Vrije Universiteit Amsterdam
Exam Evolutionary Computing
20.02.2006

Your name must be written on each sheet in CAPITALS.

NOTES:

1. You can answer the questions in English or in Dutch.
2. Points to be collected: 90, free gift: 10 points, maximum total: 100 points.
3. Grade: total number of points divided by 10, rounded up to the first decimal.

QUESTIONS

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 $c : N \rightarrow \{r, w, b\}$, 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) **(5p)** a representation (the syntax of the chromosomes and a mapping between chromosomes and colorings),
   (b) **(5p)** a fitness function,
   (c) **(5p)** an appropriate crossover operator,
   (d) **(3p)** an appropriate mutation operator,
   (e) **(3p)** an appropriate selection mechanism,
   (f) **(3p)** an initialization method,
   (g) **(3p)** a stop condition,
   (h) **(8p)** 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. **(3p)** Give arguments why Genetic Programming is suited to solve this problem.
      ii. **(6p)** Specify a function set and a terminal set that can be used in a GP implementation for this problem.

[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.

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

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

3. (a) **(5p)** Given the mutation rate p_m in a GA, what is the probability that a certain binary chromosome of length L will not be changed by bit-flip mutation?

   (b) **(8p)** Assume that we use standard uniform crossover in a GA with crossover rate p_c in such a way that it creates only one child. Let L be the chromosome length. What is the probability that the child of the parents $x = \langle 0, 0, \ldots, 0 \rangle$, $y = \langle 1, 1, \ldots, 1 \rangle$, is equal to $\langle 0, 0, \ldots, 0 \rangle$?

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

   (b) **(4p)** Describe how k-tournament selection works.

   (c) **(5p)** Make a pro's and contra's comparison between these two selection mechanisms. Which one is preferable? Why?

5. (a) **(3p)** A Genetic Algorithm is applied to an objective function of n variables: $f(x_1, \ldots, x_n)$. How long are the chromosomes?

   (b) **(3p)** 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. **(5p)** 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.