UNIVERSITY OF LIVERPOOL

Comp305: Biocomputation

First Semester Continuous Assessment 2020/21

Class Test 1: ANNs

INSTRUCTIONS TO CANDIDATES

- The expected time to complete this Class Test is 50 minutes.
- Answer TWO questions out of the following three.

If you answer more than two questions, credit will be given for the BEST two answers only.

Each question is worth 20 marks.

Calculators are permitted.

- Upload your answers as a single pdf file to the 202021-COMP305-BIOCOMPUTATION Assessment "Class Test 1: ANNs, Turnitin Submission" in VITAL

- The work must be submitted by Friday, 27 November 2020, 5pm.

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1. McCulloch-Pitts Neuron.

1(a) Draw a diagram for the McCulloch-Pitts neuron. Why is it called a discrete time machine? What values can the neuron's binary inputs take? What values are the prohibitory and the excitatory weights of connections in the MP-neuron? What is the role of a prohibitory input in the MP-neuron?

[8 marks]

1(b) Draw a diagram and explain the work of MP-neuron realisation of "OR" logical gate for two inputs.

[3 marks]

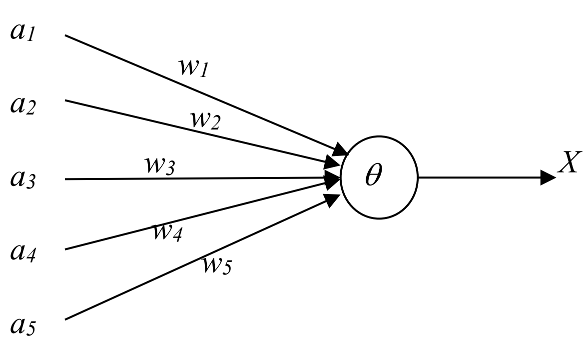
1(c) Draw a diagram and explain the work of MP-neuron realisation of "NOT" logical gate.

[3 marks]

1(d) In electronic computers, a single "AND" or "OR" gate is limited to two inputs, i.e. at each instant it can only compute ``*a* AND *b*", and not ``*a* AND *b* AND *c*", for example.

M-P neurons are able to compute conjunctions (logical ANDs) and disjunctions (logical ORs) for more than two inputs.

For the following MP-neuron with five inputs



what weights of input connections w_1, w_2, w_3, w_4, w_5 and the threshold value θ should be in order to compute:

$$a_1 \text{ AND } a_2 \text{ AND } a_3 \text{ AND } a_4 \text{ AND } a_5 \,,$$

explain your answer. **[6 marks]**

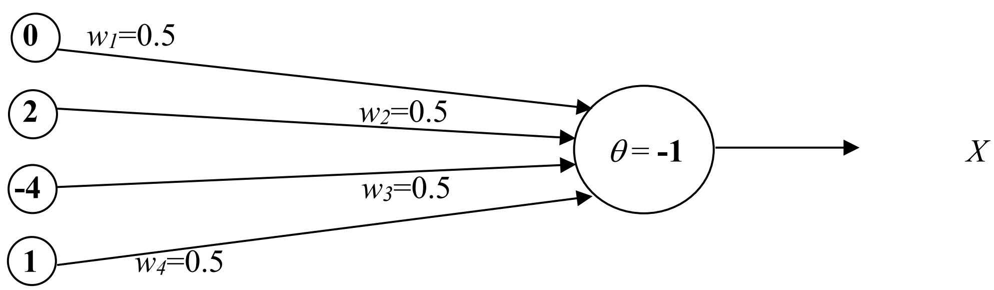
(to be continued)

2. Learning rules of the Artificial Neural Networks. Hebb's Rule.

2(a) What is a learning rule of an artificial neural network?

[3 marks]

2(b) The small neural network below uses Hebb's learning rule. At some instant, inputs to the network are as shown.



i) What output will the network produce?

[4 marks]

ii) Let the network learning rate C be set to 0.25.
Which weights of connection will increase afterwards and by how much?

[4 marks]

iii) What will be the new weights of connections? **[1 mark]**

iv) Let the norm of the vector $\vec{w}$=(w_1, w_2, w_3, w_4) is defined as

$$\|\vec{w}\| = \sqrt{\sum_i w_i^2}$$

What will be the new normalised weights of connection w_1, w_2, w_3, w_4?

[8 marks]

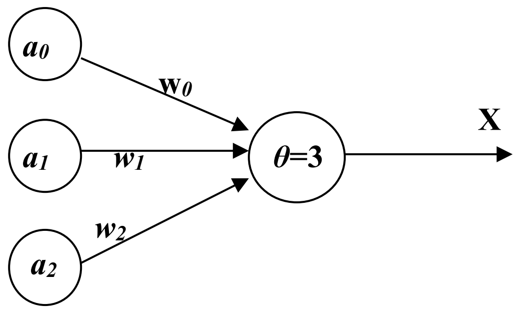
(to be continued)

3. Learning rules of the Artificial Neural Networks. Perceptron.

The neural network below uses threshold activation function

$$X(S) = \begin{cases} 1, & if\ S \geq \theta, \\ 0, & if\ S < \theta, \end{cases}$$

and the original Perceptron error-correction learning rule.



The Perceptron is trained to produce output X=1 in response to the input vector $\boldsymbol{a}=\{a_1;a_2\}=\{0; -1\}$.

3 (a) What is the value of the bias input a_0 in the perceptron? Does the bias input connection weight $\boldsymbol{w_0}$ change during the perceptron training?

[2 marks]

3 (b) Let the learning rate of the network, C = 0.25, and the weights of connections at some instant ***t*** are as given in the table below.

a_1	a_2	w_0^t	w_1^t	w_2^t	X^t	Δw_0^t	Δw_1^t	Δw_2^t	w_0^{t+1}	w_1^{t+1}	w_2^{t+1}
0	-1	0	1	2							

Complete the table by calculating:

i) The instant output value X^t; **[2 marks]**

ii) The corresponding instant error of the output unit e^t; **[2 marks]**

iii) Corrections to each of the three weights of connections Δw_0^t, Δw_1^t, and Δw_2^t.

[6 marks]

iv) The new weights w_0^{t+1}, w_1^{t+1}, and w_2^{t+1}. **[3 marks]**

(to be continued)

3 (c) A perceptron can compute only linear separable functions, *i.e.* the functions for which the points of the input space with function value (output) of "0" can be separated from the points with function value of "1" using a line.

i) Using a coordinate plane for inputs a_1 and a_2 show that the "NAND" gate, see the table below, is linear separable function. **Explain your answer.**

a_1	a_2	***"NAND"***
1	*1*	*0*
1	*0*	*1*
0	*1*	*1*
0	*0*	*1*

[2 marks]

ii) Using a coordinate plane for inputs a_1 and a_2 show that the "XOR" gate, see the table below, is linear *in*separable function. **Explain your answer.**

a_1	a_2	***"XOR"***
1	*1*	*0*
1	*0*	*1*
0	*1*	*1*
0	*0*	*0*

[3 marks]