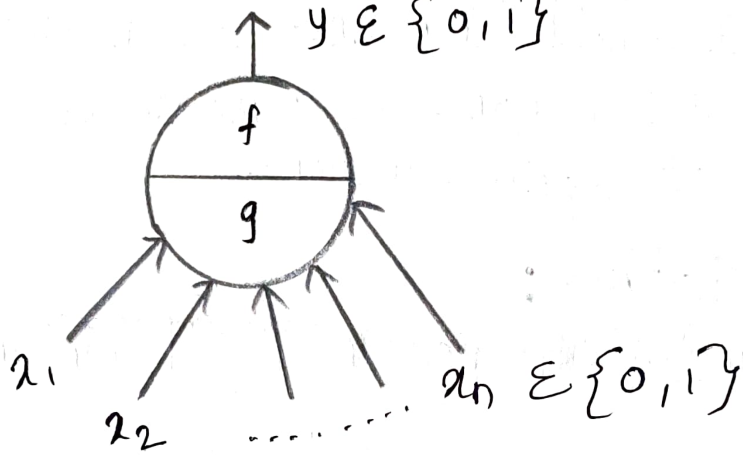
# McCulloch - Pitts Neuron

McCulloch (neuroscientist) and Pitts (logician) proposed a highly simplified computational model of the neuron (1943)




- g aggregates the inputs
- function f takes decision based on this aggregation
- The M-P neurons are connected by directed weighted paths.
- At any step, the neuron may fire or may not fire.
- The weights associated with communication links

may be excitatory (weights are +ve) or inhibitory (weights are -ve).

- Threshold plays a major role in M-P neuron.
- If the net input to the neuron is greater than the threshold then the neuron fires.
- The M-P neurons are most widely used in the case of logic functions.

## Architecture:

The simple MP neuron is shown in below fig.

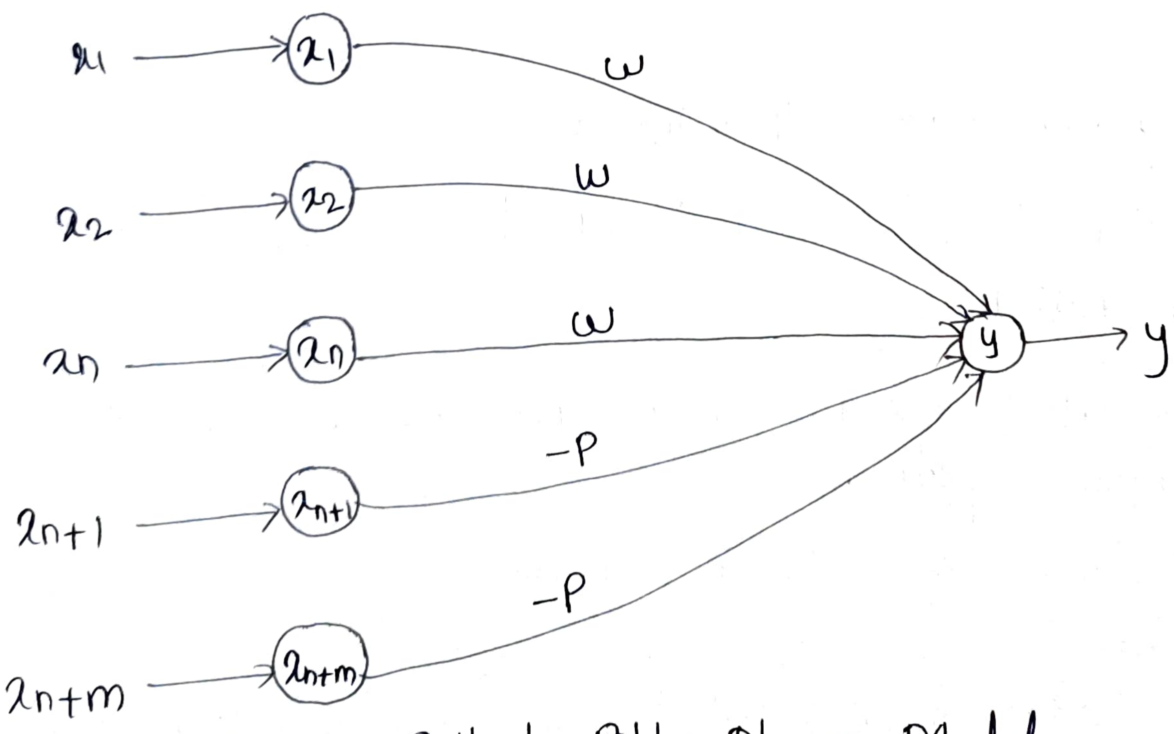



Fig. McCulloch-Pitts Neuron Model

- It is excitory with weight ($w > 0$) or inhibitory with weigh $-p$ ($p < 0$).
- In the given fig., $x_1$ to $x_n$ possess excitatory weighted connections.
- Inputs from $x_{n+1}$ to $x_{n+m}$ possess inhibitory weighted interconnections.
- The activation function here is defined as,

$$f(y_{in}) = \begin{cases} 1 & y_{in} \geq \theta \\ 0 & y_{in} < \theta \end{cases}$$

- The threshold with activation function should satisfy the following condition:

$$\theta \geq nw - p$$

- The MP neuron has no particular training algorithm.
- An analysis has to be performed to determine the values of the weights and the threshold.
- The weights of the neuron are set along with the threshold to make the neuron perform a simple logic function.

Solved Example:

Implement ANDNOT function using MP neuron.

| $x_1$ | $x_2$ | $y$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | ~~0~~ 1 |
| 1 | 1 | 0 |

case 1: Assume both weights to be excitatory
i.e. $w_1 = w_2 = 1$

Calculate net input for the 4 inputs

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

$(1,1)$, $y_{in} = 1 + 1 = 2$

$(1,0)$, $y_{in}) = 1 + 0 = 1$

$(0,1)$, $y_{in} = 0 + 1 = 1$

$(0,0)$, $y_{in} = 0 + 0 = 0$

It is not possible to fire the input $(1,0)$ only.
Hence these weights are not suitable.

Case 2: Assume 1 weight as excitatory and other as inhibitatory.

$w_1 = 1 \quad w_2 = -1$

Calculate the net inputs for 4 inputs

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

(1,1), $y_{in} = 1 - 1 = 0$

(1,0), $y_{in} = 1 - 0 = 1$

(0,1), $y_{in} = 0 - 1 = 1$

(0,0), $y_{in} = 0 + 0 = 0$

Now, it is possible to fire neuron for input (1,0), by fixing the threshold 1.

i.e. $\theta \geq 1$

$\therefore \; w_1 = 1 \quad w_2 = -1$ and $\theta \geq 1$

Value of $\theta$:

can be calculated using

$\theta \geq nw - p$

$\theta \geq (2 \times 1) - 1$

$\theta \geq 1$

[n: no. of features
w: no. of excitatory weights]

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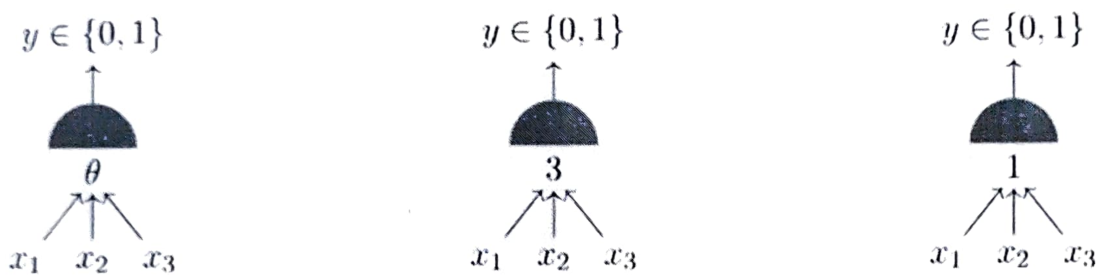
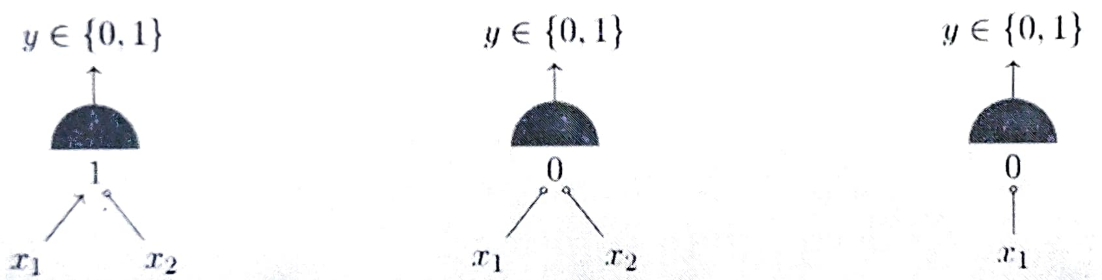



A McCulloch Pitts unit | AND function | OR function




$x_1$ AND !$x_2$' | NOR function | NOT function