PAPER CODE NO.	EXAMINER : **Dr Irina V. Biktasheva**
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THE UNIVERSITY
of LIVERPOOL

JANUARY 2006 EXAMINATIONS

Bachelor of Arts: Year 3
Bachelor of Engineering: Year 3
Bachelor of Science: Year 2
Bachelor of Science: Year 3
Bachelor of Science: Year 4
Master of Engineering: Year 3
Master of Science: Year 1
No qualification aimed for: Year 1

Biocomputation

TIME ALLOWED: Two Hours and a Half

INSTRUCTIONS TO CANDIDATES

Answer FOUR out the following six questions.

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

Each question is worth 25 marks

1 History and Concepts.

1(a) Discuss the remits of biology, bioinformatics, and Artificial Neural Networks (ANNs) and Genetic Algorithms (GAs). Why are biology inspired ANNs and GAs now considered part of Computer Science, not Computational Biology? How are biology, bioinformatics, and the biology inspired algorithms, as a part of modern Computer Science, connected and how do they interact?

[18 marks]

1(b) Explain what is meant by the ***unidirectional influence*** of biology onto biology inspired algorithms such as ANNs and Genetic Algorithms? What is the main reason for that point of view?

[7 marks]

2 The McCulloch-Pitts neuron.

2(a) Draw diagrams, including values of the weights of connections and the output unit thresholds, for MP-neuron realisations of "AND", "OR", and "NOT" logical gates. Explain how the gates work.

[18 marks]

2(b) Draw a diagram, including values of the weights of connections and the output unit threshold, for a MP-neuron realisation of a "memory cell". Explain how the memory cell works, and why does it need the "feed back" loop.

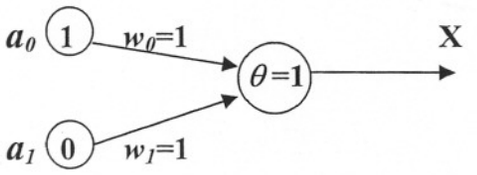
[7 marks]

3. Supervised learning. Perceptron.

A small Perceptron with two input units and one output unit is trained using the following training set

Pattern №	Input	Output
1	1	1
2	0	0

At some instant during the network training, the weights of connections and inputs to the network are as shown below



3(a) What training pattern has been used at that instant? Explain your answer.

[7 marks]

3(b) What output will the network produce? Explain your answer.

[8 marks]

3(c) Let the network learning rate C be set to 0.25. How will the weights of connections, w_0 and w_1 change? Explain your answer.

[10 marks]

4 Unsupervised Learning. Hebb's Rule.

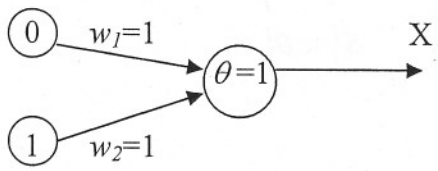
4(a) What is the simplest mathematical formulation of Hebb's learning rule, *i.e.* the rule how to find a correction to the weight of a connection according to the network instant input and output? Why is Hebb's rule called the "activity product rule"?

[12 marks]

4(b) Why does the Hebb's rule represent unsupervised learning?

[4 marks]

4(c) 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. The weight of which connection, w_1 or w_2, will increase afterwards and by how much?

[5 marks]

5. Multilayer Perceptron (MLP).

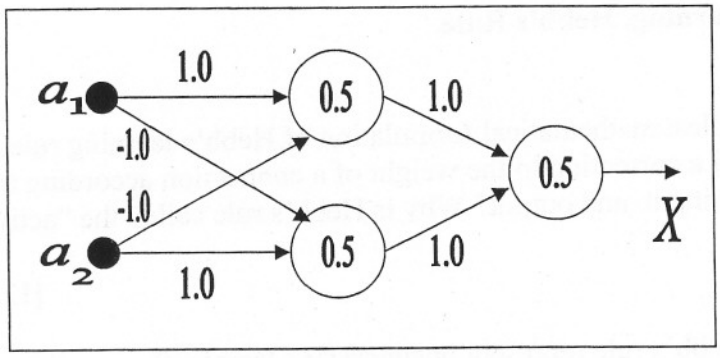
5(a) Describe the layered architecture of a MLP, in particular, what is the input layer, the hidden layers, and the output layer. Does Multilayer Perceptron include feedback loops and connections between units in a layer? Explain your answer.

[7 marks]

5(b) Describe the feedforward scheme of input processing in a Multilayer Perceptron, in particular, how the instant states of the processing units and their instant outputs are determined, including the mathematical formulae used for that purpose.

[8 marks]

5(c) A 3-layer network implements the "XOR" gate. The network has weights of connections and thresholds of the processing units as shown below, and it uses the *feedforward* scheme to produce an output.



The output unit and both hidden units use the following threshold activation step-function

$$X_j^l = f\left(S_j^l\right) = \begin{cases} 1, & S_j^l \geq \theta_j^l \\ 0, & S_j^l < \theta_j^l \end{cases}$$

where

$l=h$ for a hidden unit
$l=o$ for the output unit

Question: Following the feedforward scheme of the input processing,

i) determine outputs of the hidden units for the input $a_1=1$, $a_2=1$;

[5 marks]

ii) determine the network output for the input $a_1=1$, $a_2=1$.

[5 marks]

6. Genetic Algorithms.

6(a) Discuss the computational appeal of natural evolution. In particular consider parallelism, adaptation to changing environment, and optimisation of possible "solutions".

[8 marks]

6(b) Describe the basic structure of a Genetic Algorithm.

[8 marks]

6(c) What is a Genetic Algorithm chromosome building block, *i.e.* schema? What characters are used to describe schemas of a binary chromosome? What is the order and the defining length of a schema?

[5 marks]

6(d) Formulate the Schema theorem. What does it say on the role of highly fit, short defining length, low order schemas in the evolution of a population of chromosomes?

[4 marks]