UNIVERSITY OF SOUTHAMPTON COMP6026W1

SEMESTER 1 EXAMINATION 2009/10

EVOLUTION OF COMPLEXITY

Duration: 90 mins

Answer ALL three questions
(25 marks each, 75 marks total).
This exam is 50% of your assessment.

University approved calculators MAY be used.

An approximate marking scheme is indicated.

Number of Pages: 4

QUESTION 1

a) Describe in detail (e.g. using pseudocode) a genetic algorithm with crossover. Assume individuals are represented with bit-strings and that a fitness function is provided. Include a crossover and mutation operator. State what kind of selection is used, what kind of crossover is used and whether it is steady-state or generational.

(16 marks)

b) What are the four necessary and sufficient conditions that Ridley describes for evolution by natural selection? How are they incorporated in the genetic algorithm?

(9 marks)

QUESTION 2

a) What is a fitness landscape and what properties of a fitness landscape make it easy or difficult for evolution by natural selection to find high-fitness genotypes?

(5 marks)

b) The 'Royal Road' (Mitchell et al 1992) is a problem where blocks of eight consecutive 1s are rewarded. The problem was designed to exemplify what GAs are good for – how was it supposed to work and what went wrong?

(7 marks)

c) Describe (e.g. provide a well-labelled sketch or a verbal description) one example problem/fitness landscape where a genetic algorithm can find the global optimum quickly but other stochastic local search processes (e.g. a stochastic hill-climber) cannot. Explain why this problem demonstrates a speed advantage for the genetic algorithm.

(10 marks)

d) List some ways a natural fitness landscape might be different from landscapes of optimisation problems?

(3 marks)

QUESTION 3

a) "The complexity of living things is extraordinary and evolution by natural selection is the only theory to explain how this complexity arose. Therefore evolution by natural selection must result in increased complexity." What's logically wrong with this argument? And why might we have reasons to doubt that evolution by natural selection will necessarily result in increased complexity?

(8 marks)

b) One of the reasons that coevolution is appealing in artificial evolution is the possibility of an 'open-ended arms race' where one population provides a constant selection pressure on a second population's improvement and that population in turn provides a constant selection pressure on the first's improvement. Does coevolution provide a guaranteed method of open-ended improvement and a route to evolved complexity? Explain some ways in which it might fail.

(8 marks)

c) Describe a coevolutionary method for finding teams of individuals that solve a problem collectively. How is this approach different from adversarial coevolution?

(5 marks)

d) The major evolutionary transitions, including the origin of eukaryotic organelles from prokaryotic bacteria, imply that "entities that were capable of independent replication before the transition can replicate only as part of a larger whole after the transition" (Maynard Smith and Szathmary, 1995). Is this just an example of coevolution?

(4 marks)

END OF PAPER