Assignment -1

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1) Mc Culloch - Pitts (MCP) Neuron Model

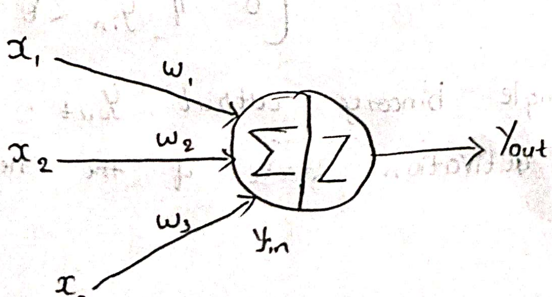
i) Give the architecture of the MCP neural network model

→ The MCP Neural Network Model refers to the Mc Culloch - Pitts Neural Network, which is one of the Earliest models of artificial neurons. The neurons are connected by directed weighted paths. Mc Culloch - Pitt neuron allows binary activation, it Either fires with an activation 1 or does not fire with an activation of 0.

If $w > 0$, then the connected path is said to be Excitatory else it is known as Inhibitory.

Excitatory connections have positive weights and inhibitory connections have negative weights. Each neuron has a fixed threshold for firing.

If the net input to the neuron is greater than the threshold, it fires



$$y_{in} = x_1 w_1 + x_2 w_2 + \dots + x_n w_n$$

$$y_{in} = \sum_{i=1}^{n} x_i w_i$$

Activation function $= f(y_{in}) = \begin{cases} 1 & \text{if } y_{in} \geq \theta \\ 0 & \text{if } y_{in} < \theta \end{cases}$ θ = threshold

i) input layer:- A set of binary inputs $x_1, x_2, x_3 \ldots x_n$ Each input represents a feature of variable and takes a binary value 0 or 1.

ii) weights:- Each input x is associated with a weight which represents the importance of the input. The weight sum of inputs is calculated as $y_{in} = \sum_{i=1}^{n} x_i w_i$

iii) Summarization function:- Computes the linear combination weighted sum of inputs

iv) Threshold function:- A threshold θ is applied to the weighted sum y_{in}. If $y_{in} \geq \theta$ the neuron fires (output = 1) If $y_{in} < T$, the neuron doesnot fire (output = 0)

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

v) Output:- A single binary output Y_{out}, which represents the activation state of the neuron

2) Generate the output of logic NOT, NAND and NOR function using MCP neuron.

NOT function

Input	Output	$y_{in} = x_1 w_1 + b$
0	1	0
1	0	1

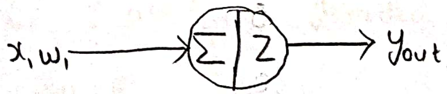
$w_1 = 1 \quad b = 0$

$x_1 = 0 \quad y_{in_1} = 1 \times 0 + 0 = 0$

$x_1 = 1 \quad y_{in_2} = 1 \times 1 + 0 = 1$

Activation function $= y_{out} = f(y_{in}) = \begin{cases} 0 & \text{if } y_{in} \geq 1 \\ 1 & \text{if } y_{in} < 1 \end{cases}$

threshold $= \theta = 1$

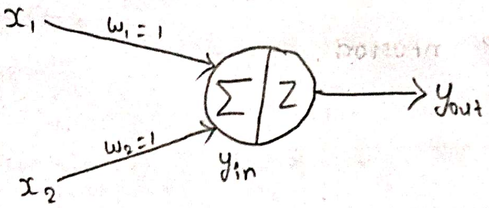


$y_{out\,1} = f(y_{in_1}) = f(0) = 1$

$y_{out\,2} = f(y_{in_2}) = f(1) = 0$

Nand function

x_1	x_2	Nand (x_1, x_2)	$y_{in} = x_1 + x_2$	y_{out}
0	0	1	0	1
0	1	1	1	1
1	0	1	1	1
1	1	0	2	0



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

$w_1 = w_2 = 1$, $b = 0$

threshold $= \theta = 1$

Activation function $= \begin{cases} 1 & y_{in} < 2 \\ 0 & y_{in} \geq 2 \end{cases}$

$x_1 = 0 \quad x_2 = 0 \Rightarrow y_{in} = (1+0) + (0 \times 1) = 0$

$x_1 = 0 \quad x_2 = 1 \Rightarrow y_{in} = (0 \times 1) + (1 \times 1) = 1$

$x_1 = 1 \quad x_2 = 0 \Rightarrow y_{in} = (1 \times 1) + (0 \times 1) = 1$

$x_1 = 1 \quad x_2 = 1 \Rightarrow y_{in} = (1 \times 1) + (1 \times 1) = 2$

NOR Function

x_1	x_2	$y_{in} = x_1 w_1 + x_2 w_2 + b$	NOR (x_1, x_2)
0	0	0	1
0	1	1	0
1	0	1	0
1	1	2	0

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

$w_1 = 1 \quad w_2 = 1 \quad b = 0 \quad \theta = 1$

$x_1 = 0 \quad x_2 = 0 \Rightarrow y_{in} = (0 \times 1) + (1 \times 0) = 0$

$x_1 = 0 \quad x_2 = 1 \Rightarrow y_{in} = (1 \times 0) + (1 \times 1) = 1$

$x_1 = 1 \quad x_2 = 0 \Rightarrow y_{in} = (1 \times 1) + (0 \times 1) = 1$

$x_1 = 1 \quad x_2 = 1 \Rightarrow y_{in} = (1 \times 1) + (1 \times 1) = 2$

Activation function

$y_{out} = f(y_{in})$

$= \begin{cases} 0 & \text{if } y_{in} \geq 1 \\ 1 & \text{if } y_{in} < 1 \end{cases}$

③ write the limitations of MCP neuron model

-> MCP neuron model is a foundational concept in neural network but it has several limitations that make it less suitable for modeling complex or real world neural networks.

Binary output :- MCP neuron produces only binary outputs (0/1), which overly simplistic, In real biological neurons, the output is more continuous (analog) and can vary in response to different stimuli,

Input :- This limitations make the MCP model less flexible when trying to model complex behaviour such as graded response that occurs in actual neural systems.

* lack of learning mechanism :- MCP neuron model does not include a mechanism for learning or adaptation. In other words, it cannot adjust its weights or bias based on Experience of feedback.

Input :- In practical neural networks, learning through adjustments to weights (such as via backpropogation) is Essential for improving performance, without learning,

* **No Temporal Dynamics:-** The MCP model does not account for the temporal delenants of neurons or there interactions over time. It operates in a static function, where the output only depends on the current input and not on previous status or sequences.

* **Inflexibility in Input Representation:-** MCP model ensures that all inputs are independent and binary. It doesn't have the flexibility to process continous or real valued inputs in a natural way.

* **Simplified Activation function:-** The activation function in the MCP model is a simple threshold function, which only determines whether the neurons fires or not based on the weighted sum of inputs it lacks the more sophisticated activation functions like the sigmoid, ReLU or tanh functions that are commonly used in modern neural network.

* Limited Expressions MCP neuron model can only represent

Limited Practical Applicability:- Due to its simplicity the MCP model cannot address modern machine learning tasks like image recognition, natural language processing, or Speech Synthesis