CS 471 Optimization - Project 2 Search Algorithms Report

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Abstract

Project 2 - Search Algorithms
Implement three search algorithms and use them on 10, 20, and 30 dimensional matrices. Compare the results of the search algorithms to the results from the random search in Project 1 - Benchmark Functions.

1 INTRODUCTION

For this project, three different search algorithms were implemented:
Blind Search, Local Search, Iterative Local Search.

Blind Search creates a random matrix using Mersenne Twister, calculates the fitness of each vector in the matrix, then takes the best fitness of that random matrix and compares it with the current best fitness that was previously found. If the new best fitness is better than the current best fitness, then the current best fitness is set to equal the new best fitness. This process is repeated *n iterations*.

Local Search creates a neighborhood of the current best fitness, using its solution and an alpha (α) value to mutate the solution.

$$neighborhood = \textbf{Current Best Solution} - \alpha * (\textbf{Current Best Fitness} - \textbf{New Fitness}) \quad (1.1)$$

This neighborhood is basically a new fitness that is compared to the current best fitness. If the new fitness is better than the current one, then the current best fitness is set equal to the new fitness and the local search restarts with the new fitness as its current best fitness. This continues until there is no more improvement in the current best fitness value.

Iterative Local Search is a Local Search that is repeated *n iterations*.

2 RESULTS

Although the tests were run on 10, 20, and 30 dimensional matrices for all search algorithms, for the sake of conserving space, only the 30 dimensional results are displayed below. The condensed results compared with the Benchmark Function results of Project 1 are at the very bottom of this section.

NOTE: In the table with the condensed results for 30 dimensions, the **Random** column of the table is the results from the Benchmark Functions of Project 1.

2.1 PROJECT 1 RESULTS - BENCHMARK FUNCTIONS

Table 2.1: Benchmark Function Results For 30 Dimensions

| Function | Avg | Standard Deviation | Range | | | Time (ms) |
			min	max	Median	
f_1	12341.51253	1163.706533	9488.994455	14314.44162	12353.64762	0
f_2	97272.37025	17587.38505	55290.9461	144455.4467	95693.21811	0
f_3	56104940369	15774691933	18498949499	1.02666E+11	53948030873	0
f_4	2624959.567	474300.5092	1492931.726	3911412.631	2560622.378	0
f_5	608.952314	109.921157	346.568413	903.846542	599.082613	0
f_6	-21.643653	1.009399	-24.170858	-19.260947	-21.691177	0
f_7	97.600163	10.073003	82.643394	123.131066	96.136725	0
f_8	568.988126	57.957783	431.531398	700.412233	571.63489	0
f_9	580.976915	13.889007	553.16074	602.776856	581.733018	0
f_{10}	-70.764505	1638.83821	-5692.138908	3205.165381	-46.096442	0
f_{11}	-42.893265	957.655211	-1908.735733	2140.643868	-92.70854	0
f_{12}	14.559129	0.431507	13.496964	15.52134	14.498783	0
f_{13}	-3.620196	1.308802	-5.449459	-0.957366	-3.547914	0
f_{14}	0.058524	0.265334	-0.671123	0.839229	0.002129	0
f_{15}	9139560991	2825705101	3174963563	15653326026	9006390166	0
f_{16}	2336.553678	1548.313724	252.266239	5650.821146	2349.026205	0
f_{17}	98748.338	17742.52334	56409.35044	146297.8465	97204.82832	0
f_{18}	973.215248	151.672617	643.945866	1224.039223	978.8405448	0

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2.2 Project 2 Results - Search Algorithms

Table 2.2: Blind Search Results For 30 Dimensions

Function	Blind Search					
	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	9488.994455	9488.994455	9488.994455	9488.994455	9488.994455	14
f_2	55290.9461	55290.9461	55290.9461	55290.9461	55290.9461	6
f_3	18498949499	18498949499	18498949499	18498949499	18498949499	9
f_4	1492931.726	1492931.726	1492931.726	1492931.726	1492931.726	7
f_5	346.568413	346.568413	346.568413	346.568413	346.568413	11
f_6	-24.170858	-24.170858	-24.170858	-24.170858	-24.170858	14
f_7	73.711015	73.711015	73.711015	73.711015	73.711015	14
f_8	406.06958	406.06958	406.06958	406.06958	406.06958	17
f_9	521.756653	521.756653	521.756653	521.756653	521.756653	19
f_{10}	-5692.138908	-5692.138908	-5692.138908	-5692.138908	-5692.138908	22
f_{11}	-2251.918579	-2251.918579	-2251.918579	-2251.918579	-2251.918579	31
f_{12}	13.496964	13.496964	13.496964	13.496964	13.496964	18
f_{13}	-6.240367	-6.240367	-6.240367	-6.240367	-6.240367	8
f_{14}	-0.671123	-0.671123	-0.671123	-0.671123	-0.671123	16
f_{15}	3174963563	3174963563	3174963563	3174963563	3174963563	6
f_{16}	252.266239	252.266239	252.266239	252.266239	252.266239	10
f_{17}	56409.35044	56409.35044	56409.35044	56409.35044	56409.35044	5
f_{18}	586.993775	586.993775	586.993775	586.993775	586.993775	6

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Table 2.3: Local Search Results For 30 Dimensions

Function		Local Search				
	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	4086.503592	4086.503592	4086.503592	4086.503592	4086.503592	1102
f_2	0.090351	0.090351	0.090351	0.090351	0.090351	18
f_3	18498949499	18498949499	18498949499	18498949499	18498949499	0
f_4	1492931.726	1492931.726	1492931.726	1492931.726	1492931.726	0
f_5	0.006048	0.006048	0.006048	0.006048	0.006048	131753
f_6	-24.170858	-24.170858	-24.170858	-24.170858	-24.170858	0
f_7	30.537529	30.537529	30.537529	30.537529	30.537529	152
f_8	310.846595	310.846595	310.846595	310.846595	310.846595	26
f_9	513.733889	513.733889	513.733889	513.733889	513.733889	3
f_{10}	-11988.54295	-11988.54295	-11988.54295	-11988.54295	-11988.54295	9127
f_{11}	-6904.512764	-6904.512764	-6904.512764	-6904.512764	-6904.512764	113
f_{12}	13.496964	13.496964	13.496964	13.496964	13.496964	0
f_{13}	-5.449459	-5.449459	-5.449459	-5.449459	-5.449459	0
f_{14}	-0.738092	-0.738092	-0.738092	-0.738092	-0.738092	3
f_{15}	3174963563	3174963563	3174963563	3174963563	3174963563	0
f_{16}	252.266239	252.266239	252.266239	252.266239	252.266239	0
f_{17}	9.191098	9.191098	9.191098	9.191098	9.191098	9
f_{18}	299.72335	299.72335	299.72335	299.72335	299.72335	0

Table 2.4: Iterative Local Search Results For 30 Dimensions

Function		Iterative Local Search				
	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	9337.349073	84.125385	9197.251136	9479.09588	9341.754098	9
f_2	28260.76057	11777.57981	12712.32857	52647.0273	26512.24023	3
f_3	18498949499	0.000011	18498949499	18498949499	18498949499	3
f_4	1492931.726	0	1492931.726	1492931.726	1492931.726	2
f_5	346.503608	0.036186	346.442992	346.564232	346.505697	9
f_6	-24.170858	0	-24.170858	-24.170858	-24.170858	8
f_7	51.519537	10.60859	39.777793	78.742264	48.355679	19
f_8	340.806305	28.939112	315.012971	418.031374	326.293183	15
f_9	517.298308	7.657417	513.733889	545.418072	513.733889	12
f_{10}	-6843.249301	565.485189	-7647.739102	-5776.801369	-6892.789344	21
f_{11}	-3233.456149	726.729675	-4188.64511	-1972.512458	-3440.899164	41
f_{12}	13.496964	0	13.496964	13.496964	13.496964	9
f_{13}	-5.449459	0	-5.449459	-5.449459	-5.449459	3
f_{14}	-0.732712	0.011912	-0.738092	-0.688045	-0.738092	10
f_{15}	3174963563	0.000001	3174963563	3174963563	3174963563	1
f_{16}	252.266239	0	252.266239	252.266239	252.266239	5
f_{17}	28832.51832	12015.7189	12969.78977	53711.95067	27048.62327	2
f_{18}	319.893563	54.598899	299.72335	547.433914	299.72335	1

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2.3 PROJECT 2 CONDENSED RESULTS COMPARED TO PROJECT 1

Table 2.5: Project 1 vs Project 2 Results For 30 Dimensions

Function	Global Fitness	Random		Blind Search		Local Search		Iterative Local Search	
		Average	Time (ms)	Average	Time (ms)	Average	Time (ms)	Average	Time (ms)
f_1	0	12341.51253	0	9488.994455	14	4086.503592	1102	9337.349073	9
f_2	0	97272.37025	0	55290.9461	6	0.090351	18	28260.76057	3
f_3	0	56104940369	0	18498949499	9	18498949499	0	18498949499	3
f_4	0	2624959.567	0	1492931.726	7	1492931.726	0	1492931.726	2
f_5	0	608.952314	0	346.568413	11	0.006048	131753	346.503608	9
f_6	-43.2535	-21.643653	0	-24.170858	14	-24.170858	0	-24.170858	8
f_7	0	97.600163	0	73.711015	14	30.537529	152	51.519537	19
f_8	-86.34685	568.988126	0	406.06958	17	310.846595	26	340.806305	15
f_9	0	580.976915	0	521.756653	19	513.733889	3	517.298308	12
f_{10}	-	-70.764505	0	-5692.138908	22	-11988.54295	9127	-6843.249301	21
f_{11}	-	-42.893265	0	-2251.918579	31	-6904.512764	113	-3233.456149	41
f_{12}	-	14.559129	0	13.496964	18	13.496964	0	13.496964	9
f_{13}	28.98	-3.620196	0	-6.240367	8	-5.449459	0	-5.449459	3
f_{14}	-29	0.058524	0	-0.671123	16	-0.738092	3	-0.732712	10
f_{15}	0	9139560991	0	3174963563	6	3174963563	0	3174963563	1
f_{16}	0	2336.553678	0	252.266239	10	252.266239	0	252.266239	5
f_{17}	0	98748.338	0	56409.35044	5	9.191098	9	28832.51832	2
f_{18}	0	973.215248	0	586.993775	6	299.72335	0	319.893563	1

[1] n = number of dimensions
[2] f_6 Global Fitness = $-1.4915(n-1)$
[3] f_8 Global Fitness = $-7.54276 - 2.91867(n-3)$
[4] f_{13} Global Fitness = $0.966n$
[5] f_{14} Global Fitness = $1-n$

3 ANALYSIS

Comparing the results from project 1, it is clear that for functions f_2, f_5, and f_{17} the results of the search algorithms were far better than the results of project 1. From among the search algorithm results, the Local Search outperformed the other algorithms for the functions listed above. Although the Local Search outperformed the other algorithms in finding the best results, it was considerably slower than the rest, especially for function f_5.

The worst of the results I have found to be from those functions that did not show any improvement from the search algorithms: f_3, f_4, f_6, f_{15}, and f_{16}. For whatever reason, all three search algorithms produced the exact same result for each of the functions, individually. My best guess is that this is due to both the number of max iterations that the algorithms could run and the alpha (α) mutation value. Altering these two values could produce a better result than the one that was achieved.

Out of all the functions, f_5 and f_{10} were the two most slowest functions for the Local Search.

4 LIST OF FUNCTIONS

1 f_1 is Schwefel's Function

2 f_2 is 1st De Jong's Function

3 f_3 is Rosenbrock

4 f_4 is Rastrigin

5 f_5 is Griewangk

6 f_6 is Sine Envelope Sine Wave

7 f_7 is Stretched V Sine Wave

8 f_8 is Ackley's One

9 f_9 is Ackley's Two

10 f_{10} is Egg Holder

11 f_{11} is Rana

12 f_{12} is Pathological

13 f_{13} is Michalewicz

14 f_{14} is Masters Cosine Wave

15 f_{15} is Quartic

16 f_{16} is Levy

17 f_{17} is Step

18 f_{18} is Alpine