Vrije Universiteit Amsterdam
Exam Evolutionary Computing
25.10.2002

Note 1 Your name must be written on each sheet in CAPITALS.

Note 2 You can answer the questions in English or in Dutch.

Points to be collected: 63.

Your grade: points collected divided by 6.3 and rounded up.

1. We are to solve a graph 3-coloring problem with evolutionary computing. That is, we have a graph $G = (N, E)$ with $n = |N|$ nodes and $m = |E|$ edges. A coloring is an assignment of colors to nodes, i.e., a function $c : N \to \{r, w, b\}$, and $c(n) \in \{r, w, b\}$ is called the color of node n. We know that the graph is 3-colorable in the sense that there is a coloring c such that no neighboring nodes have the same color, $\forall x, y \in N : \langle x, y \rangle \in E \Rightarrow c(x) \neq c(y)$.

   Specify an EA suitable[1] for solving this problem. In particular, give

   (a) **(4p)** a representation (the syntax of the chromosomes and a mapping between chromosomes and colorings),

   (b) **(4p)** a fitness function,

   (c) **(2p)** an appropriate crossover operator,

   (d) **(2p)** an appropriate mutation operator,

   (e) **(2p)** an appropriate selection mechanism,

   (f) **(2p)** an initialization method,

   (g) **(2p)** a stop condition,

   (h) **(4p)** a discussion how your solution is handling the constraints (the restrictions on nodes having different colors).

2. (a) **(6p)** Name 3 features in which Genetic Programming and Genetic Algorithms differ.

   (b) We are seeking a function f satisfying $f(x_i) = y_i$ for each i from the following table.

i	1	2	3	4	5
x_i	1	3	5	7	9
y_i	1	5	8	11	14

   i. **(3p)** Give arguments why Genetic Programming is suited to solve this problem.

   ii. **(3p)** Specify a function set and a terminal set that can be used in a GP implementation for this problem.

   iii. **(3p)** Specify a fitness function that can measure the 'goodness' of an arbitrary function g on the data in the above table.

[1] The EA does not have to be "smart" (efficient). But the representation and the operators should be such that a solution can be found.

3. Let

$$S = * \ 0 \ * \ * \ 1 \ 1 \ * \ * \ * \ 0 \ * \ *$$

be a schema. Answer the following questions.

(a) **(2p)** How is the order of a schema defined in general? What is the order of S.

(b) **(2p)** How is the defining length of a schema defined in general? What is the defining length of S.

(c) **(2p)** What is the probability for one-point crossover with crossover rate p_c that crossover breaks S? (I.e., the probability that the child created by the operator does not belong to the given schema.)

(d) **(2p)** What is the probability that mutation with mutation rate p_m breaks S?

(e) **(2p)** Is it correct to call this schema a "building block"? Explain why, or why not.

4. (a) **(3p)** Describe how roulette wheel selection works.

(b) **(3p)** Describe how k-tournament selection works.

(c) **(3p)** Make a pro's and contra's comparison between these two selection mechanisms. Which one is preferable? Why?

5. (a) **(2p)** A Genetic Algorithm is applied to an objective function of n variables: $f(x_1, \ldots, x_n)$. How long are the chromosomes?

(b) **(2p)** An Evolution Strategy is applied to an objective function of n variables: $f(x_1, \ldots, x_n)$. How long are the chromosomes if we do not use α's?

6. **(3p)** Consider the following reasoning:

> 'An EA can work without the selection mechanisms being biased by fitness information. As a proof consider Evolution Strategies that have no fitness bias in parent selection and generational GAs that have no fitness bias in survival selection.'

Is this reasoning correct or not? Give arguments.