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THE UNIVERSITY
of LIVERPOOL

JANUARY 2004 EXAMINATIONS

Bachelor of Arts : Year 3
Bachelor of Engineering : Year 3
Bachelor of Science : Year 3
Bachelor of Science : Year 4
Master of Science : Year 1

BIOCOMPUTATION

TIME ALLOWED : Two Hours and a Half

INSTRUCTIONS TO CANDIDATES

Credit will be given for the BEST four answers
Each question is worth 25 marks

If you attempt to answer more than the required number of questions (in any section), the marks awarded for the excess questions will be discarded (starting with your lowest mark).

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1 History and Concepts.

1(a) Using appropriate examples distinguish clearly between biologically motivated computing and computational biology. Suggest why a considerable overlap between these two fields of research is developing.

[4 marks]

1(b) Distinguish clearly between the general doctrines of *instructivism* and *selectionism* and describe how each has been used to underpin theories of adaptation. Illustrate your answer with reference to appropriate examples.

[6 marks]

1(c) From your knowledge of developments in adaptive and biologically inspired computing discuss the importance of work undertaken during the 1940s and 1950s and how it has contributed to contemporary developments. Credit will be given for reference to specific examples and mention should be made of the Macy Conferences.

[15 marks]

2 Biological cells excitability.

2(a) Describe the biophysical processes underlying membrane potential.

[18 marks]

2(b) Choose **one** correct answer to the question:

Change of which biophysical characteristics of a living cell acts as an electrical signal to the outside world?

(i) Energy barrier
(ii) Extracellular concentration of K^+ ions
(iii) Membrane potential
(iv) Intracellular concentration of Na^+ ions

Explain your answer.

[7 marks]

3 The McCulloch-Pitts neuron.

3(a) Draw diagrams and explain the work of MP-neuron realisations of "AND", "OR", and "NOT" logical functions.

[18 marks]

3(b) Draw a diagram and explain the work of MP-neuron realisation of a "memory cell".

[7 marks]

4 Perceptron.

4(a) Describe the architecture and the signal processing algorithm of the Perceptron. In particular, explain what is the network two-layer architecture, and how the states and instant outputs of the output units of Perceptron are defined. What is the threshold activation function?

[13 marks]

4(b) Formulate the Perceptron learning rule. In particular, what is the Perceptron training set for and how are the weights of the network connections updated. What do you consider the Perceptron "supervised learning process"?

[12 marks]

5 Genetic Algorithms.

5(a) With reference to the general structure of a Genetic Algorithm explain what effect

(i) increasing the mutation rate

(ii) increasing crossover

could have on the likelihood that the G.A. would converge to a "good" solution.

[10 marks]

5(b) With reference to G.A.s, explain what a schema is and how an understanding of schemata can help us appreciate the changes in the frequency of bit substrings within an evolving population. Illustrate your answer with an appropriate example.

[7 marks]

5(c) With reference to the structure of a G.A., explain what is meant by saying that the mutation rate is usually set as a "global external parameter".

[4 marks]

5(d) It is also possible to introduce operators into a G.A. that modulate the mutation rate so that it ceases to be a global external parameter. Explain some ways **in which** this could be achieved.

[4 marks]

6 Classifier Systems.

6(a) Draw a diagram of a Michigan style Genetics Based Learning (Classifier) system and explain how the different parts work together to produce an adaptive device.

[10 marks]

6(b) With reference to the construction and workings of a Michigan style Genetics Based Learning (Classifier) system describe what is meant by:

(i) Emergent computation
(ii) Reinforcement learning
(iii)Generation of novelty

[Each of the parts is worth 3 marks each]
[9 marks]

6(c) Explain how Genetics Based Learning (Classifier) systems have been adapted to support individual based modelling of biological systems. Illustrate your answer with appropriate examples.

[6 marks]