Vrije Universiteit Amsterdam
Exam Evolutionary Computing
29.10.2004

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: 90, free gift: 10 points

Grade: total number of points divided by 10, rounded up to the first decimal.

1. We define the circle covering problem as follows. Consider the unit circle on the 2 dimensional plane, that is, a circle with its origin at $\langle 0, 0 \rangle$ and $r = 1$. The task is to position as many as possible squares of 0.1 by 0.1 within this circle. We assume that the squares are not rotated, but lie parallel with the axes. Clearly, this can be seen as a maximization problem, where a *layout* is defined as a number of squares together with the position of each square and we are looking for the largest layout fitting in the circle. (With the trivial definition of "the size of a a layout is the number of squares in it".)

   Your task is to specify an EA suitable[1] for solving this problem. In particular, give

   (a) **(5p)** a representation, that is, the syntax of the chromosomes (genotypes) and a mapping between chromosomes and layouts (phenotypes),

   (b) **(5p)** a fitness function,

   (c) **(5p)** an appropriate crossover operator,

   (d) **(3p)** an appropriate mutation operator,

   (e) **(3p)** an appropriate parent selection mechanism,

   (f) **(3p)** an appropriate survivor selection mechanism,

   (g) **(3p)** an initialization method,

   (h) **(3p)** a stop condition.

2. **(12p)** You have developed a GA for the n-queens problem (algorithm A) and want to show that it is more efficient than a traditional heuristic method for this problem (algorithm B). Explain how you could measure efficiency for both algorithms, how you could compare them, and what experiments you want to do to obtain the necessary data for this comparison. Furthermore, give a figure (that is, graph, table, histogram, whatever form you prefer) that you would like to use for exhibiting the outcomes of the experiments. NB. This figure will be imaginary, in the sense that it is not based on real data, but on data as you could obtain.

[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. **(8p)** What does the No Free Lunch Theorem say? Give an informal description of this theorem and mention two of its implications.

4. **(6p)** Consider the following statement:

   'GP is just GAs with trees.'

   Is this statement correct or not? Give arguments.

5. (a) **(3p)** What does the term memetic algorithm stand for?

   (b) **(5p)** Illustrate your answer with a simple example. That is, give the description of a memetic algorithm of your choice.

   (c) **(3p)** Explain why your MA is memetic by pointing out those features that justify this name.

6. **(8p)** We use a generational bit-string GA with population size 100 and chromosome length 200, with fitness proportional selection, one-point crossover ($p_c = 0.8$), and bit-flip mutation ($p_m = 0.0$). After n generations we perform the selection step to create the mating pool. Looking at the first bit we observe that in this mating pool 60% of the individuals contains 1, and 40% of them contains 0. What will be the percentage of individuals containing 1 at the first bit in the $(n+1)$-th generation?

7. Sketch the differences and similarities between Genetic Algorithms, Evolution Strategies and Genetic Programming with respect to

   (a) **(3p)** typical problems it is applied to

   (b) **(3p)** typical representation,

   (c) **(3p)** role of mutation,

   (d) **(3p)** role of crossover,

   (e) **(3p)** self-adaptation.

   Make a table to present your comparison.