

# CS471 Project2

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February 6, 2026

## 1 INTRODUCTION

This report contains the results of running 30 iterations of Blind Search and Repeated Local Search on 10 different fitness functions. The description of the benchmark functions are listed in Section 2. Condensed Results and statistical analysis are in Section 3. Tabulated results for Blind Search can be found in Table 3.1. Tabulated results for Repeated Local Search can be found in Table 3.2.

## 2 BENCHMARK FUNCTION DESCRIPTION AND FULL RESULTS

Each of the following functions were evaluated 30 times using Blind Search and Repeated Local Search. The Blind Search generates 30 random and evaluates them using the below list fitness functions. The Repeated Local Search uses the best randomly generated vector from a population of 30 and runs local search on that vector to find a local minima for each iteration. The Experiment specifications can be found in Table 2.1. The results can be seen in Section 3.

### 2.1 BENCHMARKING FUNCTIONS

1. Schwefel's function

$$f_1(x) = 418.9829 * n - \sum_{i=1}^n -x_i \cdot \sin(\sqrt{|x_i|}) \quad (2.1)$$

2. 1st De Jong's function:

$$f_2(x) = \sum_{i=1}^n x_i^2 \quad (2.2)$$

3. Rosenbrock:

$$f_3(x) = \sum_{i=1}^{n-1} 100(x_i^2 - x_{i+1})^2 \quad (2.3)$$

4. Rastrigin:

$$f_4 = 10 * n \sum_{i=1}^n (x_i^2 - 10 \cdot \cos(2\pi \cdot x_i)) \quad (2.4)$$

5. Griewangk:

$$f_5 = 1 + \sum_{i=1}^n \frac{x_i^2}{4000} - \prod_{i=1}^n \cos\left(\frac{x_i}{\sqrt{i}}\right) \quad (2.5)$$

6. Sine Envelope Sine Wave:

$$f_6 = - \sum_{i=1}^{n-1} 0.5 + \frac{\sin(x_i^2 + x_{i+1}^2 - 0.5)}{(1 + 0.001(x_i^2 + x_{i+1}^2))^2} \quad (2.6)$$

7. Stretched V Sine Wave:

$$f_7 = \sum_{i=1}^{n-1} \left( \sqrt[4]{x_i^2 + x_{i+1}^2} \cdot \sin\left(50 \sqrt[10]{x_i^2 + x_{i+1}^2}\right)^2 + 1 \right) \quad (2.7)$$

8. Ackley's One:

$$f_8 = \sum_{i=1}^{n-1} \frac{1}{e^{0.2}} \sqrt{x_i^2 + x_{i+1}^2} + (\cos(2x_i) + \sin(2x_{i+1})) \quad (2.8)$$

9. Ackley's Two:

$$f_9 = \sum_{i=1}^{n-1} 20 + e - \frac{20}{e^{0.2 \sqrt{\frac{x_i^2 + x_{i+1}^2}{2}}}} - e^{0.5(\cos(2\pi \cdot x_i) + \cos(2\pi \cdot x_{i+1}))} \quad (2.9)$$

10. Egg Holder:

$$f_{10} = \sum_{i=1}^{n-1} -x_i \cdot \sin\left(\sqrt{|x_i - x_{i+1} + 47|}\right) - (x_{i+1} + 47) \cdot \sin\left(\sqrt{\left|x_{i+1} + 46 \frac{x_i}{2}\right|}\right) \quad (2.10)$$

Table 2.1: Experiment Specifications

	Name	Dimensions	Range	Step Size
$f_1$	Schwefel	30	$[-512, 512]^n$	0.512
$f_2$	De Jong 1	30	$[-100, 100]^n$	0.1
$f_3$	Rosenbrock's Saddle	30	$[-100, 100]^n$	0.1
$f_4$	Rastrigin	30	$[-30, 30]^n$	0.03
$f_5$	Griewangk	30	$[-500, 500]^n$	0.5
$f_6$	Sine Envelope Sine Wave	30	$[-30, 30]^n$	0.03
$f_7$	Stretch V Sine Wave	30	$[-30, 30]^n$	0.03
$f_8$	Ackley One	30	$[-32, 32]^n$	0.032
$f_9$	Ackley Two	30	$[-32, 32]^n$	0.032
$f_{10}$	Egg Holder	30	$[-500, 500]^n$	0.5

## 2.2 EXPERIMENT SPECIFICATIONS

Specifications for each experiment specifies which function to evaluate fitness with, how many dimensions to evaluate on, the Domain of the search space can be seen in Table 2.1, and the step size used in local search for each function (0.05% of the functions domain range).

## 3 STATISTICAL ANALYSIS

Comparing the results of Blind Search and Repeated Local Search(RLS) we can see all functions, except Rosenbrock's Saddle, has a lower minimum fitness value found with RLS. The average and median of solution vectors for all functions were lower using RLS. The range and standard of solution vectors for all functions, except Ackley Two and Egg Holder, were lower using RLS. Execution time increased for all functions with RLS; however the increased execution time for Rosenbrock's saddle, Rastrigin, and Sine Envelope Sine Wave is minimal and likely only from the repeated selection of best solution starting vectors for each iteration of RLS showing that they ran minimal rounds of Local Search each iteration. The De Jong 1 function and Griewangk function results were much better using RLS; however Griewangk's execution time was much greater than De Jong 1, this is expected as De Jong 1 doesn't have any local minima apart from its global minima. The increase of range and standard deviation with decrease in average and median from Blind Search to RLS for Ackley Two and Egg Holder solution vectors show that with RLS local minima were found but these local minima were not the same and their fitness varied more than random selection for the whole function.

Overall, Repeated Local Search found lower fitness values on average than Blind Search. Some functions performed very well with Repeated Local Search, however some functions only slightly increased and this is likely only from repeated selection of best solution vectors.

Table 3.1: Results from 30 Iterations of Blind Search

Problem	Min. Fitness	Avg	Median	Range	SD	T(s)
$f_1$	10644.92	12595.95	12734.45	4588.16	947.44	0.093
$f_2$	70516.30	100745.41	100965.89	57686.28	15720.63	0.0079
$f_3$	30535673856.0	618927190069.87	59273242624.87	72944695296.00	17852542746.91	0.0079
$f_4$	1770362.75	2612840.58	2687280.38	1892502.50	463796.24	0.0081
$f_5$	395.16	603.49	612.24	442.63	91.58	0.0079
$f_6$	-2.07	-0.09	-0.15	4.00	1.02	0.0078
$f_7$	78.49	96.51	96.47	35.21	9.43	0.0084
$f_8$	491.75	588.39	595.04	228.66	55.27	0.0079
$f_9$	551.12	580.74	582.46	55.55	14.12	0.0088
$f_{10}$	-2887.62	-586.49	-560.49	6569.74	1387.01	0.0081
Mean	3053752400.70	6189544653.44	5927604492.99	7294665740.87	1785302476.97	0.0082

<sup>†</sup> Run on Intel Core i5 2.9 GHz, 16 GB RAM

Table 3.2: Results from 30 Iterations of Repeated Local Search

Problem	Min. Fitness	Avg	Median	Range	SD	T(s)
$f_1$	3704.14	5166.65	5165.80	2583.31	614.82	0.2511
$f_2$	0.06	0.07	0.07	0.02	0.01	0.1190
$f_3$	36707037184.00	60536886067.20	61749622784.00	4217380928.00	9970739419.40	0.0179
$f_4$	1035964.94	1564854.99	1572250.69	1070962.56	225872.46	0.0213
$f_5$	0.12	0.13	0.13	0.02	0.01	66.9404
$f_6$	-2.59	-1.77	-1.71	1.56	0.49	0.0231
$f_7$	29.47	33.18	32.05	14.69	3.34	60.7543
$f_8$	270.10	348.58	350.85	142.17	31.72	1.4111
$f_9$	462.70	499.33	499.04	61.73	13.44	1.1468
$f_{10}$	-12946.81	-9261.85	-9889.17	8456.50	2539.99	0.3029
Mean	3670806466.61	6053844770.65	6175119119.17	4217490315.06	997096849.57	13.0988

<sup>†</sup> Run on Intel Core i5 2.9 GHz, 16 GB RAM