Exam Evolutionary Computing
06.02.2007

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, rounded up.

QUESTIONS

1. We are to solve an industrial optimization problem with evolutionary computing. Interviews with the domain experts reveal that the problem has 50 parameters $x_1, \ldots, x_{50}$:

   - 10 real valued parmeters, $x_1, \ldots, x_{10}$, all between 0 and 1;
   - 38 integer valued parmeters, $x_{11}, \ldots, x_{48}$, all between 0 and 511;
   - 2 Boolean parmeters, $x_{49}, x_{50} \in \{0, 1\}$.

   The objective function F to be maximized does not have an analytical form (i.e., no mathematical formula describing it). Rather, for each vector $x_1, \ldots, x_{50}$, the objective function value can be calculated by a problem specific simulator that returns $F(x_1, \ldots, x_{50})$ for the input $x_1, \ldots, x_{50}$. 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)** a representation (the syntax of the chromosomes and a mapping between chromosomes and the original parameter vector $x_1, \ldots, x_{50}$,

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

   (d) **(5p)** an appropriate mutation operator,

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

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

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

2. Self-adaptation is standard (i.e., "always" used) in one of the branches of evolutionary computing.

   (a) **(2p)** Which branch is this?

   (b) **(2p)** Which parameter is self-adapted?.

   (c) **(6p)** Explain in detail how this parameter is self-adapted.

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[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. (a) **(3p)** Explain what order-based representation is.

   (b) **(3p)** Sketch a problem that can be well treated by order-based representation.

   (c) **(5p)** Give the description of an order-based crossover operator.

   (d) **(3p)** Give the description of an order-based mutation operator.

4. Let us assume that we have a population of four individuals $S = \{a, b, c, d\}$ with fitness values given by $f(x)$ as shown in the following table (to be maximized).

x	$f(x)$	$\mathbb{P}_f(x)$	$g(x)$	$\mathbb{P}_g(x)$
a	1			
b	1			
c	2			
d	4			

   (a) **(10p)** What are the probablities $\mathbb{P}_f(x)$ for each $x \in S$ to be selected by fitness proportional (roulette wheel) selection, based on this fitness function f?

   (b) **(10p)** Let g be another fitness function, obtained as $g = f + 100$. What are the probabilities $\mathbb{P}_g(x)$ for each $x \in S$ to be selected by fitness proportional (roulette wheel) selection, based on this fitness function g?
   NB. You may give approximate figures of these probabilities without decimals, e.g., "around 75 %".

5. (a) **(3p)** What is a memetic algorithm?.

   (b) **(3p)** Name 3 components of an evolutionary algorithm that can be hybridized.

   (c) **(6p)** Give an example of a hybrid EA: specify what problem is solved by the EA, specify what component is hybridized, specify the heuristic used for this.

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

   'A (1+1) Evolution Strategy is not a real evolutionary algorithm.'

   Is this statement correct or not? Give arguments.