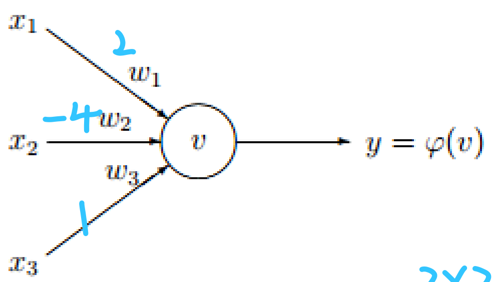
INT301 Bio-Computation Week 4 Tutorial

Question 1. Below is a diagram of a single artificial neuron (unit):



→ 2x2x2=8

1) It has three inputs x = (x_1, x_2, x_3) that receive only binary signals (either 0 or 1). How many different input patterns this node can receive? What if the node has four inputs? Five? Can you give a formula that computes the number of binary input patterns for a given number of inputs?

2^4, 2^5, 2^n

2) Suppose that the weights corresponding to the three inputs have the following values:

$$w_1 = 2$$
$$w_2 = -4$$
$$w_3 = 1$$

The activation of the unit is given by the step-function:

$$\varphi(v) = \begin{cases} 1 & \text{if } v \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

Calculate the output value y of the unit for each of the following input.

Pattern	P_1	P_2	P_3	P_4
x_1	1	0	1	1
x_2	0	1	0	1
x_3	0	1	1	1
y	2	−3	3	−1
	1	0	1	0

Question 2. Assume that you have a single layer perceptron with these weights:

w = [0.3, -1.2, 0.6] b = 0.1 (bias)

Given that you are training the network with the perceptron learning rule with a learning rate of 0.1. What values will the weights become after this positive (t = 1) training pattern has been presented to the perceptron (same activation as Q1):

t=1 不是时刻

x = [1.0, 1.0, 1.0]

Show how you have calculated the new weights.

$S = w_1 x_1 + w_2 x_2 + w_3 x_3 + w_0 \cdot b = 0.3 - 1.2 + 0.6 + 0.1 = -0.2 < 0$

$\varphi(S) = 0$

$\Delta w_i = \eta \cdot (t - \varphi(S)) \cdot x_i = 0.1 \times 1 \cdot x_i = 0.1 x_i$

$\Delta w_1 = 0.1$ $\Delta w_2 = 0.1$ $\Delta w_3 = 0.1$ $\Rightarrow w' = [0.4\ \ -1.1\ \ 0.7]$

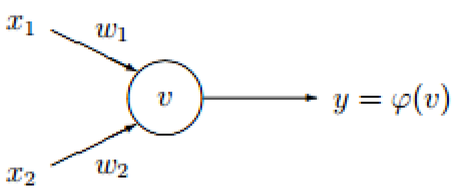
$t = \varphi(S)$

$S' = 0.4 - 1.1 + 0.7 + 0.1 = 0.1 > 0 \Rightarrow \varphi(S') = 1 \Rightarrow \Delta w = 0$ as

Question 3. Logical operators (i.e. NOT, AND etc) are the building blocks of any computational device. Logical functions return only two possible values, true or false, based on the truth or false values of their arguments. For example, operator AND returns true only when all its arguments are true, otherwise (if any of the arguments is false) it returns false. If we denote truth by 1 and false by 0, then logical function AND can be represented by the following table:

x_1 :	0	1	0	1
x_2 :	0	0	1	1
x_1 AND x_2 :	0	0	0	1

This function can be implemented by a single-unit with two inputs:



with the weights are w1 = 1 and w2 = 1 and the activation function is:

$$\varphi(v) = \begin{cases} 1 & \text{if } v \geq 2 \\ 0 & \text{otherwise} \end{cases}$$

$$\begin{cases} V_{11} = 1\times1 + 1\times1 = 2 \Rightarrow \varphi(v) = 1 \\ V_{12} = 1\times1 + 1\times0 = 1 \Rightarrow \varphi(v) = 0 \\ V_{21} = 1\times0 + 1\times1 = 1 \Rightarrow \varphi(v) = 0 \\ V_{22} = 1\times0 + 1\times0 = 0 \Rightarrow \varphi(v) = 0 \end{cases}$$

Note that the threshold level is 2.

a) Test how the neural AND function works.
b) Suggest how to change the weights of this single-unit in order to implement the logical OR function (true when at least one of the arguments is true):

x_1 :	0	1	0	1
x_2 :	0	0	1	1
x_1 OR x_2 :	0	1	1	1

$$S = w_1 x_1 + w_2 x_2$$

$$\begin{cases} 0 < 2 \Rightarrow 0 \\ w_1 \geq 2 \Rightarrow 1 \\ w_2 \geq 2 \Rightarrow 1 \\ w_1 + w_2 \geq 2 \Rightarrow 1 \end{cases} \Rightarrow \begin{cases} w_1 = 2 \\ w_2 = 2 \end{cases}$$