

SCHOOL OF MATHEMATICAL AND COMPUTER SCIENCES

Computer Science

F21BC

BIOLOGICALLY INSPIRED COMPUTATION

Semester 1 2017/18

December 2017

Duration: Two Hours

ANSWER THREE QUESTIONS

Answer each question in a separate script book

Q1

- (a) In the context of evolutionary algorithms:
- (i) Describe the difference between a steady-state replacement method and a generational replacement method. (3)
 - (ii) What is a replacement strategy? Mention two common strategies used. (3)
 - (iii) Give an example of the use of a steady-state replacement method with one of the replacement strategies you identified in part (ii). (4)
- (b) This part of the question concerns search spaces.
- (i) What is a search space? (2)
 - (ii) Draw examples of unimodal, plateau, multimodal and deceptive landscapes and add a brief description of each of them. (4)
 - (iii) Describe the concept of neighbourhood and explain how the size of the neighbourhood affects the search. (4)

Q2 In supervised learning, Artificial Neural Networks (ANN) can be applied to solve both classification and function approximation problems.

- (a) Describe these two types of problem, and give an example of each type. (8)
- (b) Assuming the use of a Multilayer Perceptron, enumerate the general differences in both the topology and the parameters (input and output nodes, hidden layers, weights, biases and type of activation function) that you should consider when approaching both type of problems. 3 marks each for discussing differences in the following: the input layer, the output layer, the activation function, the hidden units/layers. (12)

Q3

(a) What is “genetic programming”? (2)

(b) Various types of genetic programming (GP) were introduced during the course, including Koza GP, Cartesian GP, Linear GP, Grammatical Evolution, and Genetic Improvement.

Consider the following three scenarios. For each one:

- Identify which type of GP is most suitable, and indicate why this is the case. [2 marks out of 6]
- Briefly outline the main characteristics of the chosen type of GP. [2 marks out of 6]
- Point out any issues that may be faced when applying this type of GP in this situation, and indicate how these might be overcome. [2 marks out of 6]

(i) You want to find a mathematical equation that describes a relationship in some scientific data. The equation should be simple for scientists to interpret. (6)

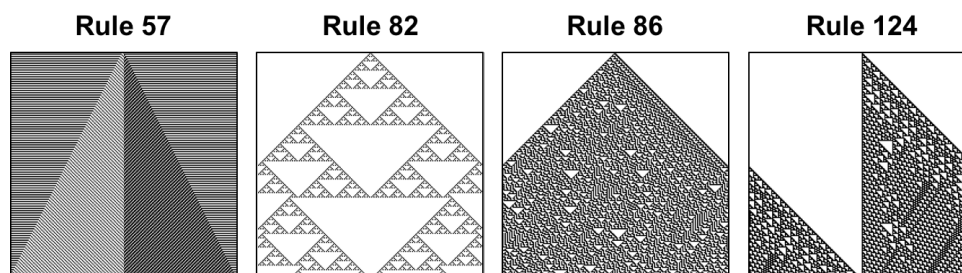
(ii) You want to generate some code to control a character in a computer game. You can assume a suitable fitness function is already available. This code is to be integrated into a larger program which is written in C++. (6)

(iii) You want to reduce the execution time of an existing program. (6)

Q4

- (a) Cellular automata and Boolean networks are both forms of discrete dynamical system. Briefly describe each of these models and indicate the main differences between them. (6)

- (b) These are the space-time diagrams for various elementary cellular automata.



- (i) What is an “elementary” cellular automaton, and what does its rule number refer to? (2)
- (ii) For each of the four rules depicted, comment on whether or not you think the rule has useful computation properties, and why this is the case. (4)
- (c) Evolutionary algorithms (EAs) and particle swarm optimisation (PSO) are two forms of population-based metaheuristic.
- (i) What is a metaheuristic? (1)
- (ii) What are the advantages of population-based metaheuristics over local search algorithms (e.g. hill-climbers, simulated annealing)? (3)
- (iii) A prominent difference between EAs and PSO is that search points in PSO have a velocity as well as a location. Describe how this velocity is updated at each iteration of a typical PSO algorithm. (3)
- (iv) In the context of PSO, what is an informant? (1)

END OF PAPER