

**SCHOOL OF MATHEMATICAL AND COMPUTER SCIENCES**

**Computer Science**

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**F21BC**

**BIOLOGICALLY INSPIRED COMPUTATION**

Semester 1 2013/14

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**19<sup>th</sup> December 2013**

Duration: Two Hours

**ANSWER THREE QUESTIONS**

Answer each question in a separate script book

## Q1

- (a) Write pseudocode for Particle Swarm Optimisation, and indicate both the role and typical settings for each of the parameters in your pseudocode. (8)
- (b) Consider the following optimisation problem. Every day, Boxdelivery Inc. must deliver a large number of boxes to various sites in Edinburgh. Each box has a different weight, and is one of five types (North, South, East, West, or Central), depending on where it has to be delivered. The boxes need to be packed into vans. Each van has a maximum weight capacity. The optimisation problem that must be solved every day is as follows: pack the boxes into vans in a way that minimises the number of vans used, and also minimises the extent to which each individual van carries different types of boxes.
- (i) Devise and explain a suitable fitness function for this problem. (3)
- (ii) Devise and explain a direct encoding for this problem. (3)
- (iii) Devise and explain a suitable constructive algorithm for this problem, and then devise and explain a suitable indirect encoding that uses your constructive algorithm. (6)

## Q2

- (a) Briefly explain each of the following terms:
- (i) Exact algorithm. (2)
- (ii) Problem complexity. (3)
- (b) Using examples to illustrate, describe two different crossover operators and two different mutation operators that are suitable for order-based encodings. (8)
- (c) Name and briefly describe an exact algorithm for building minimal spanning trees, and invent an encoding, based on this algorithm, for constrained spanning tree problems. (7)

Q3

- (a) A biologist is training a Multi-Layer Perceptron to identify bacteria from a number of characteristics including size, colour and growth behaviour. In order to keep the size of the network down the biologist uses just one input node per characteristic.
- (i) Discuss the wisdom of this decision. (6)
- (ii) The biologist knows that, in theory, only one layer of hidden nodes is necessary. Why might this fact mislead the biologist? (5)
- (b) The backpropagation algorithm used in the Multi-Layer Perceptron suffers from three main problems. Describe these problems and indicate how they might be handled (9)

Q4

- (a) Show the full process of training and execution/recall, step by step, of a Hopfield neural network designed to learn the pattern "0100" (draw all the matrices involved during the execution of the pseudocode during "training" and "execution/recall"). (9)
- (b) Consider the pattern "1011":
- (i) Execute the trained network from part (a) to recall the pattern "1011". (4)
- (ii) Could this network recall the pattern "1011" correctly? Explain why or why not. (3)
- (c) Suppose you are designing a MLP with two output neurons. These two output neurons will determine the motor outputs of a wandering 2-wheeled robot that must explore a maze by doing forward and backward movements. Which activation function would you choose for these two output neurons? Why? Represent the chosen activation function graphically. (4)

**END OF PAPER**