Exam Evolutionary Computing
16.02.2010

NOTES:

1. YOUR NAME MUST BE WRITTEN ON EACH SHEET IN CAPITALS.
2. You can answer the questions in English or in Dutch.
3. Points to be collected: 90, free gift: 10 points, maximum total: 100 points.
4. Grade: total number of points divided by 10.

QUESTIONS

1. You are asked to evolve a controller for playing the game 'PONG'. This game is the 1972 simplified electronic version of a tennis-game. It is played on a 2-dimensional 10x10 grid, and the objective is simply to return the ball to the other side of the court. The players are only allowed to move up and down, and if the ball passes you, then the other player earns a point. The game stops if one of the two players has got 10 points. The objective is to find the best possible controller for your player. In other words, we are looking for a good controller function $cf : I \longrightarrow O$, where I is the space of all possible input vectors (sensory information) and O the space of all possible output vectors (actions).

   The input of the controller consists of the position of the ball in the grid $< b_x, b_y > \epsilon \{1, 2, \ldots, 10\}^2$ and your vertical position $p_y \epsilon \{1, 2, \ldots, 10\}$. Each timestep, the possible actions are 'move one step up' or 'move one step down', staying in place is not allowed. Your task is to define an EA suitable[1] of solving this problem. To this end you may make assumptions and add details as you wish, as long as they are consistent with the description above.

   Your answer must be formulated through specifying:

   (a) **(5p)** what "dialect" of EAs to use for this problem and why (EP, ES, GA, GP?),

   (b) **(5p)** an appropriate fitness function,

   (c) **(10p)** a representation, that is, the syntax of the chromosomes (genotypes) and a mapping between chromosomes and controllers (phenotypes),

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

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

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

   (g) **(3p)** an appropriate survivor selection mechanism.

   (h) **(5p)** Furthermore, give a well-motivated advise on how to extend the set of input variables (sensory information to the player) and/or the set of output variables (player actions) in such a way that the attainable performance of player is likely to improve.

[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.

2. (a) **(7p)** Under what conditions can it be guaranteed that an evolutionary algorithm will find the optimal solution? Provide the relevant theorem to specify how the term "will find" is meant.

3. (a) **(5p)** Describe the characteristic features of a modern Evolution Strategy, in terms of representation, variation and selection operators.
   (b) **(7p)** Describe the method of mutation for an ES with n variables and a single mutation stepsize. Provide the related formulas in detail.
   (c) **(3p)** Why is the order of steps in this method important?

4. Explain what the following terms mean, and illustrate each type with an example:
   (a) **(5p)** Deterministic parameter control.
   (b) **(5p)** Adaptive parameter control.
   (c) **(5p)** Self-adaptive parameter control.

5. (a) **(3p)** What is Genetic Drift and how does it affect an Evolutionary Algorithm ?
   (b) **(5p)** Give an example of an implicit method to preserve diversity in a population.
   (c) **(5p)** Give an example of an explicit method to preserve diversity in a population.

6. **(5p)** Consider the following statement:

   > In case of a continuous numerical optimization problem, an evolution strategy is always preferred over the other historical dialects.

   Is this statement correct or not? Motivate your answer.