Exam Evolutionary Computing
25.10.2010

NOTES:

1. YOUR NAME MUST BE WRITTEN ON EACH SHEET IN CAPITALS.
2. You can answer the questions in English or in Dutch.
3. This is an 'open book' exam. You can use the course book – but nothing else.
4. Points to be collected: 90, free gift: 10 points, maximum total: 100 points.
5. Grade: total number of points divided by 10.

QUESTIONS

1. Given the following data table, we are seeking a function f that satisfies $f(x_i) = y_i$ for each i from this table.

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

   (a) **(5p)** Give arguments why Genetic Programming is suited to solve this problem.

   (b) **(5p)** Specify a function set and a terminal set that can be used in a GP implementation for this problem.

   (c) **(6p)** Give fitness function that reflects the 'goodness' of any arbitrary function g.

2. **(10p)** Suppose you have two algorithms for the travelling salesman problem (TSP): a GA and a Simulated Annealing algorithm. How can you combine these two algorithms? Describe a memetic algorithm obtained by their combination in pseudo code.

3. **(6p)** Under what conditions can it be guaranteed that an evolutionary algorithm will find the optimum of a function over a finite search space? Provide the relevant theorem to specify how the term "will find" is meant.

4. Invent a multi-parent recombination mechanism for permutation representation. That is, describe a recombination mechanism that can be applied to an arbitrary number of $n > 1$ parents and has the property that if all parents are permutations (over the same alphabet) then so are the offspring. You can solve this problem in two steps:

   (a) **(6p)** Describe a recombination mechanism that can be applied to $n = 3$ parents and permutations over the alphabet $\{a, b, c, d, e, f\}$. Illustrate its working with a concrete example.

   (b) **(10p)** Describe a recombination mechanism for permutations that can be applied to an arbitrary number of $n > 1$ parents and provide an argument to "prove" that it always produces correct offspring. NB. The quotes in "prove" indicate that you needn't provide a formal proof with mathematical rigor.

5. The following table describes a population in a GA, showing the population members and their fitness, e.g., $f(a) = 1$.

individual x	a	b	c	d	e
fitness $f(x)$	1	1.5	2	2.5	3

   (a) **(4p)** What is the probability of selecting individual c when using fitness proportional selection?

   (b) **(8)** What is the probability of selecting individual c when using 2-tournament selection?

6. **(6p)** Invent a mechanism to modify the population size of a GA over time. Position your mechanism within the taxonomy of parameter setting in EAs. Motivate your method by (intuitive) arguments: why would it be helpful?

7. **(8p)** 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?

8. **(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 $\langle 0, 0, \ldots, 0 \rangle$?

9. **(8p)** Consider the following statement:

   'When comparing two EAs the one with a higher average solution quality is always preferable.'

   Is this statement correct or not? Give arguments.