Methods and Heuristics for Learning and Optimization

Exercise 6: Genetic Algorithms and Function Minimization

Assignment for 2 week; return no later than December 8, 2019

1 Introduction

In this exercise we will introduce the concept of Genetic Algorithms. The task we will focus on is the minimization of the following function:

$$f(x,y) = -\left|\frac{1}{2}x\sin\left(\sqrt{|x|}\right)\right| - \left|y\sin\left(30\sqrt{\left|\frac{x}{y}\right|}\right)\right|$$

where $x, y \in [10, 1000] \cap \mathbb{N}$.

2 Instructions for the Genetic Algorithm

2.1 Individuals and Fitness

An individual of the evolving population must represent a solution of the optimization problem to be solved. You should code a solution as a binary sequence made up of two halves, representing x and y, respectively. Indicate the size of the search space in this case.

Propose and implement a *fitness function* suitable to minimize $f(x, y)$ where $x, y \in [10, 1000] \cap \mathbb{N}$.

2.2 Mutation

You should implement a mutation operator that with a small probability (p_m) will swap each element of an individual.

2.3 Crossover

You should use the `One Point Crossover` with a `Mid-Break` policy and a probability p_c [1].

2.4 Other parameters

You can choose a population of size 100. Additionally use the 5-tournament selection method.

[1] Crossover probability p_c can be set to 0.6 for instance.

3 Work to do

3.1 Function visualization

Visualize the function to minimize in a 3D space to get an idea on how difficult is to find its global minimum, and localize its global minimum.

3.2 Tests and evaluation

You should experiment with 2 different probabilities of mutation p_m:

- 0.01
- 0.1

and with the following crossover operators:

- without crossover
- `One Point Crossover` with a `Mid-Break` policy and a probability p_c

You should run the algorithm (in each of the above 4 cases) several times by changing the seed of a random number generator.

Report the average value of the objective function as well as the average number of generations needed to reach the optimum together with the corresponding standard deviations.

Measure and present:

1. The success rate of the algorithm after $10^3, 10^4$, and 10^5 fitness evaluations. The number of fitness evaluations can be estimated by the product of the population size with the number of generations. The success rate is the number of executions where the algorithm found the optimal solution divided by the total number of executions.

2. The cumulative empirical probability to reach the following solution qualities (optimum, relative distance to optimum = 1.0%, relative distance to optimum = 2.5%) over the number of evaluations.

4 Report

The report should contain an introduction to the genetic algorithms, as well as a description and discussion about the methodology adopted, achieved experiments, and obtained results.

5 General conditions

The submitted work should be solely of your own. Both report and code, entitled *Surname Name TP number*, have to be uploaded on Moodle (TP6).