CENTRAL WASHINGTON UNIVERSITY OF THE COMPUTER SCIENCE DEPARTMENT

Project 3

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1 INTRODUCTION

For this lab we took our 15 optimization functions and ran them through 3 new methods of determining the global minimum. The functions being: Differential evolution (DE) which uses a population approach with strategies for computing new solutions, Genetic evolution (GE) which takes a genetic approach with genes, crossover and mutation, and Particle swarm (PS) which simulates swarm movement to find the global minimum.

2 METHODS

Our rewrite in the previous lab allowed us to just extend three more classes from the search function class we had implemented. These extended classes were then called with a python script and the output printed to the console where I was able to analyze the data. Each test was ran 15 times using the python script and the data stored to a file.

Upon referencing multiple online sources, we also decided to use a different method of initializing particle velocity vectors and velocity maximums. Settling with velocityMaxium = 4.0, and the initial velocities being created between velocityMaxium \3, and -velocityMaximum \3. These values seemed to produce accurate results.

3 ANALYSIS

This lab produced some interesting results regarding the performance of the new functions. Overall, the three new functions (PS, GE, DE) were more efficient and accurate than the previous 3 functions (Random Walk, Local Search, Iterative Local Search), but there were some

discrepancies with some functions. These discrepancies showed themselves as completely inaccurate results on some functions, while the method would then produce extremely accurate results on other functions. For example, GE produced a 23185.53 average for DeJong, the actual minimum being 0. Yet for the Michalewicz function GE produced an average that was much more competitive to the the other functions.

Another interesting point on the performance of these functions can be seen when comparing them to the values received from the previous search functions we used. Rosenbrocks saddle is a great example of the performance difference, where Iterative Local Search's best value was in the range of 2.51E+10. DE on the other hand was able to produce a minimum value of 19 and PS a value of 37, massive increases in accuracy. Interestingly enough, for rosenbrocks saddle GE produced a value similar to Iterative local search, a minimum of 3.21E+09.

More differences between the three functions can be again found with the Rastrigin function. ILS was able to produce a value of 83731.6, GE produced 65280, but PS and DE both had massively more accurate results of: PS -> -6902.05, and DE -> -8000 which we believe is the actual minimum of the Rastrigin function.

There are other examples of these new functions attaining greater accuracy than the previous functions did, but that information can easily be seen in the results table in figure 5.1. One last point we want to cover is the actual time performance of these algorithms. Previously Local Search and Iterative Local Search both took an excessive amount of time to compute on solutions with larger dimensions (20 +). Based on previous performance, it was estimated that the Griegwangk function running with 30 dimensions would run for 8 hours using Iterative Local Search. To contrast this, the complete computation time taken for the 15 functions, at 15 iterations, using all 3 search functions completed faster than one iteration of 20 dimensional Iterative Local Search with the Griewagnk function.

4 Conclusion

Coming away from this lab we saw that these new functions have the ability to not only improve the accuracy of our results, but also improve the running time of the search. With this improved running time we could run more trials and get even more accurate results than the ones that we are getting currently.

There were some difficulties and issues when running the tests for this lab. The first being our inability to completely verify our results. We mentioned some discrepancies earlier where GE produced values that were wildly inaccurate for some functions. It is unknown to us whether this is simply a product of the strengths and weaknesses of this specific search method, or if there is something wrong with out implementation. Another issue is that of the Shekels Foxholes function. For Particle Swarm and Genetic Evolution there was no deviation from the single value that they returned. Either the algorithm is able to deterministic produce the apparent global minimum, or there is something wrong with the function.

5 RESULTS

Figure 5.1: Computation comparison of DE, GA and PSO

Problem	DE					GA					PSO				
	Avg	Median	Range	SD	T(s)	Avg	Median	Range	SD	T(s)	Avg	Median	Range	SD	T(s)
f_1	-6112.33	-6084.59	114.26	47.83	1.14	-3276.12	-3292.95	943.02	245.68	2.69	-2871.98	-2904.39	1194.77	322.06	0.12
f_2	129.53	25.00	900.00	251.52	0.53	23185.53	22853.00	10310.00	3148.43	0.72	0.17	0.15	0.25	0.08	0.09
f_3	26105.67	10019.00	168100.00	43662.88	0.78	5291234666.67	5017400000.00	5739020000.00	1539343402.74	0.68	421.98	200.19	1657.68	497.31	0.10
f_4	-7600.00	-7960.00	2560.00	728.99	1.00	79752.00	81520.00	23240.00	8507.40	2.12	-5206.62	-5324.98	3479.78	1178.83	0.13
f_5	0.00	0.00	0.00	0.00	1.08	145.86	150.55	51.89	17.68	2.31	9.17	8.93	5.88	1.95	0.13
f_6	12.38	12.71	2.19	0.60	1.46	12.04	11.97	0.67	0.22	2.52	12.15	12.18	1.25	0.33	0.14
f_7	19.06	19.01	0.62	0.16	1.67	36.69	36.60	5.76	1.54	4.20	20.55	20.45	2.63	0.68	0.18
f_8	58.74	58.73	4.74	1.54	1.60	212.86	213.95	41.20	11.06	3.41	-9.92	-11.64	35.51	9.72	0.10
f_9	-83.30	-80.69	21.87	6.99	2.09	276.38	276.83	14.65	4.35	4.10	251.53	288.37	173.05	64.83	0.14
f_{10}	-4959.12	-4579.12	2896.23	966.10	3.02	-4778.37	-4822.17	978.82	327.79	4.72	-4107.05	-3830.50	2663.98	711.61	0.13
f_{11}	-8478.48	-8821.20	5161.40	1330.20	3.56	-3188.30	-3181.83	1334.30	339.30	8.34	-2899.33	-2888.72	901.67	227.81	0.21
f_{12}	0.00	0.00	0.00	0.00	1.48	8.00	8.01	0.69	0.17	2.70	7.02	7.08	1.30	0.37	0.15
f_{13}	-4.28	-4.22	2.71	0.83	3.06	-4.27	-4.22	2.30	0.57	5.54	-10.39	-9.86	4.92	1.50	0.14
f_{14}	-18.99	-19.00	0.04	0.01	1.47	-10.88	-10.53	3.70	1.00	3.65	-16.07	-16.15	5.22	1.59	0.14
f_{15}	-21.91	-23.03	8.39	2.95	6.05	-14.64	-14.64	0.00	0.00	12.55	-18.70	-18.70	0.00	0.00	0.27

[1] ThinkPad, 3.4GHz Intel Core i7 (3rd gen), 16 GB RAM

Iterative Local Search, 20 dimensions

Function	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	-4549.4	0.0605	2.51E+10	83731.6	0.651206	14.7944	21.9681	279.695	321.001	-1566.84	-5338.46	9.21621	-0.142619	-17.715	-11.8869
	-6050.16	0.0605	4.55E+10	80745.8	0.268086	16.284	19.3337	343.725	313.969	-1993.75	-4148.75	9.46446	-0.548652	-18.1772	-11.5925
	-5398.23	0.0591995	5.06E+10	82401.3	0.032413	15.3526	23.9768	296.889	321.956	-4633.19	-4848.21	9.01646	0.218791	-18.4282	-11.5925
	-5675.22	0.0605	4.42E+10	82591.3	0.00544314	14.7622	22.6234	331.276	323.228	-4014.04	-5436.05	9.26537	0.626347	-18.2969	-12.1455
	-3976.37	0.0588747	3.25E+10	82036.8	0.0128344	13.9223	25.6647	325.015	329.982	-1246.54	-4823.87	9.12409	-1.33997	-17.3054	-11.5925
	-5082.38	0.0605	2.61E+10	87382.5	0.0201434	14.3422	21.3897	396.392	326.205	-392.775	-6280.62	9.13477	-2.26781	-18.1703	-11.5925
	-5891.86	0.0605	3.85E+10	89279.1	0.684922	15.2594	23.0754	329.302	326.381	-337.14	-3871.16	9.02972	-0.0242582	-18.4513	-11.5925
	-5003.93	0.0605	3.00E+10	85879	0.0151074	14.8268	19.9157	325.527	314.19	-1212.15	-4189.52	9.17302	0.0681864	-18.2963	-11.5925
	-5418.57	0.0605	4.30E+10	82890.7	0.00544314	15.9129	20.2634	332.571	325.788	-1548.21	-5548.41	9.39065	-0.906265	-18.5396	-11.5925
	-5516.7	0.0599162	3.51E+10	82665.9	0.03008	16.1692	19.9074	388.651	327.169	923.714	-563.104	9.20288	-1.59829	-18.1054	-11.5925
	-3937.92	0.0547374	3.35E+10	86354.3	0.0153078	15.3926	19.532	312.15	322.111	-1598.94	-4648.01	8.87789	-1.49817	-17.8506	-11.5925
	-4588.88	0.0605	3.51E+10	81101.4	0.00542657	15.7841	21.7808	357.263	330.684	-1319.67	-4261.9	9.33048	-1.93719	-18.2627	-12.1791
	-5082.97	0.0559769	2.42E+10	76218.4	0.00544314	15.1429	22.4065	346.209	324.783	1500.62	-6032.9	9.18852	-1.88437	-18.2285	-11.5925
	-6070.01	0.0594556	3.21E+10	83486.2	0.0201913	14.966	19.342	393.145	324.682	-404.273	-5094.61	8.57302	0.126058	-16.446	-11.5925
	-5043.31	0.0605	1.85E+10	82935.5	0.220955	14.0295	20.2134	316.233	325.996	2079.2	-4572.43	9.70061	-1.33897	-18.2227	-11.5925
	-5161.34	0.0605	3.87E+10	85337.7	0.00541984	14.9478	19.5923	274.232	327.758	-1727.17	-4684.33	9.01989	0.290542	-18.4796	-12.1791
	-4589.3	0.060484	3.08E+10	83765.5	0.01776	14.714	20.0449	314.196	325.896	-1632.08	-5179.06	8.52944	-0.524841	-18.3505	-18.4163
	-4332.6	0.0600202	6.77E+10	81498.7	0.0153003	16.5447	20.0096	314.165	307.423	1567.7	-4461.73	9.43874	-1.20997	-18.3268	-11.5925
	-6267.41	0.0605	4.65E+10	81603.3	1.88596	16.1234	20.2482	316.52	317.494	-5550.9	-3693.39	9.4962	0.510028	-18.1621	-11.5925
	-4588.98	0.0605	4.06E+10	85076.2	0.0225431	14.0527	20.8396	325.67	324.854	-2326.43	-5346.36	9.33666	-1.32004	-18.555	-11.5925
	-5477.69	0.0604347	5.13E+10	80799.5	0.00535823	14.7108	20.8015	261.241	319.17	485.619	-4782.73	9.17792	-1.22079	-17.7232	-18.1189
	-6109.42	0.0472961	2.54E+10	83373.9	0.177322	15.6127	22.9987	286.368	321.812	-2998.41	-4456.01	8.6997	-2.29998	-18.4625	-11.5925
	-4885.09	0.0570039	4.39E+10	80163.4	0.255374	15.6927	23.8355	324.354	325.002	-1578.78	-4075.51	9.10547	-0.131814	-17.7901	-11.5925
	-4035.51	0.0600693	4.32E+10	81415.3	0.0152417	14.9575	19.5572	296.019	321.434	824.034	-4011.91	9.31902	-1.51993	-17.8755	-11.5924
	-3917.22	0.0586818	4.16E+10	87878.4	0.0128369	14.4221	19.8007	375.301	300.768	1043.95	-5037.25	9.57629	-1.73324	-18.2571	-11.5925
	-5754.04	0.0575467	2.76E+10	83622.3	0.272711	17.8043	20.3977	370.717	317.424	-1133.68	-4973.3	9.0252	-1.10353	-18.3087	-11.5925
	-4786.87	0.0605	5.54E+10	81190	0.0324796	14.4401	19.8204	358.965	296.103	692.475	-4121.91	8.76355	-0.860885	-18.484	-18.4163
	-4510.47	0.0597792	3.24E+10	83530.5	4.0042	16.0272	20.4454	225.399	326.39	-478.625	-5370.33	9.32801	-1.13941	-18.4418	-11.5729
	-5398.26	0.0605	2.12E+10	85510.6	0.43707	14.8375	19.3774	332.986	327.903	-985.672	-316.499	8.94067	0.336942	-17.9256	-11.5925
	-4253.69	0.0600716	3.11E+10	84551	0.0128391	15.5474	21.1043	361.928	322.473	-2662.15	-5159.38	7.88002	-0.784451	-18.5094	-11.5924
Avg.	-5045.1266666667	0.05921826	3.70E+10	8.33E+04	3.06E-01	1.52E+01	2.10E+01	3.27E+02	3.21E+02	-1.07E+03	-4.51E+03	9.11E+00	-8.39E-01	-1.81E+01	-1.23E+01
Med.	-5062.845	0.06045935	35130150000	83154.7	0.02016735	15.05445	20.33055	325.5985	323.955	-1229.345	-4733.53	9.17547	-1.0048975	-18.2599	-11.5925
Std. Dev.	698.8094252189	0.0026900942	10975111347.1528	2619.8872400694	0.791604351	0.8539153929	1.6317417953	39.4394076324	8.0216805796	1808.4389363295	1268.809305736	0.3628603461	0.8562948838	0.4364346365	2.0376857083

Iterative Local Search Running Times in Seconds

Dimensions	10	20	30
Function 1	5.355587244	21.5247523785	47.5882720947
Function 2	0.4999251366	1.151144743	2.4649145603
Function 3	0.0042607784	0.0112228394	0.0144929886
Function 4	0.0058951378	0.0114533901	0.0161828995
Function 5	150.1059572697	2928.3961615563	N/A
Function 6	0.0101454258	0.0255510807	0.0222308636
Function 7	32.4964332581	41.5021996498	168.8056237698
Function 8	0.3526818752	1.6770370007	3.8826031685
Function 9	0.0110986233	0.0125215054	0.0229070187
Function 10	0.0899729729	0.2644715309	0.7342042923
Function 11	30.093629837	165.0208876133	384.6772966385
Function 12	297.458874464	25.3617525101	21.2174470425
Function 13	0.0197796822	0.0436241627	0.0463643074
Function 14	1.5726833344	7.7616007328	9.7854065895
Function 15	6.6486163139	23.9164574146	32.7224471569