Exam Evolutionary Computing
17.02.2009

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. We are working on a robotics project and need to develop a good robot controller, that is, a piece of program code that 1) takes inputs from the robot sensors (camera, microphone, infrared sensors, etc.) and 2) produces appropriate outputs to the robot actuators (motors driving the wheels, lamps to give light signals, etc.). 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 and O is the space of all possible output vectors.

   As an example you can think of a simple robot having two input variables, $x \in \{0, 1\}$ belonging the light sensor (1 is light, 0 is dark), $y \in \{0, 1\}$ belonging to the microphone (1 is sound, 0 is silence), and four output variables $m_L, m_R \in \{0, 100\}$ specifying the motor speed of the left/right wheel and $r, g \in \{0, 1\}$ corresponding to the red/green lamps (1 is on, 0 is off).

   We assume that a task is given that the robot must learn to perform, for example switching on its lights and/or moving somewhere according to different environmental conditions. We do not specify this task here, just assume that task performance can be measured by a robot simulator that calculates this performance $P(cf)$ for any given controller cf. Your task is to define an EA suitable[1] for solving this problem. In particular, specify

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

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

   (c) **(7p)** a representation, that is, the syntax of the chromosomes (genotypes) and a mapping between chromosomes and controllers (phenotypes),

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

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

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

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

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

   (i) **(3p)** a way to handle constraints (if applicable/necessary within your EA).

[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) **(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) **(4p)** 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?

   (c) **(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 use α's?

3. **(5p)** Consider the following statement:

   > It has been formally proven that a GA will always find the optimal solution for a problem.

   Is this statement correct or not? Motivate your answer.

4. Give the definition of

   (a) **(3p)** a schema (in GAs),

   (b) **(3p)** instance of a schema,

   (c) **(3p)** order of a schema,

   (d) **(3p)** length of a schema,

   (e) **(3p)** fitness of a schema.

   (f) **(6p)** What is the Schema Theorem in GAs?

5. (a) **(3p)** What is the difference between parameter tuning and parameter control in EAs?

   (b) **(3p)** What types of parameter control do you know?

   (c) **(6p)** Provide an illustration of one of the types of control you mentioned in your answer to the previous question. That is, reproduce the details of a known control mechanism, or choose an EA parameter and invent a suitable control mechanism for illustration.

6. **(7p)** Why is tournament selection to be preferred over roulette wheel selection?