

Questions 11: Feed-Forward Neural Networks

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Question 1

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

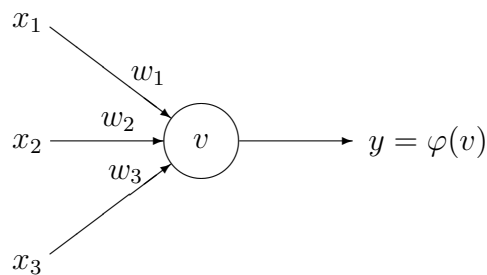


Figure 1: Single unit with three inputs.

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

Question 2

Consider the unit shown on Figure 1. Suppose that the weights corresponding to the three inputs have the following values:

$$\begin{array}{l} w_1 = 2 \\ w_2 = -4 \\ w_3 = 1 \end{array}$$

and 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 what will be the output value y of the unit for each of the following input patterns:

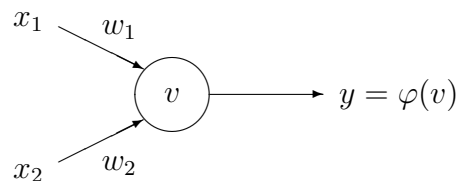
Pattern	P_1	P_2	P_3	P_4
x_1	1	0	1	1
x_2	0	1	0	1
x_3	0	1	1	1

Question 3

Logical operators (i.e. NOT, AND, OR, XOR, 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:



if the weights are $w_1 = 1$ and $w_2 = 1$ and the activation function is:

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

Note that the threshold level is 2 ($v \geq 2$).

- Test how the neural AND function works.
- Suggest how to change either the weights or the threshold level 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

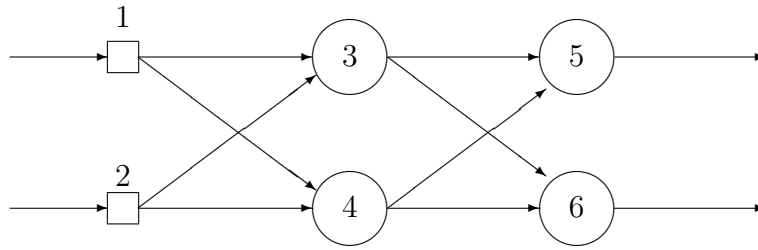
- c) The XOR function (exclusive or) returns true only when one of the arguments is true and another is false. Otherwise, it returns always false. This can be represented by the following table:

$x_1 :$	0	1	0	1
$x_2 :$	0	0	1	1
$x_1 \text{ XOR } x_2 :$	0	1	1	0

Do you think it is possible to implement this function using a single unit? A network of several units?

Question 4

The following diagram represents a feed-forward neural network with one hidden layer:



A weight on connection between nodes i and j is denoted by w_{ij} , such as w_{13} is the weight on the connection between nodes 1 and 3. The following table lists all the weights in the network:

$w_{13} = -2$	$w_{35} = 1$
$w_{23} = 3$	$w_{45} = -1$
$w_{14} = 4$	$w_{36} = -1$
$w_{24} = -1$	$w_{46} = 1$

Each of the nodes 3, 4, 5 and 6 uses the following activation function:

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

where v denotes the weighted sum of a node. Each of the input nodes (1 and 2) can only receive binary values (either 0 or 1). Calculate the output of the network (y_5 and y_6) for each of the input patterns:

Pattern:	P_1	P_2	P_3	P_4
Node 1:	0	1	0	1
Node 2:	0	0	1	1

Question 5

What is a training set and how is it used to train neural networks?

Question 6

What is an epoch?

Question 7

Describe the main steps of the supervised training algorithm?

Question 8

Suppose that a credit card company decided to deploy a new system for assessing credit worthiness of its customers. The new system is using a feed-forward neural network with a supervised learning algorithm. Suggest in a form of essay what should the bank have before the system can be used? Discuss problems associated with this requirement.