Benchmark Optimization Functions Using Genetic Algorithms

Student Assignment

Objective

The purpose of this assignment is to explore benchmark optimization functions and apply Genetic Algorithms (GAs) for finding their minima. You will select and implement two multimodal functions in Python, optimize them using a configurable GA, and conduct a statistical performance analysis of different GA configurations.

Instructions

1. **Function Selection**
   - Select **two multimodal functions** from the bibliographic reference [1]—focus on 2-dimensional functions from the first set of optimization functions.
   - Clearly state the domain and the functional form:

$$f_1 : [a_1, b_1] \times [c_1, d_1] \longrightarrow \mathbb{R}, \quad f_1(x, y) = \dots$$

$$f_2 : [a_2, b_2] \times [c_2, d_2] \longrightarrow \mathbb{R}, \quad f_2(x, y) = \dots$$

2. **Function Implementation and Visualization**
   - Implement both functions in Python.
   - Represent each function visually using 2D contour plots and 3D surface plots.
3. **Genetic Algorithm (GA) Optimization**
   - Implement a Genetic Algorithm capable of:
     - **Two representations:** binary encoding and real-valued encoding.
     - **Two crossover types** per representation:
       - Binary: 1-point, 2-point crossover.
       - Real-valued: arithmetic crossover, BLX-α crossover.
     - Adjustable parameters: mutation rate, crossover rate, population size, number of generations.
4. **Optimization Experiments**
   - Run experiments for both f_1 and f_2 using all combinations of representations and crossover methods.

- Ensure a fixed number of fitness function evaluations across configurations.
- For each configuration, conduct at least **30 independent runs**.

5. **Statistical Analysis**
   - Collect performance metrics: best fitness, mean, standard deviation.
   - Use appropriate statistical tests (e.g., t-test, Wilcoxon, ANOVA) to determine if performance differences are statistically significant.
   - Present your findings in tables and graphs.

Deliverables

- Python codebase with modular structure and documentation.
- A written report (`.pdf`) including:
  - Description of the selected functions and their plots.
  - Explanation of GA configurations.
  - Tables and plots of experimental results.
  - Statistical comparison and conclusions.
- (Optional) Jupyter notebook or GUI application.

Deadline

Last laboratory of the semester!

Evaluation Criteria

Criterion	Weight
Correct implementation of functions	15%
GA flexibility (representation and crossover options)	20%
Code structure and documentation	10%
Visual representation of functions	10%
Experimental execution and data analysis	25%
Statistical test and result interpretation	20%

Note: Academic honesty is expected. Cite any code or libraries used.

Bibliographic Reference

1. Surjanovic, S. & Bingham, D. (2013). Virtual Library of Simulation Experiments: Test Functions and Datasets. Retrieved May 13, 2025, from http://www.sfu.ca/ ssurjano.