

## Homework #2

Due date & time: May 14, 2020, 10:00AM

Do the following problems and exercises.

1. Discuss why generational GAs and ES form opposites regarding where the fitness information influences the search.
2. Given a population of  $\mu$  individuals, which are bit-strings of length  $L$ . Let the frequency of allele 1 be 0.35 at position  $i$ , that is, 35% of all individuals contains a 1, and 65% a 0 at the  $i$ th position on the chromosome. How does this allele frequency change after performing  $k$  crossover operations with one-point crossover? How does it change if uniform crossover is performed?
3. In order to minimize the  $n$ -dimensional sphere model

$$f(x) = \sum_{i=1}^n x_i^2, \quad x_i \in \mathbb{R}, i = 1, \dots, n,$$

where  $n = 10$ , implement the following evolution strategies:

- (a) (1,1)-ES with fixed step-sizes for Gaussian mutation;
  - $\sigma = 0.01, 0.1$ , and  $1.0$
- (b) (1 + 1)-ES with fixed step-sizes for Gaussian mutation.
  - $\sigma = 0.01, 0.1$ , and  $1.0$

The starting point for all experiments is  $(1, 1, \dots, 1)$ . The termination criteria are either (1) the objective value of the individual is equal to or less than 0.005, or (2) the number of generation/iteration is equal to or greater than 10 million (10,000,000). Do ten independent runs of each experiment and record the time (in terms of the number of generations/iterations) when the search stops. Organize two tables for (1,1)-ES and (1 + 1)-ES, respectively. The table should look like

(1 <sup>+</sup> 1)-ES	$\sigma = 0.01$	$\sigma = 0.1$	$\sigma = 1.0$
Run #1	...	...	...
...	...	...	...
Run #10	...	...	...

4. Observe the running processes of problem 3. Compare and contrast the results you obtained in problem 3 and discuss what you think about the difference between  $(1, 1)$ -ES and  $(1 + 1)$ -ES.
5. Repeat problem 3 with uncorrelated Gaussian mutation with  $n$  step-sizes. Use the step-sizes specified for each condition in problem 3 as the starting step-sizes. Decide your own  $\tau$ ,  $\tau'$ , and  $\varepsilon_0$  for mutating the individual.
6. Compare and contrast the results you obtained in problems 3 and 5. Discuss what you think about the self-adaptation.
7. Repeat problem 3 with the  $1/5$ -rule. Use the step-sizes specified for each condition in problem 3 as the starting step-sizes and adjust them with the  $1/5$ -rule. Decide your own  $G$  and  $a$  for using the  $1/5$ -rule.
8. Compare and contrast the results you obtained in problems 3, 5, and 7. Discuss what you think about the  $1/5$ -rule for the self-adaptation of strategic parameters.