UNIVERSITY OF SOUTHAMPTON COMP6026W1

SEMESTER 1 EXAMINATION 2010/11

EVOLUTION OF COMPLEXITY

Duration: 90 mins

Answer THREE questions.
(25 marks each, 75 marks total)

University approved calculators MAY be used.

Number of Pages: 5

Question 1.

a) Describe (e.g. using pseudo-code) an algorithm for uniform crossover between two bit-string individuals. (3 marks)

b) Describe (e.g. using pseudo-code) an algorithm for mutating a bit-string individual. (2 marks)

c) Describe (e.g. using pseudo-code) an algorithm to select a parent for reproduction with probability proportional to their fitness. Assume that an array of individuals and a corresponding array of their fitnesses is provided. (7 marks)

d) Assuming the mutation, crossover, selection and evaluation routines are all provided, describe in detail (e.g. using pseudo-code) an algorithm for a generational genetic algorithm. (8 marks)

e) Consider a fitness function for the travelling salesperson problem that returns 1/<length of tour>. For large problems, why might it be a good idea to use rank-based selection rather than fitness proportionate selection. (5 marks)

Question 2.

a) Describe, using both biological and engineering examples for each, two different types of modularity. (4 marks)

b) Which type of modularity might a developmental representation be useful for? Explain briefly. (2 marks)

c) Consider the schema **1*00*11*** where '*' can be either 0 or 1. How many strings are there in this schema, what is its order, what is its defining length. (3 marks)

d) What is the definition of a 'building-block'. (2 marks)

e) According to the building block hypothesis, what is the significance of building blocks for the operation of the genetic algorithms and why are they defined as they are? (6 marks)

f) Student A says "Crossover can take the good parts of one individual and combine them with the good parts of another individual. That's why crossover is good." Student B says, "Sure, but more often than not, crossover will disrupt good combinations of alleles by mixing them with the alleles of other individuals. So crossover is generally bad." Which student is right? Discuss using the concepts of building-blocks, linkage disequilibrium, and the Fisher-Muller benefit of sex.

(8 marks)

Question 3.

a) How is a fitness landscape defined? (3 marks)

b) What properties of a fitness landscape make it difficult for a local search process to solve? (3 marks)

c) In what way does the choice of variation operators used (e.g. mutation, uniform crossover, one-point crossover) alter a fitness landscape? (4 marks)

d) Consider the following two-locus genotypes (i-iv) and their fitnesses. Is there epistasis between the first and second locus? Show your working. (3 marks)

i. 00 fitness 3
ii. 01 fitness 4
iii. 10 fitness 5
iv. 11 fitness 4

e) Describe in detail (using a definition or a labelled sketch) one fitness landscape where a genetic algorithm finds high-fitness genotypes faster than a hill-climber. Describe briefly how this landscape is easy for the GA but difficult for the hill-climber. (8 marks)

f) Describe some of the differences between natural fitness landscapes and the fitness landscapes common to engineering problems. (4 marks)

Question 4.

a) “If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down.” (Darwin 1859) Comment on the validity of this statement. (7 marks)

b) “The genome of organisms, even for bacteria, is at least 10^6 nucleotides long each of which can be one of 4 bases (A, C, T or G). The number of possible genomes is therefore at least $4^{1000000}$. A single mutation to any of the bases in an organism can be fatal or produce non-viable offspring. It is therefore inconceivable that a random trial and error process like evolution could have produced the genomes of living organisms.” Comment on the validity of this argument. (7 marks)

c) “Living things are exquisitely adapted to their environments and evolution by natural selection is the only theory to explain how they became so. Therefore evolution by natural selection must be the explanation for the adaptedness of organisms.” Comment on the validity of this argument. (5 marks)

d) “The complexity of living things is very high (by any reasonable measure) therefore it must be the case that evolution by natural selection produces a generic trend toward increasing complexity in nature.” Comment on the validity of this argument. (6 marks)

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