

Tutorial 11:

Neural networks

Name	Student no.

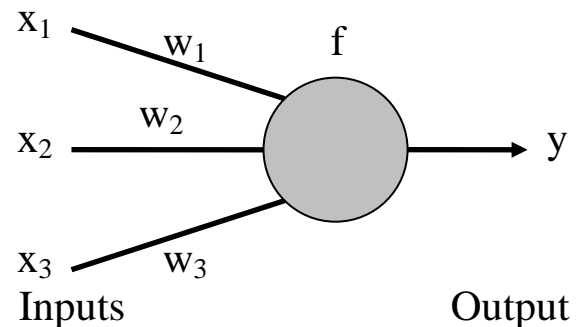
For this tutorial, you can work in groups of 1 or 2. Submit the answers to each of the 5 Questions.

Question 1

Here is an example network:

The summed input is: $u = \sum_{j=0}^p w_j x_j$

Note that the bias weight is labelled w_0 , assumed to be connected to a 'permanent' input of $x_0=+1$. Network output should be an o ; y is now used to mean the target value.



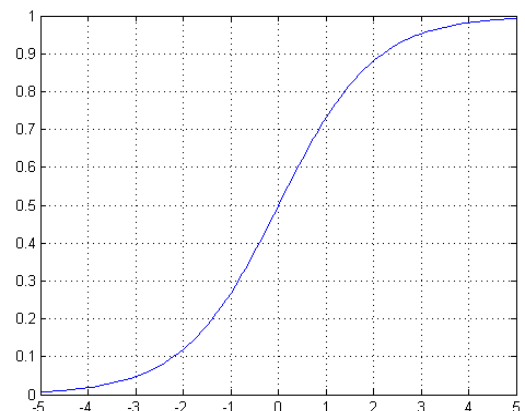
We use two different output functions (f in the diagram):

- the threshold function:

$$f(u) = \begin{cases} 0, & u < 0 \\ 1, & u \geq 0 \end{cases}$$

- the logistic function:

$$f(u) = \frac{1}{1 + e^{-u}}$$



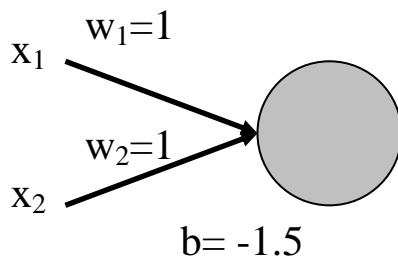
What output is produced by the following networks? For real numbers, round to one decimal place (e.g. '0.5').

	Inputs			Weights			Bias	Output function	Output
1	1	-2	2	0	-1	0.5	-0.5	Threshold	
2	1	-2	2	0	-1	0.5	-0.5	Logistic	
3	0	1	2	4	2	-1.5	-1.2	Threshold	
4	0	1	2	4	2	-1.5	-1.2	Logistic	
5	1	1	-2	1	-2	-1	0	Logistic	
6	1	1	-1	1	-2	-1	0	Logistic	
7	1	1	-1	1	-2	-1	1	Logistic	

Question 2

Using the threshold function, the neural network below implements the logical-AND-function

$(a \wedge b)$:



a) Come up with different weight and bias values that implement the same logical function.

b) Come up with a three-input network that implements the following logical function:

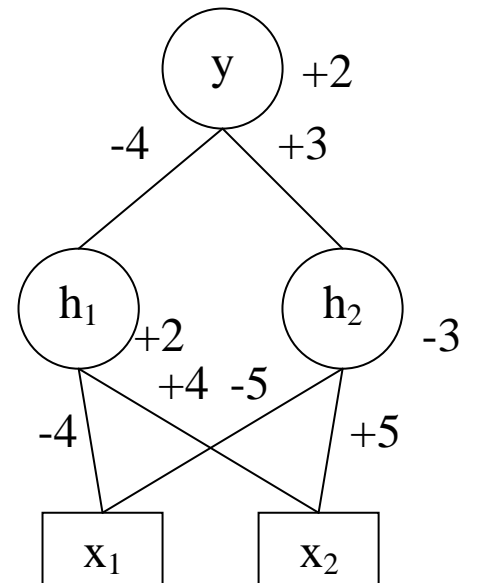
$a \wedge b \wedge (\neg c)$ (Note: \neg means NOT)

Question 3

The multi-layer network on the right uses the logistic output function (see Question 1).

- a) Determine the hidden activations (h_1, h_2), output (y), and class (c) for the following input patterns. Assume that the output is treated as Class A if $y < 0.5$ and Class B if $y \geq 0.5$.

	Inputs		Hidden		Output	Class
	x_1	x_2	h_1	h_2	y	c
1	0	0				
2	0	1				
3	1	0				
4	1	1				



Question 4

Neural networks with a single layer of weights (no hidden units) are useful for a variety of classification tasks. What tasks are multi-layer networks (2+ layers of weights: some hidden units) necessary for? In other words, what is fundamentally different about a multi-layer neural network?

Question 5

Come up with a three-input multi-layer network that implements the following truth table:

Inputs				Output
	X1	X2	X3	Y
1	0	0	0	0
2	0	0	1	1
3	0	1	0	1
4	0	1	1	0
5	1	0	0	1
6	1	0	1	0
7	1	1	0	0
8	1	1	1	0