HERIOT WATT UNIVERSITY

SCHOOL OF MATHEMATICAL AND COMPUTER SCIENCES

Computer Science

F21BC

Biologically Inspired Computation

Semester 2, 2012/13

Date

22 April 2013

Duration: Two Hours

ANSWER THREE QUESTIONS

Answer each question in a separate script book

Q1

(a) State Reynold's Rules for flocking behaviour, and briefly explain how the use of these rules leads to more realistic simulations of flocking than previous attempts. (6)

(b) Consider a swarm of ants that has two separate routes from its nest to a food source, and one route is shorter than the other. Initially, an individual ant is equally likely to choose either route. Eventually, ants will choose the shorter route far more often than the longer route. Explain how this happens. (4)

(c) Imagine that you have been asked to develop an optimization algorithm to solve the following problem that occurs every day: A delivery driver needs to deliver between 40 and 50 parcels, each to a different address in Edinburgh, within one day. Each of the deliveries has a specific address, and a specific time (if it is delivered later than this time, there is a £100 penalty for the delivery company; if it is delivered earlier, there is no penalty). The problem is to find a schedule of deliveries that starts from the delivery company's headquarters, makes each delivery, and then returns to the company's headquarters.

(i) Describe a suitable encoding and a suitable fitness function for this problem. (3)

(ii) You have decided to produce an Ant Colony Optimization (ACO) algorithm that will be used every morning to solve the problem, but to find the best parameters for your ACO algorithm, you have decided to do initial experiments with an Evolutionary Algorithm (EA), where each candidate solution of the EA specifies a particular parameterisation of an ACO algorithm, and the fitness of a candidate solution is based on its performance on the problem. Describe the key details of the EA that you would design for these experiments, in particular: specific details of the encoding and the fitness function, suitable operators that you would use, and a discussion of the varied experiments you would perform to find an ACO algorithm that would perform well on this problem. (7)

Q2 (a) Climateville is a village of 1,000 homes. At the moment, 10 of these homes have solar panels on the roof, allowing them to reduce the degree to which they depend on fossil fuels for their energy. The presence of a solar panel on the roof indicates that the family in that house are conscious of the problems caused by climate change, and are trying to do something about it. The presence of the solar panel has another important effect: neighbours and passers by, who see the solar panel, will become a little more likely to consider installing one on their own roof.

Of course, some people (call them type A) will be very reluctant to instal a solar panel, since they cannot afford the cost; others (call them type B) will be very reluctant to instal a solar panel, in the belief that it would make no difference if they did. Others, however, will become more likely to instal a solar panel if they see others have done so. Meanwhile, even type A and B people will feel pressure to instal a solar panel if a majority of their neighbours have done so.

You have been asked to investigate the spread of "solar panel installation behaviour" in villages like Climateville, so that questions like the following can be answered: If 1% of homes have solar panels, how long will it be before 50% of homes have installed solar pabels? How will this change if we increase awareness of climate change via TV advertisements (so that, for example, type B people will become more responsive). How will this change if we provide government grants to aid with the cost of installation (so that type A people will become more likely to instal one)?

Describe how you would design and use a Cellular Automaton to investigate these questions. Your answer should include details about the following aspects of your Cellular Automaton:

(i) The states; (5)

(ii) examples of state transition rules; (7)

(iii) how you might obtain suitable parameters for the transition rules; (4)

(iv) how you will use your CA to address the research questions. (4)

Q3

(a) Define "unsupervised learning" and "reinforcement learning" and explain why both are categorised as "learning without a teacher"? (4)

(b) "Learning" and "adaptation" are the most important mechanisms in biological neural networks. Explain how they are modelled in artificial neural networks and their link to synaptic modulation? Give an example. (6)

(c)

(i) Define the Hopfield Neural Network model. Draw a schematic with 6 neurons. (3)

(ii) Highlight the main differences between the Hopfield Neural Network model and the MLP (Multi-Layer Perceptron) model, in terms of type of connections between neurons, weight values and training algorithm. (6)

(iii) What kind of task are Hopfield Neural Networks mostly applied to? (1)

Q4

(a) Show the full process of training and execution/recall, step by step of a Hopfield neural network designed to learn the pattern "1100" (draw all the matrices involved during the execution of the pseudocode during "training" and "execution/recall"). (9)

(b) Consider the pattern "0011":

(i) Execute the trained network in part (a) to recall the pattern "0011". (4)

(ii) Could this network recall the pattern "0011" correctly? Explain why or why not. (3)

(c) What is the main difference between the "Sigmoid" activation function and the "Hyperbolic Tangent" activation function? Represent both activation functions graphically. (4)

END OF PAPER