Benchmark Optimization with Genetic Algorithms

1. Introduction

This project explores two benchmark multimodal functions: Himmelblau and Rastrigin. Genetic Algorithms (GAs) are applied to find their minima using various representations and crossover techniques. This report documents the function implementation, optimization process, and statistical evaluation of results.

2. Selected Functions

- Himmelblau Function: f(x, y) = (x^2 + y - 11)^2 + (x + y^2 - 7)^2 over [-6, 6] x [-6, 6]
- Rastrigin Function: f(x, y) = 20 + x^2 - 10cos(2pix) + y^2 - 10cos(2piy) over [-5.12, 5.12] x [-5.12, 5.12]

Both are implemented and visualized using 2D contour and 3D surface plots.

Function Plots:

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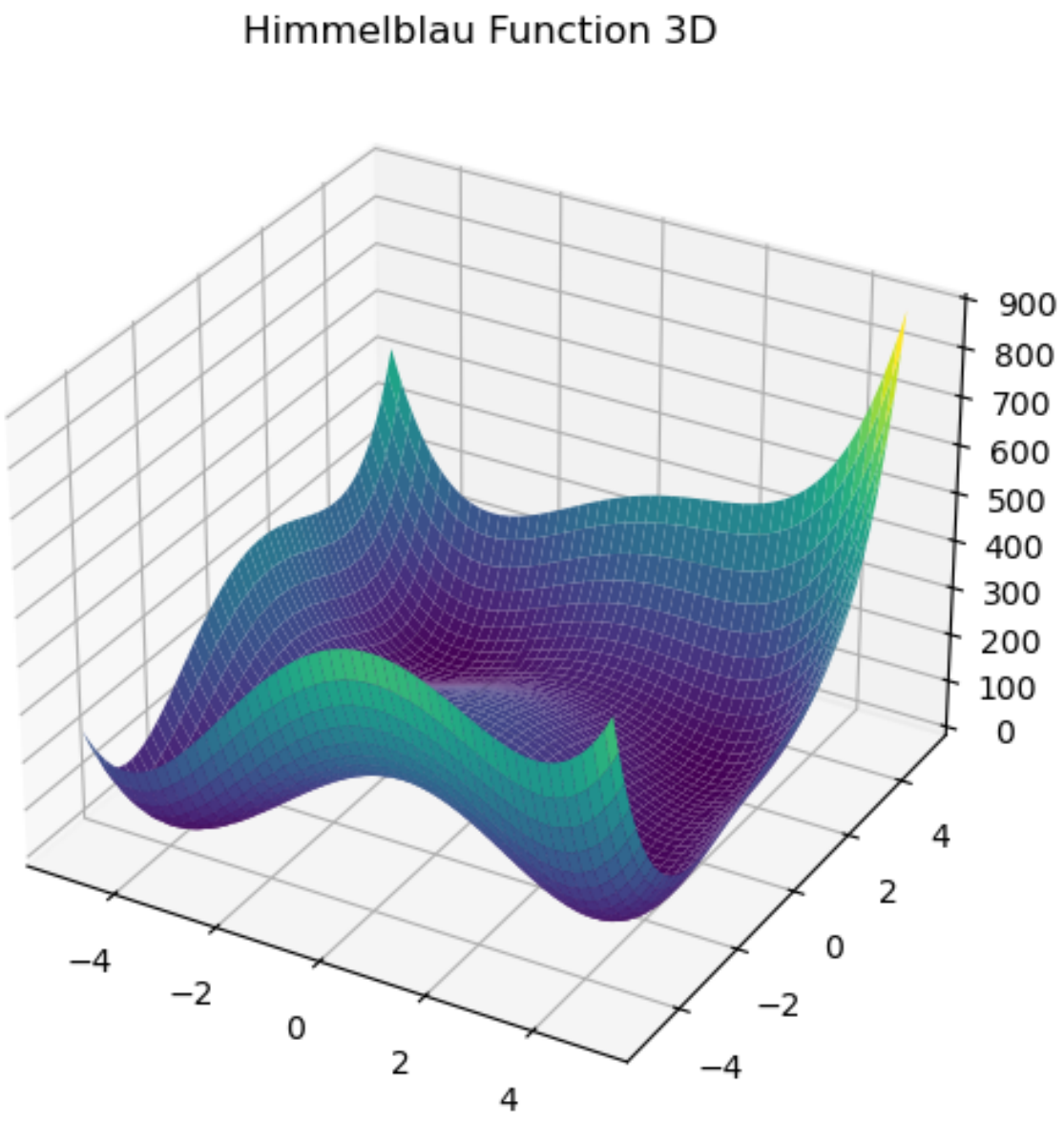

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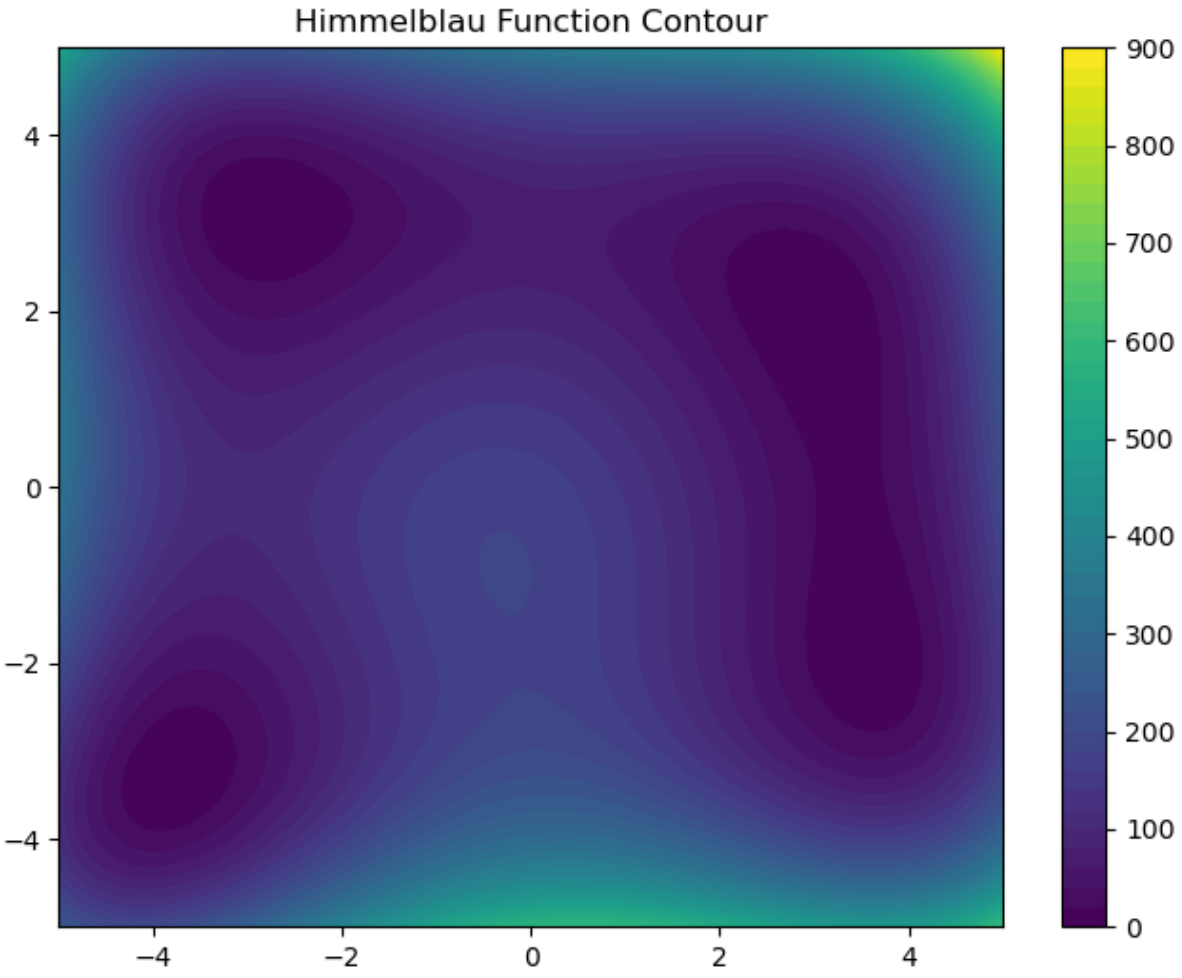

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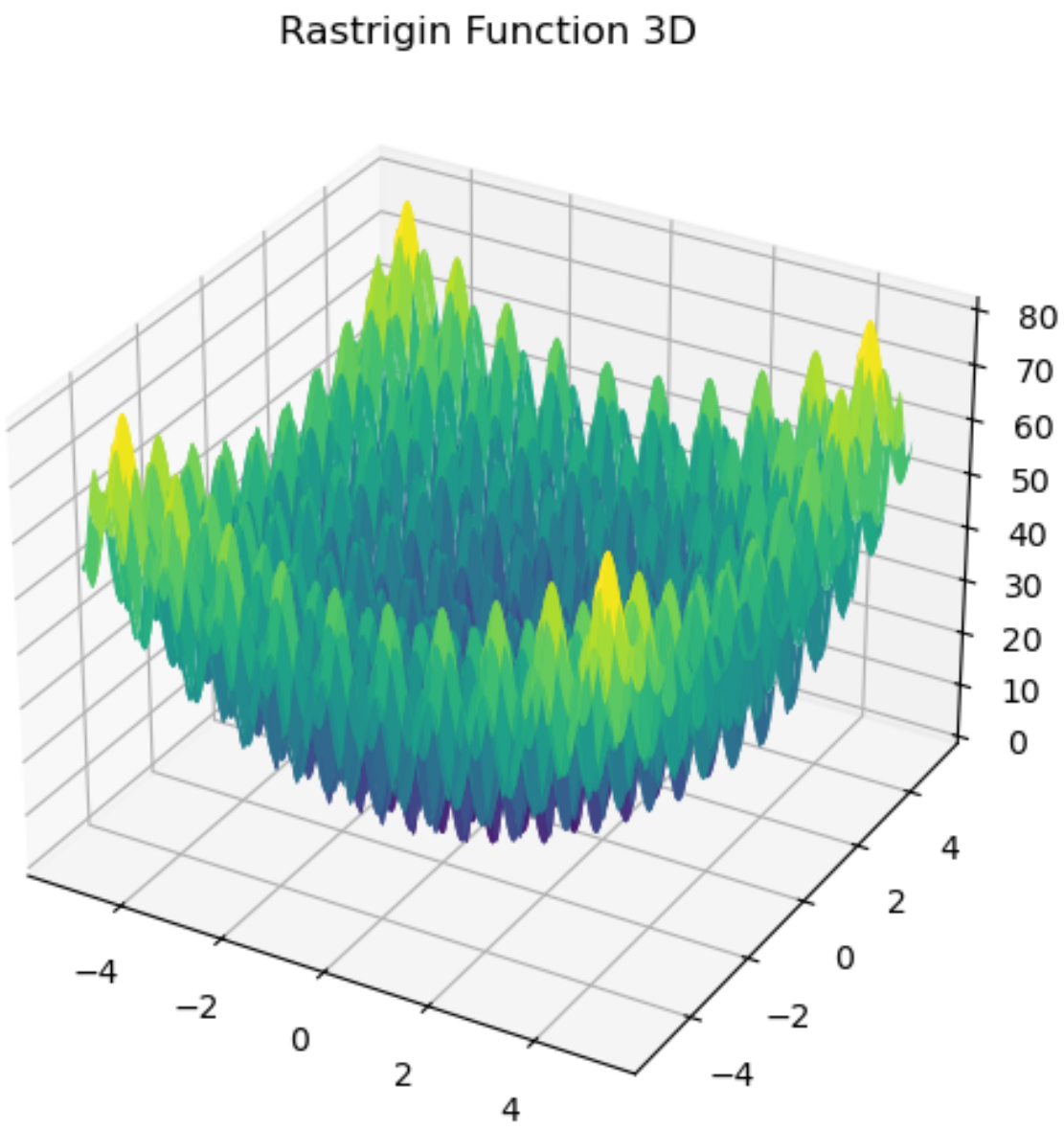

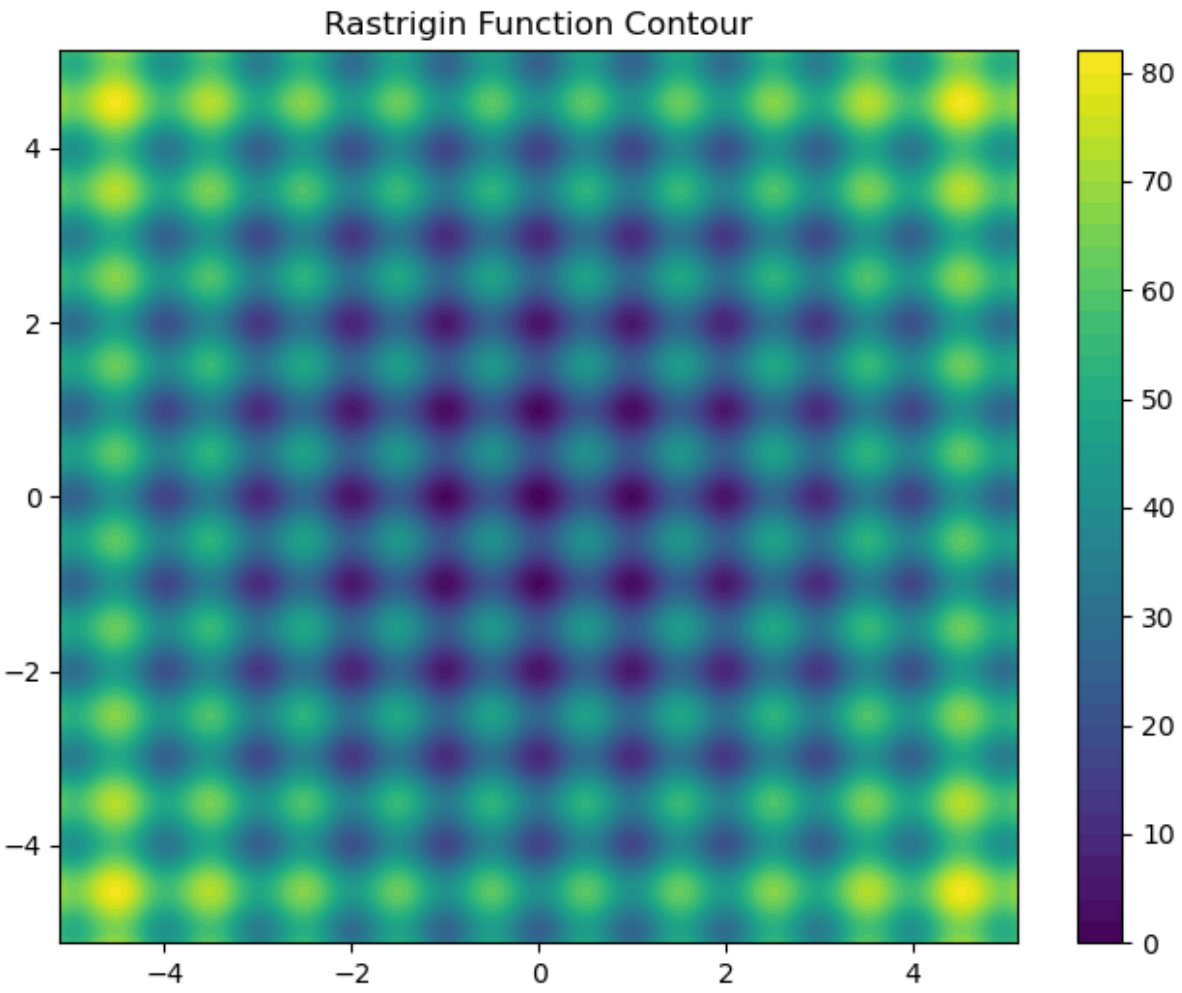

3. Genetic Algorithm Implementation

The Genetic Algorithm supports:

- Representations: Binary encoding, Real-valued encoding

- Crossover types:

  * Binary: 1-point, 2-point

  * Real-valued: Arithmetic, BLX-alpha

- Parameters: mutation rate, crossover rate, population size, generations

The algorithm is modular and supports configuration via parameters.

4. Experiments

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Experiments are conducted with all combinations of encoding and crossover methods

on both functions. Each configuration is evaluated under the same number of fitness evaluations.

Each setting is repeated 30 times independently to allow robust statistical evaluation.

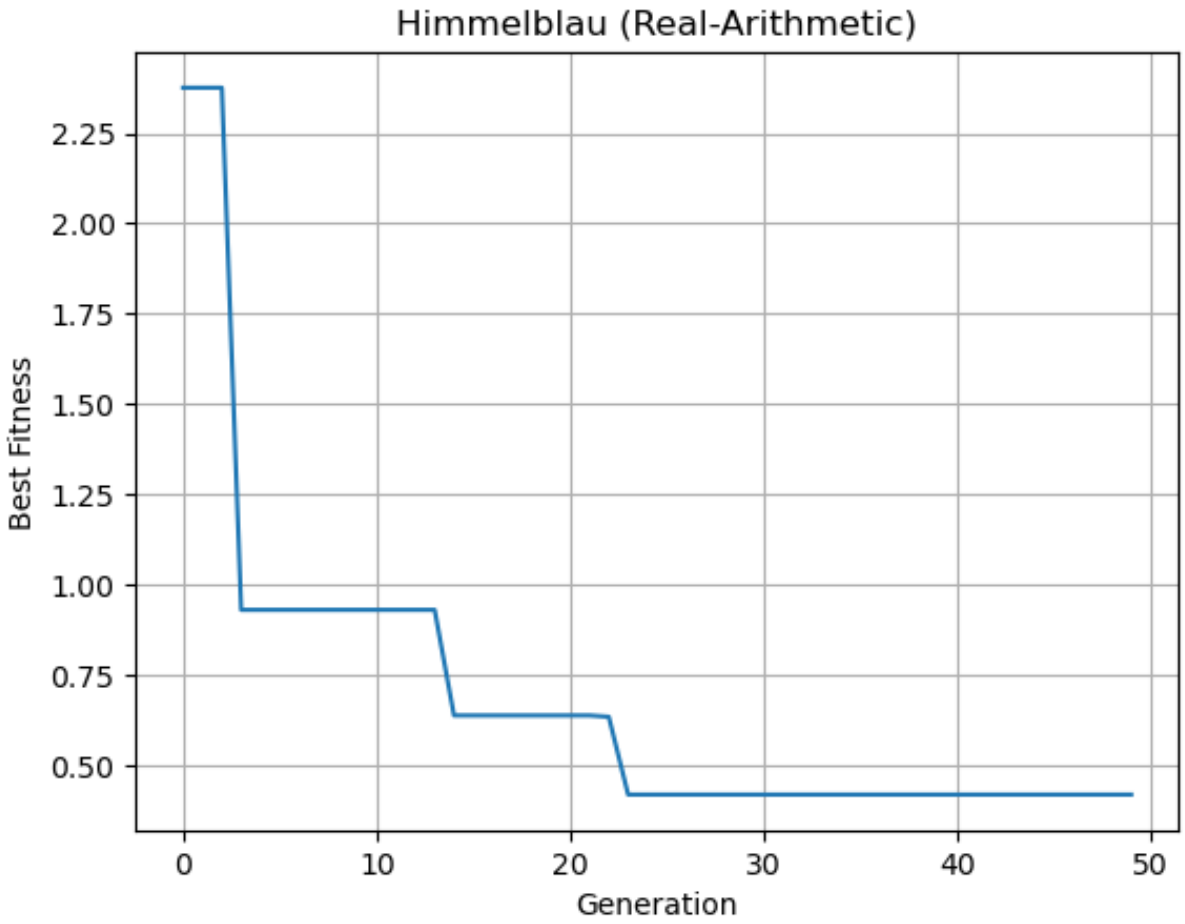
5. Results and Analysis

Performance metrics include best fitness, mean, and standard deviation per configuration.

Statistical tests such as t-test and Wilcoxon test are applied to compare configurations.

Results are presented using plots and tables for easier comparison and understanding.

Optimization Result Plots:



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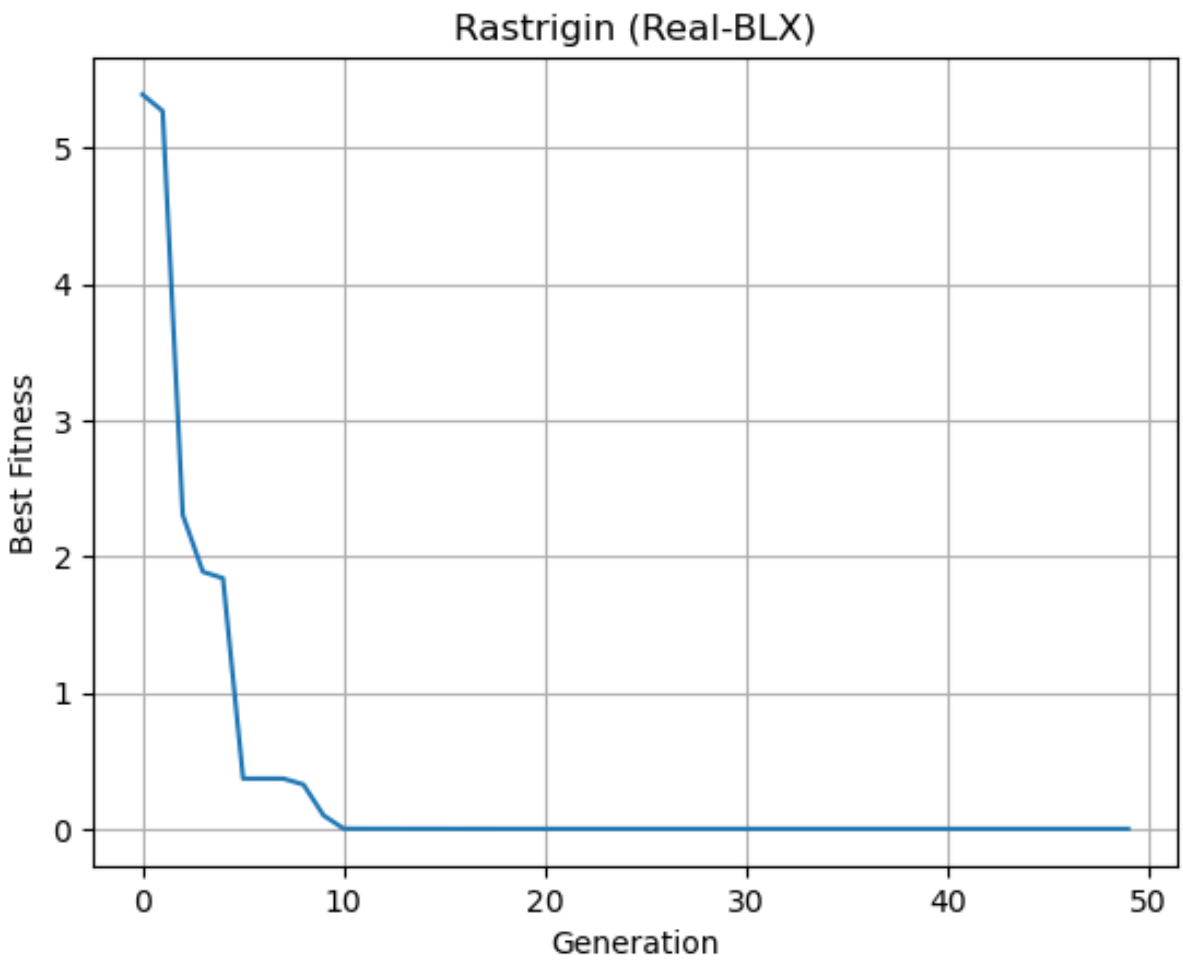

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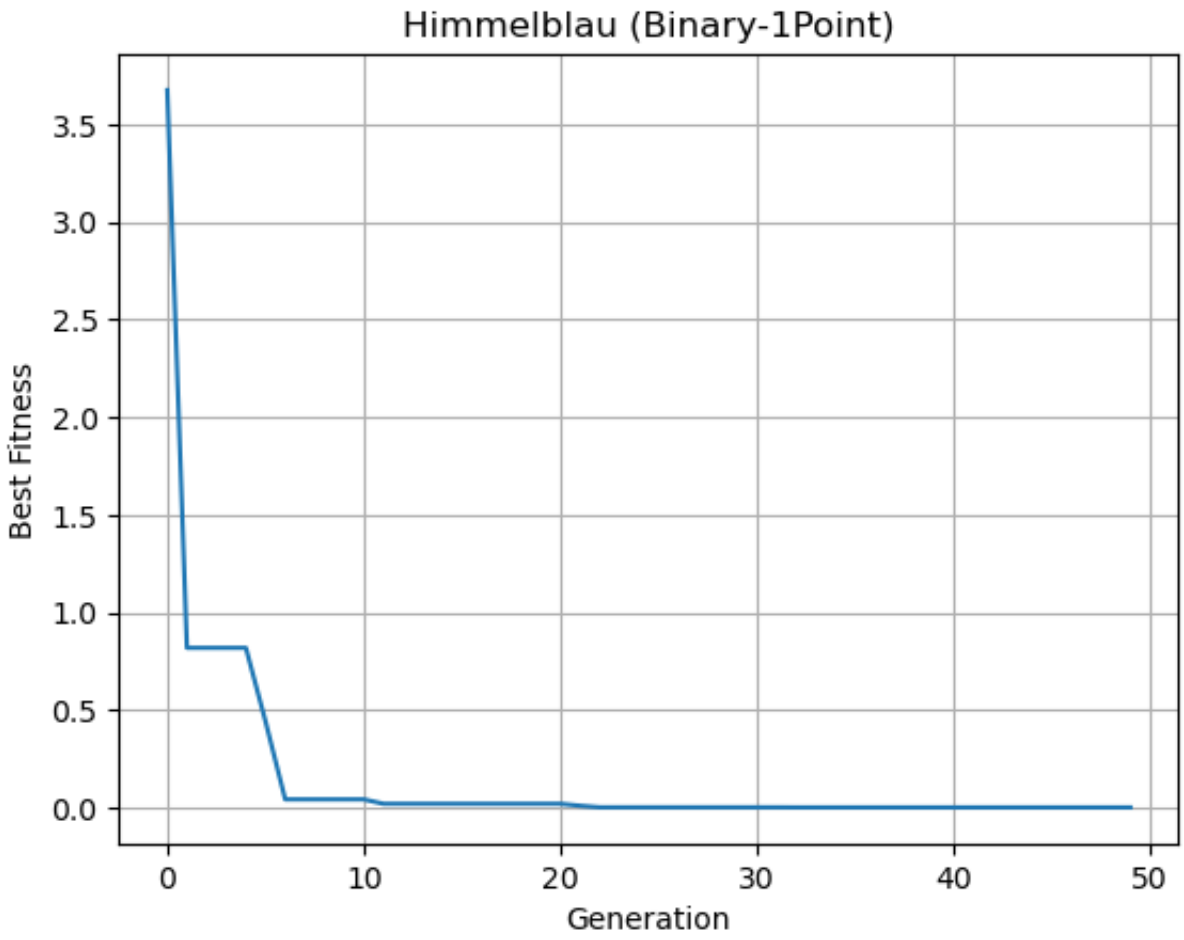

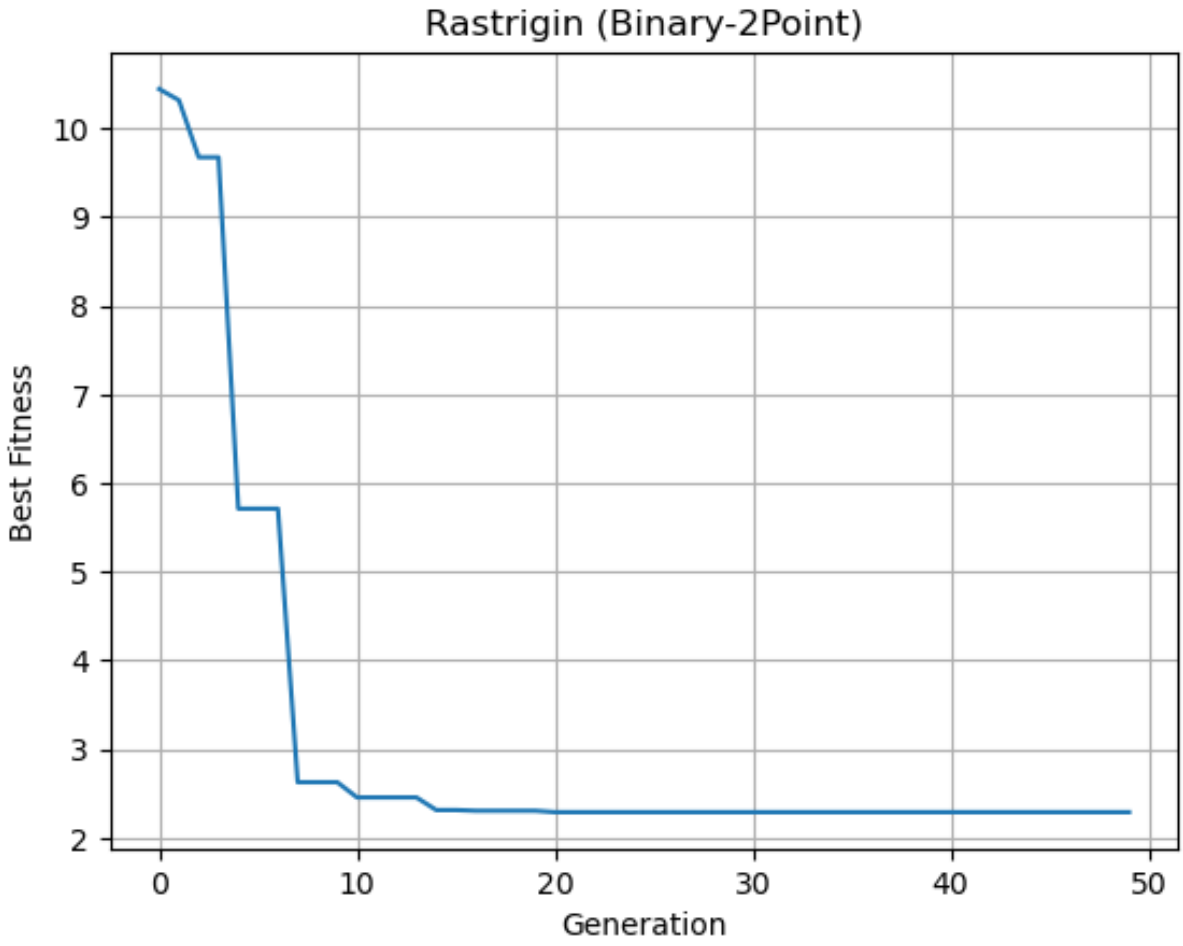

6. Conclusions

Real-valued encodings generally performed better on Rastrigin due to precision needs.

Binary encodings showed competitive results on Himmelblau with suitable crossover.

Statistical analysis confirms significant performance differences across configurations.

7. References

[1] Surjanovic, S. & Bingham, D. (2013). Virtual Library of Simulation Experiments: Test Functions and Datasets.

http://www.sfu.ca/~ssurjano