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UNIVERSITY OF BIRMINGHAM

School of Computer Science

Final Year – BSc Computer Science
Third Year – MSci Computer Science
Third Year – MEng Computer Science/Software Engineering
Third Year – MSci Mathematics & Computer Science
Final Year – BSc Computer Science with Industrial Year
Third Year – MSci Computer Science with Industrial Year

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Nature Inspired Search and Optimisation

Summer May/June Examinations 2017

Time allowed: 1 hour 30 minutes

[Answer ALL Questions]

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Answer the following questions:

1. [Total: 40%]

(a) Given N chromosomes (individuals) in a population and their fitness f1,f2,...,fN, describe the probability of selecting the i-th chromosome (where i in {1,..,N}) using the roulette-wheel selection. [4%]

(b) Roulette-wheel selection may lead to premature convergence due to the "super-individuals" problem. Explain this problem. [4%]

(c) What is bloat in a genetic programming, and how can we manage it in a tree-based representation? [4%]

(d) Suppose we want to minimize a real valued fitness function f:R->R over the interval [-5,10], of which the subintervals [-1,0] and [2,4] are infeasible. Draw an example of a fitness function with an associated penalised fitness. [4%]

(e) What is the main practical difficulty with the penalty approach and how can the penalty approach be enhanced? [4%]

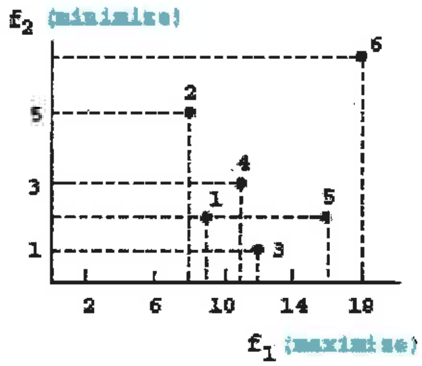
(f) Would it be a good idea in constrained optimisation to simply discard the infeasible individuals from the population? Why or why not? [4%]

(g) State the No-Free-Lunch theorem in plain English, and say what implication it has. [4%]

(h) What is co-evolutionary learning and how does it differ from evolutionary learning? Do you see any relation between co-evolution and fitness sharing? [4%]

(i) What is the difference between the Michigan and the Pitt approach of evolving a classifier system? [4%]

(j) The following figure depicts a population of individuals trying to maximize the objective f1 and to minimize the objective f2.Give the first two non-dominated fronts. [4%]



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2. [Total: 30%]
The payoff matrix of the N-player iterated prisoner dilemma game can be defined as follows:

		Nr co-operators among the other N-1 players				
		0	1	2	...	N-1
Player A:	C	0	2	4	...	2(N-1)
	D	1	3	5	...	2(N-1)+1

Players have two possible actions: cooperate (C) or defect (D). Players cannot communicate within a round of the game. The numbers in the table represent the payoff received by player A as a function of his/her the action and the number of cooperators amongst the other participants. All players in an N-player game are treated equally. So the payoff matrix is symmetrical to all players.

Design an evolutionary / co-evolutionary algorithm for learning to play the iterated 4-player prisoner's dilemma game, assuming that players remember the history of the last 3 rounds of the game. Each individual in your population will be a playing strategy, and you try to evolve the best strategy. In particular, the following is required, justifying your design decisions:

(a) Design the chromosome representation of the strategies.

(i) Explain how to encode a strategy as a binary string? [6%]

(ii) What is the size of such a chromosome? [6%]

(b) Design suitable evolutionary operators (crossover, mutations). [6%]

(c) Design a suitable fitness evaluation function, and a suitable selection scheme [6%]

(d) Comment on strengths and weaknesses of your design. [6%]

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3. [Total 30%]
Diagnosis prediction is an important medical problem. The input data corresponds to a number of medical variables encoding the results of different tests and measurements, and the target is to predict the diagnosis of a patient. However there is usually a complicated relationship between the input variables and the target. A predictor is a system that is able to learn this relationship from examples and based on that can perform the prediction task. Design an evolutionary algorithm to evolve a predictor capable of predicting diagnosis. Explain, discuss and justify all your design decisions.

(a) Describe in words the predictor that you will use, in terms of inputs, outputs and architecture [6%]

(b) Design a chromosome representation for the individuals in your population. [6%]

(c) Design appropriate evolutionary operators to be used, detailing and explaining how and in which order they will be used. [6%]

(d) How will the fitness be evaluated? [6%]

(e) What selection schemes will be used? [6%]

Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.