Multiple Choice Questions - write the letter of your choice on your answer paper

1. Would you expect in general a change in performance of an EA if you change $\lambda$ but maintain the same total number of fitness evaluations by making a compensatory change in the number of generations? [1]

   (a) yes, because increasing $\lambda$ will decrease the generational gap and therefore lead to a better exploitation of the genetic knowledge encoded in the current population

   (b) yes, because this will change the ratio of exploitation versus exploration

   (c) no, because as long as the total number of fitness evaluations remains constant, the total number of recombines as well as the total number of mutations remains per definition constant too and therefore the EA’s performance remains unchanged

   (d) no, because the EA’s performance depends on its representation (genotype) and its fitness function (environment/problem) which together determine its phenotype (expression of the genotype in a given environment)

2. Fitness proportional selection suffers from the following problems: [1]

   (a) When fitness values are all very close together, mediocre individuals take over the entire population very quickly, leading to premature convergence

   (b) Outstanding individuals cause the selection pressure to drop because they decrease the number of slots on the virtual roulette wheel from which individuals are selected

   (c) Transposed versions of the fitness function all behave identically while they represent different problems which we obviously want to be able to differentiate between

   (d) All of the above

   (e) none of the above

3. Evolution Strategies typically use discrete recombination for the encoded solution alleles, but intermediary recombination for the strategy parameter alleles. Is this to: [1]

   (a) maintain phenotypic diversity while assuring a more cautious adaptation of the strategy parameters

   (b) prevent the mixing of solution alleles and strategy parameter alleles

   (c) support arbitrary solution representations which might not always be suitable for intermediary recombination

   (d) all of the above

   (e) none of the above

4. Disengagement in a two-population competitive CoEA occurs when: [1]

   (a) the individuals in both populations stop competing and start collaborating

   (b) both populations get stuck in local optima leading to a loss of search gradient

   (c) one population gets stuck in a local optimum and the other population stops evolving because of a loss of evolutionary pressure

   (d) all of the above

   (e) none of the above
5. The selective pressure of fitness rank based truncation survival selection is much higher than that of fitness proportional survival selection because: [1]

(a) the takeover time of fitness rank based truncation survival selection is much larger than that of fitness proportional survival selection
(b) \( \lambda \) is typically much higher than \( \mu \) (a 1/7 ratio is recommended)
(c) \((\mu, \lambda)\) selection discards all parents and is therefore in principle able to leave (small) local optima
(d) all of the above
(e) none of the above

6. The phenomenon of bloat in GP occurs most likely because: [1]

(a) individuals with bigger genomes have a larger chance of survival (also known as “survival of the fattest”)
(b) the variable length aspect of GP causes a natural tendency for the population to reflect the different possible sizes
(c) the ratio of alleles to genes in bloated individuals is higher than non-bloated individuals which gives them an evolutionary advantage
(d) all of the above
(e) none of the above

7. In multi-objective problems a solution \( x \) is said to be dominated by a solution \( y \) when: [1]

(a) solution \( x \) is strictly worse than \( y \) in no more than one objective
(b) solution \( x \) is no better than \( y \) in all objectives
(c) only if both the above are true
(d) none of the above

**Regular Questions**

8. Explain why the closure property in GP holds or does not hold for the following combination of function and terminal sets: [2]

<table>
<thead>
<tr>
<th>Function set</th>
<th>{+, −, sin, cos, or, not, and}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal set</td>
<td>( \mathbb{R} \cup {true, false} )</td>
</tr>
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</table>

It does not hold because the functions in the function set cannot accept all the terminal types present in the terminal set; for example, the sine function does not accept boolean arguments.

9. Explain the current GP practice of strongly limiting the role of mutation in favor of recombination. [2]

The reason for this is the generally shared view that crossover has a large shuffling effect, acting in some sense as a macromutation operator.

10. List one countermeasure to cycling in coevolution and explain how that countermeasure works. [2]

Maintain a hall of fame consisting of the best individuals of previous generations and compete current individuals with them. The hall of fame acts as a type of permanent memory, preventing later populations from “forgetting” about the winning traits of earlier generations.

11. Describe briefly the difference between a cooperative CoEA and a competitive CoEA. [2]

In cooperative CoEAs each population is a different species representing part of a larger problem, the populations need to cooperate to solve the larger problem; in competitive CoEAs individuals compete which each other to gain fitness at each others expense.
12. List two metrics for assessing the performance of a MOEA and explain each metric very briefly. [2]

**Convergence** A measure of how close a solution set is to the Pareto-optimal front

**Diversity** A measure of how evenly distributed the solutions in a solution set are

13. Explain concisely the concept of island model EAs in the context of Eldredge and Gould’s theory of punctuated equilibria. [3]

Island model EAs run multiple populations of the same species in parallel in some kind of communication structure. After a usually fixed number of generations, a number of individuals are selected from each population to be exchanged with others from neighboring populations. During this migration, the injection of individuals of potentially high fitness, and with possibly radically different genotypes, facilitates exploration. In terms of the theory of punctuated equilibria, these injections interrupt periods of evolutionary stasis by rapid growth when the main population is invaded by individuals from a previously spatially isolated group of individuals of the same species.

14. The standard linear ranking selection formula in your textbook is as follows:

\[ P_{\text{lin-rank}}(i) = \frac{2 - s}{\mu} + \frac{2i(s - 1)}{\mu(\mu - 1)} \]

with rank 0 being the least fit individual and rank \( \mu - 1 \) being the fittest individual. Now assume the generational model where \( \mu \) population members are selected with replacement to fill the mating pool.

(a) Show why \( s \) cannot be larger than 2. [2]

\[ E(\# \text{ copies of least fit individual in mating pool}) = \mu \cdot P_{\text{lin-rank}}(0) = \mu \cdot \frac{2 - s}{\mu} = 2 - s \geq 0 \Rightarrow s \leq 2 \]

(b) Show your derivation of the expected number of copies of the fittest individual in the mating pool. [3]

\[ E(\# \text{ copies of fittest individual in mating pool}) = \mu \cdot P_{\text{lin-rank}}(\mu - 1) = \mu \cdot \left( \frac{2 - s}{\mu} + \frac{2(\mu - 1)(s - 1)}{\mu(\mu - 1)} \right) = \mu \cdot \frac{2 - s + 2(s - 1)}{\mu} = \mu \cdot \frac{s}{\mu} = s \]