Vrije Universiteit Amsterdam

Exam Evolutionary Computing

26.11.2003

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: 62.

Grade: points collected divided by 6.2, rounded up to the first decimal.

1. We are to solve the magic square problem with evolutionary computing. The short definition of this problem is as follows. We are given a board of 10 by 10 and we have to place the integers $1 \ldots 100$ on this board in such a way that

   (a) each integer is placed on the board excatly once,

   (b) the sum of integeres in a row is the same for each row,

   (c) the sum of integeres in a column is the same for each column,

   (d) the sum of integeres in a diagonal is the same for both diagonals.

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

   (a) **(4p)** a representation, that is, the syntax of the chromosomes (genotypes) and a mapping between chromosomes and board configurations (phenotypes),

   (b) **(4p)** a fitness function,

   (c) **(4p)** an appropriate crossover operator,

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

   (e) **(2p)** an appropriate parent selection mechanism,

   (f) **(2p)** an appropriate survivor selection mechanism,

   (g) **(2p)** an initialization method,

   (h) **(2p)** a stop condition.

2. (a) **(6p)** Name 3 features in which Genetic Programming and Genetic Algorithms differ.

   (b) **(4p)** The logical operators for negation ($\neg$) and conjunction ($\wedge$) are sufficient to define other Boolean operators, e.g., disjunction ($\vee$), implication ($\rightarrow$), equivalence ($\leftrightarrow$). Therefore, the function set $\{\ \neg,\ \wedge\ \}$ is sufficient to define any Boolean expression. Is the minimal set of operators $\{\ \neg,\ \wedge\ \}$ as function set prefereable above the set $\{\ \neg,\ \wedge,\ \vee,\ \rightarrow,\ \leftrightarrow\ \}$ for solving a problem whose solution is a Boolean formula? Give arguments backing up your answer.

3. (a) **(3p)** What is anytime (algorithm) behaviour?

   (b) **(3p)** Given an anytime algorithm, is it worth to spend efforts on heuristic initialisation? Give arguments.

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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.

(c) **(3p)** Given an anytime algorithm, is it worth to spend efforts on "long" runs? Give arguments.

4. (a) **(4p)** Present the general scheme of an evolutionary algorithm and give a list of its most important components.

   (b) **(6p)** Choose a component (parameter within a component) and describe a mechanism to change it during a run. To this end:

      i. Give some motivation why changing this component/parameter can be advantageous.

      ii. Give a precise description of this mechanism.

      iii. Characterise this mechanism in terms of the general parameter control taxonomy.

5. (a) **(4p)** Give the definition of Boltzmann selection by providing the formula of accepting a newly generated point (neighbour).

   (b) **(3p)** Explain the effect of lowering the "temperature" on the selection pressure (i.e., on the chance that an inferior neighbour is selected).

6. **(4p)** 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.