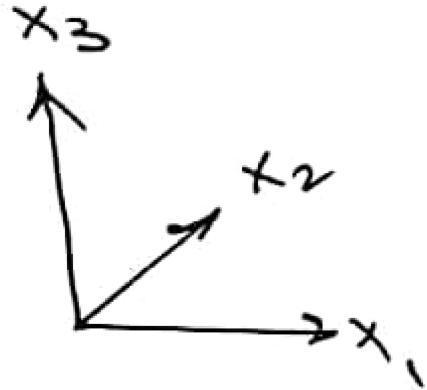
(x_2, x_1)

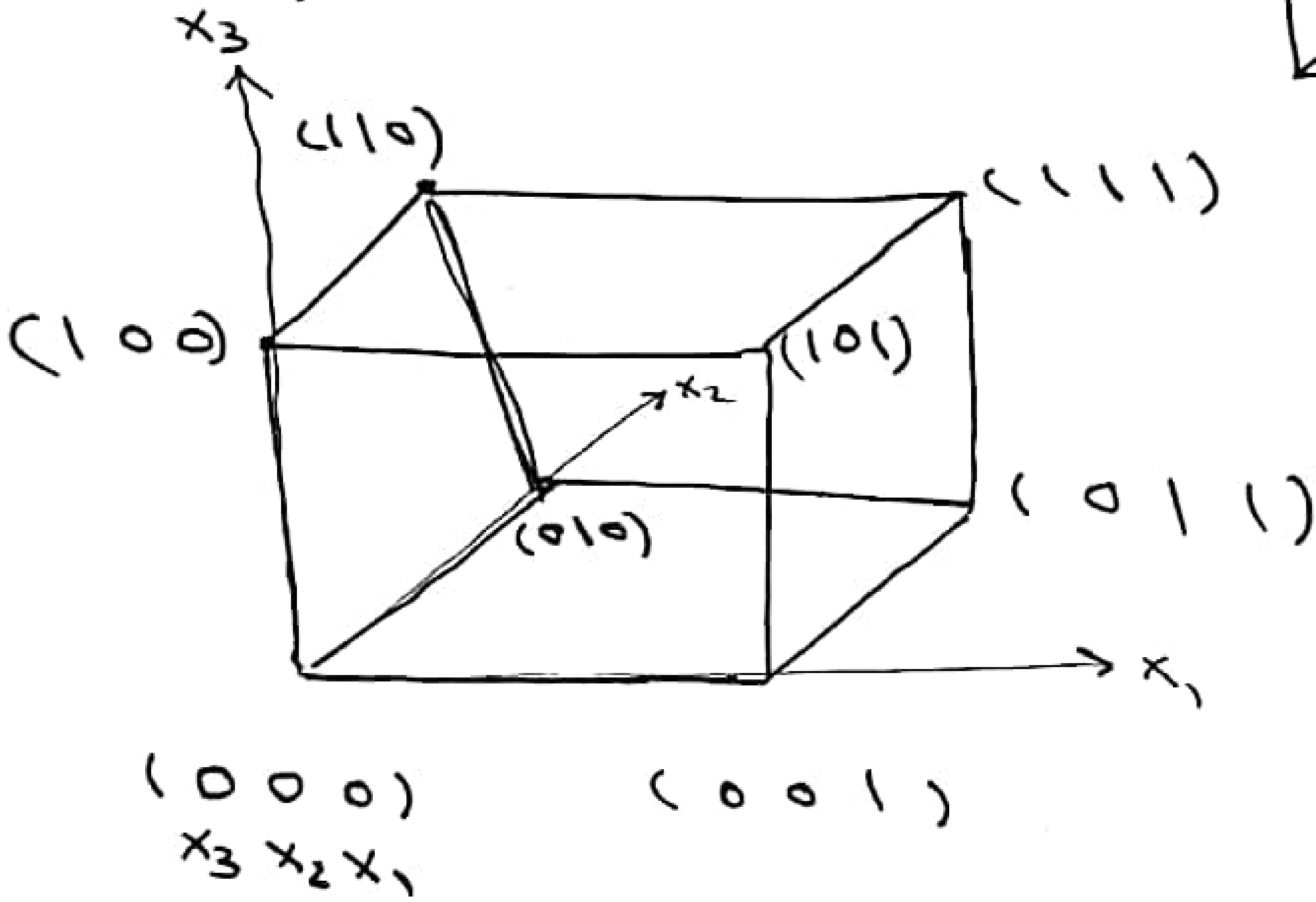




$x_1, x_2, x_3 \rightarrow$ Three dimation

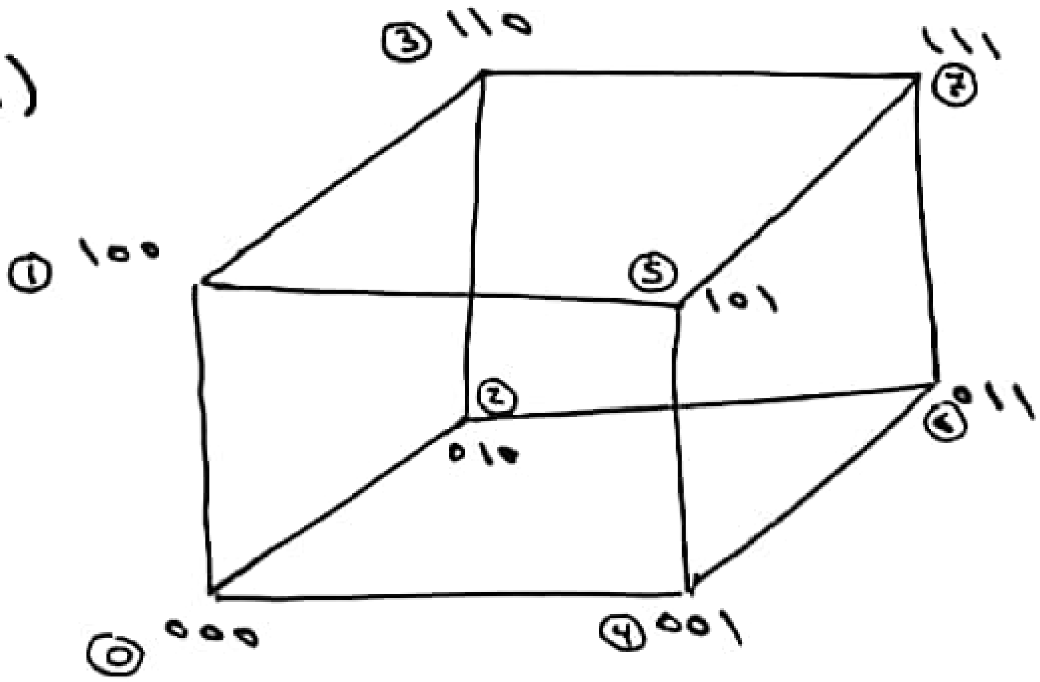
(x_3, x_2, x_1)





ingeneral

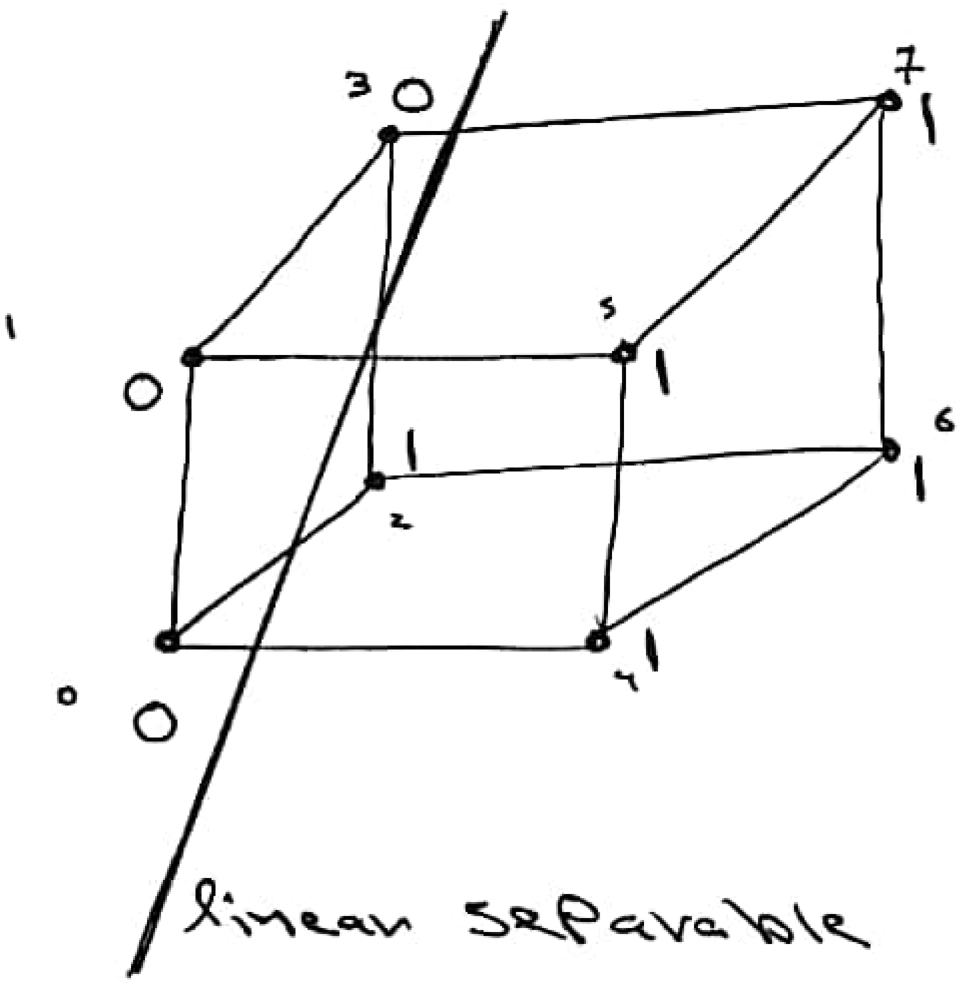
(x_3, x_2, x_1)



Ex for the function $f(x) = x_1 + x_2\bar{x}_3$
can be represented by 3-dimational or not with linear separable

ans

	x_1	x_2	x_3	f
0	0	0	0	0
1	0	0	1	0
2	0	1	0	1
3	0	1	1	0
4	1	0	0	1
5	1	0	1	1
6	1	1	0	1
7	1	1	1	1



can represented with Threshould one stage

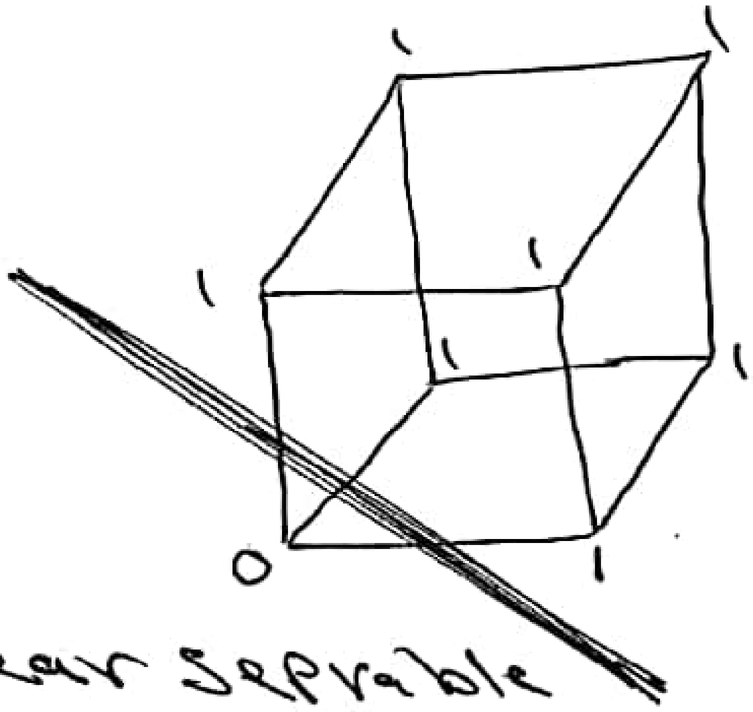
$$\Sigma = W_1X_1 + W_2X_2 + W_3X_3$$

H.W Show if function are linearly seperable or not

$$f_5 = X_1 + \bar{X}_1 X_2 + X_3$$

ans

	x_1	x_2	x_3	f_5
0	0	0	0	0
1	0	0	1	1
2	0	1	0	1
3	0	1	1	1
4	1	0	0	1
5	1	0	1	1
6	1	1	0	1
7	1	1	1	1



yes canbe linear seprable

∴

* linear seprable mean can be realize by using Single Threshuld gate.

Synthesis of threshold Network
Cohw parameter (b_i)

to find coho parameter

$0 \rightarrow -1$

$1 \rightarrow +1$

$$b_i = \sum_{P=1}^{2^n-1} f(x)\, x_i$$

طريقة 1 domain (-1, 1)

use $x_0 = +1$ for all min term

طريقة 2 domain (0, 1)

$b_0 = (\text{no. of } f(x)=1) - (\text{no. of } f(x)=0)$

b_i = agreements - Disagrement

to find Threshould

$$T = \frac{1}{2}\left[\left(\sum_{i=1}^{n} a_i\right) - (a_0) + 1\right]$$

Where a_i is wieghted according to Value of b_i

Ex for $f(x) = \bar{x}_1 x_2 + x_3$ find chow parameter

ans

x_0	x_1	x_2	x_3	$f(x)$	$f(x)x_0$	$f(x)x_1$	$f(x)x_2$	$f(x)x_3$
+1	-1	-1	-1	-1	-1	+1	+1	+1
+1	-1	-1	+1	+1	+1	-1	-1	+1
+1	-1	+1	-1	+1	+1	-1	+1	-1
+1	-1	+1	+1	+1	+1	-1	+1	+1
+1	+1	-1	-1	-1	-1	-1	+1	+1
+1	+1	-1	+1	+1	+1	+1	-1	+1
+1	+1	+1	-1	-1	-1	-1	-1	+1
+1	+1	+1	+1	+1	+1	+1	+1	+1
chow parameter					+2	-2	+2	+6
					b_0	b_1	b_2	b_3

$b_0 = +2 \quad b_1 = -2 \quad b_2 = +2 \quad b_3 = +6$

Ex (a) for function $f(x) = \bar{x}_1 x_2 + x_3$ find Chow parameter using (0,1) domain

ans (b) realize

x_0	x_1	x_2	x_3	$f(x)$	with x_0	with x_1	with x_2	with x_3
1	0	0	0	0	d	a	a	a
1	0	0	1	1	a	d	d	a
1	0	1	0	1	a	d	a	d
1	0	1	1	1	a	d	a	a
1	1	0	0	0	d	d	a	a
1	1	0	1	1	a	a	d	a
1	1	1	0	0	d	d	d	a
1	1	1	1	1	a	a	a	a
					+2	−2	+2	+6

$b_0 = 5 - 3 = 2$

$b_1 = 3 - 5 = -2$

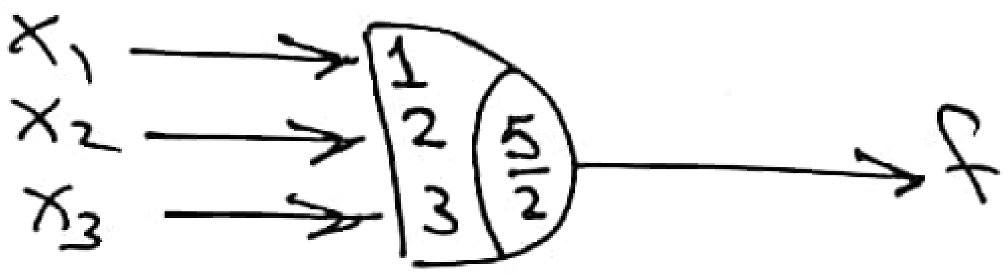
$b_2 = 5 - 3 = +2$

$b_3 = 7 - 1 = +6$

b_0	b_1	b_2	b_3
+2	−2	+2	+6
↓	↓	↓	↓
2	1	2	3
a_0	a_1	a_2	a_3

$$T = \frac{1}{2}\left[a_1 + a_2 + a_3 - a_0 + 1\right]$$

$$= \frac{1}{2}\left[1 + 2 + 3 - 2 + 1\right] = \frac{5}{2}$$



realize the Boolean function $f(x)$ with single threshold gat

x_1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
x_2	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
x_3	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
x_4	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
$f(x)$	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1

ans

$b_0 = 11 - 5 = 6$

$b_1 = 11 - 5 = 6$

$b_2 = 13 - 3 = 10$

$b_3 = 9 - 7 = 2$

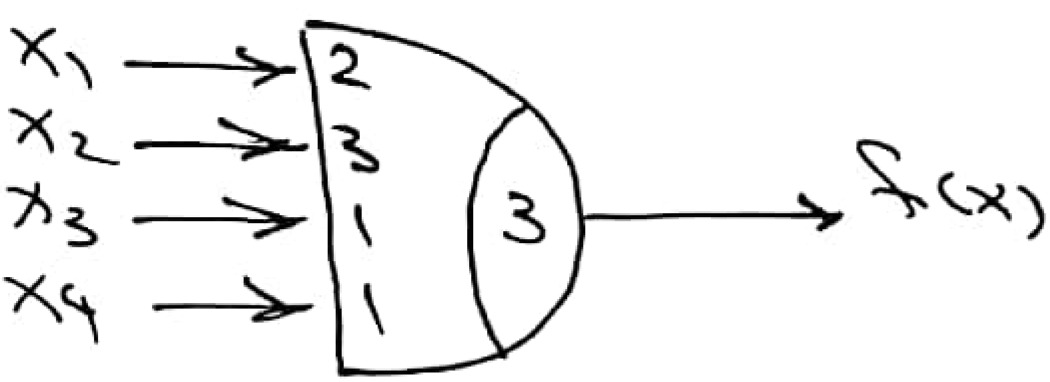
$b_4 = 9 - 7 = 2$

b_0	b_1	b_2	b_3	b_4
6	6	10	2	2
↓	↓	↓	↓	↓
2	2	3	1	1
a_0	a_1	a_2	a_3	a_4

$$T = \frac{1}{2}\left[a_1 + a_2 + a_3 + a_4 - a_0 + 1\right]$$

$$= \frac{1}{2}\left[2 + 3 + 1 + 1 - 2 + 1\right]$$

$T = 3$



note

x_1

x_3x_4 \ x_1x_2	00	01	11	10
00				
01				
11				
10				

x_4

x_3

x_2

Ex realize the following switching function with single threshold logic gate

x_1

x_3x_4 \ x_1x_2				
			1	
		1	1	1
		1	1	1
			1	1

x_4

x_3

x_2

ans

$b_0 = 9 - 7 = 2$

$b_1 = 2(7-2) = 10$

$b_2 = 2(6-3) = 6$

$b_3 = 2(5-4) = 2$

$b_4 = 2(6-3) = 6$

b_0	b_1	b_2	b_3	b_4
2	10	6	2	6
$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$
1	3	2	1	2
a_0	a_1	a_2	a_3	a_4

$$T = \frac{1}{2}\left[a_1 + a_2 + a_3 + a_4 - a_0 + 1\right]$$

$$= \frac{1}{2}\left[3 + 2 + 1 + 2 - 1 + 1\right]$$

$$= 4$$