t gait $w_1=0$ $w_2=0$ $b=0$. $\begin{cases} 1 & y_{in} \geq 1 \\ -1 & y_{in} < 1 \end{cases}$

$\theta = 1$ learning rate threshold $\theta = 1$.

x_1	x_2	t
1	1	1
1	-1	1
-1	1	-1
-1	-1	-1

$y_{in} = w_1 x_1 + w_2 x_2$ $w_1 new = w_1 old + \alpha t * x_1$.

$y_{in} = w_1 x_1 + w_2 x_2 + b$,

$0+0+0=0$ $f(1) \Rightarrow -1$.

$0 + 1*1*1 = 1$.

$w_2 new = w_2 old + \alpha t * x_2$.

$0 + 1*1*1 = 1$.

$b_{new} = b_{old} + \alpha t$

$0 + 1*1 = 1$.

$w_1 = w_2 = b = 1$.

$x_1 = 1$ $x_2 = -1$ $t = 1$.

$w_1 = 1$, $w_2 = 1$ $b = 1$.

$y_{in} = x_1 w_1 + x_2 w_2 + b \Rightarrow 1.1 + (-1.1) * 1 = 1 = 1 \Rightarrow$ ✓

$y_{in} = t$

$x_1 = 1$ $x_2 = -1$ $t = 1$.

$w_1 = 1$ $w_2 = 1$ $b = 1$

$y_{in} = x_1 w_1 + x_2 w_2 + b \Rightarrow (1.1) + (-1.1) + 1 = 1 \Rightarrow$ ✓.

$y_{in} = t$

$x_1 = -1$ $x_2 = 1$ $t = 1$

$w_1 = 1$ $w_2 = 1$ $b = 1$.

$y_{in} = x_1 w_1 + x_2 w_2 + b \Rightarrow (-1.1) + (1.1) + 1 = 1$ ✓.

$y_{in} = t$

$x_1 = -1$, $x_2 = -1$, $t = 1$

$w_1 = 1$ $w_2 = 1$ $b = 1$.

$y_{in} = x_1 w_1 + x_2 w_2 + b \Rightarrow -1.1 + -1.1 + 1 = -1 \Rightarrow$ ✓

$y_{in} = t$ ✓

$x_1 w_1 + x_2 w_2 + b = x_1 + x_2 + 1 \Rightarrow x_1 + x_2 = 1$

NAND. $\alpha=1$ $\theta=1$ $w_1=w_2=b=0$

x_1	x_2	target
1	1	-1
1	-1	1
-1	1	1
-1	-1	1

$y_{in}=w_1x_1+w_2x_2+b$

$\begin{cases} -1 & y_{in} \le 1 \\ 1 & y_{in} \ge 1 \end{cases}$

$(1,1) \Rightarrow 1.0+1.0+0=0$ $\quad y_{in} \le 1$ $\quad -1=-1$ ✓

$(1,-1) \Rightarrow 1.0+1.0+0=0$ $\quad y(0)=-1 \neq t=-1$

update weights.

$w_{1new}=w_{1old}+\alpha t x_1$ $\quad w_{2new}=w_{2old}+\alpha t x_2$

$\Rightarrow w_{1new}=0+1*1*1=1$ $\quad 0+1*1*-1=-1$

$b_{new}=b_{old}+\alpha t \Rightarrow 0+1*1=1$

$w_1=1,\ w_2=-1,\ b=1$

$(1,-1) \Rightarrow y_{in}=w_1x_1+w_2x_2+b$

$1.1+1.-1+1=1 \Rightarrow y_{in}=1 \quad y(1)=1=t=1$

$(-1,1) \Rightarrow y_{in}=w_1x_1+w_2x_2+b$

$1.(-1)+(-1).1*1=-2$

$y(-2)=-1 \neq t=1$

update weights.

$w_{1new}=w_{1old}+\alpha t x_1$ $\quad w_{2new}=w_{2old}+\alpha t x_2$

$2+1*1*(-1)=1$ $\quad 0+1*1*1=1$

$b_{new}=b_{old}+\alpha t \Rightarrow 1+1*1=2$

$w_1=1$ $\quad w_2=1$ $\quad b=2$

$(-1,1) \Rightarrow y_{in}=w_1x_1+w_2x_2+b$ $\quad y(2)=1$

$1(-1)+1.1+2=2=t=1$ ✓

$(-1,-1) \Rightarrow y_{in}=w_1x_1+w_2x_2+b$

$(1).-1+(1)(-1)+2=0$

$y_{in}(0)=-1 \neq t \neq 1$

update weights $w_{1new}=w_{1old}+\alpha t x_1$ $\quad w_{2new}=w_{1old}+\alpha t x_2$ $\quad b_{new}=b_{old}+\alpha t$

$\Rightarrow w_{1new}=1+1*1*-1=0$, $\quad w_{2new}=1+(1)(1)*(-1)=0$.

$b=2+1*1=3$

$w_1=w_2=b=3$

$(-1,-1) \Rightarrow y_{in}=w_1x_1+w_2x_2+b \Rightarrow 0-1+0-1+3=$

$x_1 \rightarrow 0$

$x_2 \rightarrow 0$ → AND → NAND

$w_1=w_2=b=0$. $\quad \alpha=1$ $t=1$

$y_{in}=w_1x_1+w_2x_2+b$

$0.1+0.1+0=y_{in}=0 \neq t_1=1$

update weights.

Input x_1	x_2	t_1	t_2
1	1	1	-1
1	-1	1	
-1	1	-1	1
-1	-1	-1	

$w_{1new}=w_{old}+\alpha t.x_1 \quad w_{2new}=w_{2old}+\alpha t x_2$

$=0+1.1.1=1 \quad =0+1.1.1=1$

$b_{new}=b_{old}+\alpha t \Rightarrow 0+1.1=1$ ✓.

$y_{in}=w_1x_1+w_2x_2+b \Rightarrow w_1=w_2=b=1$

$y_{in}=1.1+(1.1)*1=3 \quad y(3)=1$.

$\begin{cases} 1 & y_{in} \ge \theta \\ -1 & y_{in} \le \theta \end{cases}$

$x_1=1 \quad x_2=-1 \quad t=-1$

$y_{in}=1.1+(-1).1+1=1$

$y(1)=1 \quad t=-1$

update weights.

$w_{1new}=1+1.1.(1)=2$

$w_{2new}=1+1.1.(-1)=0$

$b_{new}=1+1.1=1$

$y_{in}=2.(1)+0+1$

$x_1=-1 \quad x_2=1 \quad t=-1$

$y_{in}=1.(-1)+(1).(-1)+1=-1$

$x_1=-1 \quad x_2=-1 \quad t=-1$

$y_{in}=1.(-1)+1.(-1)+1=-1$

$y_1 = 1$ $w_{11} = 1$ $b_{11} = 1$

$y_2 = -1$ $y_{2in} = w_{11} y_i + b =$

$y_3 = 1$ $1 \cdot 1 + 1 = 2$

$y_4 = -1$ $y_{2in} = w_{11} y_i + b$

$1 + 1 = 0$

$\begin{cases} 1 & y_2 \geq 0 \\ -1 & y_2 \leq 0 \end{cases}$

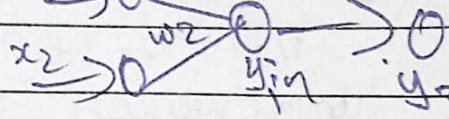
$y_{3in} = 1 \cdot -1 + 1 = 0$ $y_4 = 1 \cdot -1 + 1 = 0$

$w_1 = w_2 = b = 1$ $w_{11} = b_{11} = 1$

$\begin{cases} 1 & y_{in} > 1 \\ -1 & y_{in} \leq 1 \end{cases}$ $\begin{cases} 1 & y_{in} \geq 1 \\ -1 & y_{in} \leq 1 \end{cases}$

NOR.

x_1	x_2	t_1	t_2
1	1	1	-1
1	-1	1	-1
-1	1	-1	-1
-1	-1	-1	1



$\alpha = 1$ $\theta = 1$

$\begin{cases} 1 & y_{in} \geq 1 \\ -1 & y_{in} < 1 \end{cases}$

$w_1 = w_2 = b = 0.$

$y_{in} = w_1 x_1 + w_2 x_2 + b.$

$0 + 1 + 0 \cdot 1 + 0 = 0$

$w_1 = 0 + 1 \cdot 1 (1) = 1$ update weight.

$w_2 = 0 + 1 \cdot 1 (1) = 1$ $w_{1new} = w_{1old} + \alpha t x_1$

$b = 0 + 1 \cdot 1 = 1$ $w_{2new} = w_{2old} + \alpha t x_2$

$w_1 = w_2 = b = 1$ $b_{new} = b_{old} + \alpha t.$

$y_{in} = w_1 x_1 + w_2 x_2 + b \Rightarrow 1 \cdot 1 + 1 \cdot 1 + 1 = 3.$

$y_{in}(3) = 1 \Rightarrow t = 1$ ✓

$x_1 = 1$ $x_2 = -1$ $t = 1$ $\Rightarrow$ $1 \cdot 1 + (1 \cdot (-1)) + 1 = 1$

$w_1 = 1$ $w_2 = 1$ $b = 1$ $y_{in}(1) = 1 \Rightarrow t = 1$

$y_{in} = x_1 w_1 + x_2 w_2 + b$

$x_1 = 1$ $x_2 = 1$ $t = 1$ $\quad x_1 = -1$ $x_2 = -1$ $t = -1$

$w_1 = 1$ $w_2 = 1$ $b = 1$ $\quad w_1 = 1$ $w_2 = 1$ b

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~~$y_{in} = x_1 w_1 + x_2 w_2 + b$~~ $\quad 1.1 + 1.-1 + 1.$

-2

$1.1 + 1.1 + 1 = 1$ $\quad y(-2) = -1$ $t = -1$ ✓

$y_{in}(1) = t = 1$.

second gate ≠ NOT. $\quad y_2 in = w_{11} x_{y_1} + b$ $\quad w_{11} = b = 1$

1	-1
-1	1

$w_1 = w_2 = b\,1 = w_{11} = b_{11} = 1$ ✓ $\quad \{1 \; y_{in} \geq 1 \;\; -1 \; y_{in} < 1\}$

NOT t

1	-1
-1	1

$y_{in} = w_1 x_1 + b$. $\quad w_1 = b = 1$.

$1.1 + 1 = 2$

$y_{in}(2) = -1 = t = -1$ $\quad \{1 \; y_{in} \geq 1 \;\; -1 \; y_{in} \geq 1\}$.

$1.-1 + 1 = 0$

$y_{in}(0) = 1 = t = 1$.