Applied computational intelligence

Homework IV

This exercise set deals with function optimization using genetic algorithms.

The function to be optimized is the so-called "eggholder function"[1] given by equation 1.

$$f(\mathbf{x}) = -(x_2 + 47)\sin\left(\sqrt{\left|x_2 + \frac{x_1}{2} + 47\right|}\right) - x_1 \sin\left(\sqrt{\left|x_1 - (x_2 + 47)\right|}\right) \tag{1}$$

Due to the large number of local minima, the Eggholder function is a difficult function to optimize. The function is evaluated on the domain $x_i \in [-512, 512]$ for all $i = 1, 2$ and it has a global minimum located at $x^* = (512, 404.2319)$, $f(x^*) = -959.6407$.

You must

1. Plot the function in its domain.
2. Design and implement a genetic algorithm search to find the global minimum of the eggholder function over the domain $x_i \in [-512, 512]$ for all $i = 1, 2$ [You might want to use native functions available in your selected programming language].

   Explore the influence of the main parameters, such as population initialization and size, elitism, crossover, mutation and genetic selection, maximum number of generations, on the method performance.

   Plot the best and average fitness values along the iterations. Plot the genetic algorithm results on a contour plot.
3. Compare the genetic algorithm results with other optimization methods, as for instance Nelder-Mead and simulated annealing algorithms[2].

   Comment on the achieved results, is there any benefits of using genetic algorithms for finding the minimum of the eggholder function?

[1] Momin Jamil and Xin-She Yang, *A literature survey of benchmark functions for global optimization problems*, Int. Journal of Mathematical Modelling and Numerical Optimisation, Vol. 4, No. 2, pp. 150-194 (2013). Available at: `https://arxiv.org/pdf/1308.4008v1.pdf`

[2] In R, you can use the function `optim()` or `nml()` for the task.

Guidelines

You must generate a report in the format of a conference paper following the template of the IFAC (International Federation of Automatic Control) conferences. The template is attached to the homework assignment. The paper should not be longer than 6 pages and must include the following sections:

- Abstract: Here, you introduce the main objective and overview of the work [Provide a short and informative view of the paper and its scope and results].
- Introduction: Here, you provide some context and background [Briefly, explore the literature in order to define how and why genetic algorithms have been used to optimize complex functions. Explain the benefits, if any, of such methods compared with other optimization techniques. Provide references].
- Methods: Here, you explain the genetic algorithms and the function to be optimized [Explain the challenges of optimizing of the eggholder function. Describe the main features of the method. Explain it using, for instance, a pseudo-code of the algorithm. Describe the main parameters and their influence and importance. Explain how it can be implemented in your selected programming language]
- Results: Here, you explain the optimization results [Describe the code you used for solving the problem. Comment on the results achieved with the genetic algorithms in comparison with other optimization methods]
- Reference: Here, you provide bibliographic references [Report the books and/or articles that you used for studying the methods. Note that each reference reported in this section must be cited in the main text].

Together with the report, you must provide the code you developed to perform the task. Regardless of your choice of programming, your code must be executable/functioning. The code (and the relevant functions, if needed) can be either pasted in the report (for instance, as an appendix) or packaged together with the report as a zip file.

Note that, Homework IV is not compulsory but its final mark might substitute your lowest grade among the other homework assignments (HW1, HW2 and HW3).

The report must be submitted by **December 11, 2017**. No submission will be accepted after the deadline.