COMP305

2.5 hours

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

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THE UNIVERSITY
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1 History and Concepts.

1(a) Discuss the remit of and connections between biology, bioinformatics, and biology inspired algorithms such as Artificial Neural Networks (ANNs) and Genetic Algorithms.

[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 Computational appeal of Natural Evolution.

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

[18 marks]

2(b) Nature uses the universal Genetic Code to store genetic information in biological chromosomes. Does a universal code for Genetic Algorithms exist? What restrictions does the necessity of coding impose on the class of problems that can be solved by Genetic Algorithms?

[7 marks]

3 Genetic Algorithms.

3(a) Describe the basic structure of a Genetic Algorithm

[10 marks]

3(b) 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]

3(c) Consider the following 2bit chromosome "11". How many schemas are there in this chromosome? List all of the schemas.

[5 marks]

3(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?

[5 marks]

4   The McCulloch-Pitts neuron.

4(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?
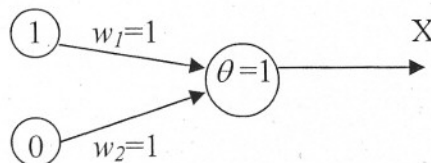
[8 marks]

4(b) Draw the flow chart for the McCulloch-Pitts neuron algorithm which is used to compute an output in response to a particular input.
NB. Assume that all weights of connections and the neuron threshold are set up in advance.

[17 marks]

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

5(a)   What is a learning rule of an artificial neural network?   **[5 marks]**

5(b)   Give the simplest mathematical formulation of Hebb's learning rule, *i.e.* how to find out a correction to the weight of connection according to the instant input and output. Why is the rule called "activity product rule"? Why does the Hebb's rule represent unsupervised learning?

[12 marks]

5(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?
ii) Let the network learning rate C be set to 0.25. Which weight of connection, w_1 or w_2, will increase afterwards and by how much?

[8 marks]

6 Perceptron.

6(a) Describe the two-layer fully interconnected architecture of the Perceptron. How are the states and instant outputs of the Perceptron output units defined? What is the threshold activation step-function?

[13 marks]

6(b) What is the Perceptron training set? How is it used during the *error-correction* training of the Perceptron? How is an output unit error computed and used to define corrections to the Perceptron weights of connections – state the Perceptron learning rule? What is the learning rate (C) and how does it affect the speed of the Perceptron training?

[12 marks]