CENTRAL WASHINGTON UNIVERSITY, DEPARTMENT OF COMPUTER SCIENCE

CS 471 Optimization - Project 3 Evolutionary Algorithms Report

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May 8, 2019

Abstract

Project 3 - Evolutionary Algorithms
Implement two evolutionary algorithm and compare their results to the results of the Iterative Local Search from project 2.

1 INTRODUCTION

For this project, two different evolutionary algorithms were implemented:
Genetic Algorithm, Differential Evolution Algorithm.

Genetic Algorithm creates a random population using Mersenne Twister, calculates the fitness of each vector in that population, then takes this initial population and its fitness values and continuously evolves the individuals of the population using mutation, crossover, and selection. For this implementation we also added an elitism rate to retain some of the best values of the old population.

Differential Evolution Algorithm creates a random population using Mersenne Twister, calculates the fitness of each vector in that population, then takes this initial population and its fitness values and continuously evolves the individuals of the population using one of the 10 DE Strategies. Mutation and crossover happen pretty much at the same time and these two steps are what use one of the DE Strategies. The mutation and crossover creates one new individual for every individual in the population, and compares it with its parent. If the new solution is better than the parent, then the new solution replaces the parent solution and will be passed down to the next generation. Otherwise, the parent is used in the next generation and the new solution is discarded.
It's good to note that both evolutionary algorithms run for a set number of generations.

2 RESULTS

For the testing of the Genetic Algorithm the parameters that were set were as follows:
Number of Dimensions = 30, Population size = 200, Maximum Number of Generations = 100, Crossover Rate(CR) = 0.8, Mutation Probability = 0.005, Mutation Range = 0.1, Mutation Precision = 5, Elitism Rate = 0.2, Selection Type = Roulette wheel (2), Number of Crossover Points = 1.

For testing of the Differential Evolution Algorithm the parameters that were set were as follows:
Number of Dimensions = 30, Population size = 200, Maximum Number of Generations = 100, Crossover Rate(CR) = 0.8, F Scaling Factor = 0.6, Lambda Scaling Factor = 1.6, Strategy Used = 1 through 10.

Here are the results for the Iterative Local Search from Project 2 and the results from the two evolutionary algorithms from this project.

Table 2.1: Iterative Local Search Analysis For 30 Dimensions

	Iterative Local Search					
Function	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

Table 2.2: Genetic Algorithm Analysis For 30 Dimensions

	Genetic Algorithm					
Function	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	3803.216978	1721.955064	2257.129744	9192.371231	3060.593134	578.000000
f_2	8370.029993	12079.314955	951.585084	55910.118899	3297.725303	402.000000
f_3	1651378884.915602	4230065796.826636	27704644.773254	23506021397.837814	227551550.711000	476.000000
f_4	264718.737516	328132.049637	-5441.283301	1291806.086456	132222.810218	399.000000
f_5	57.771858	80.801409	6.062556	299.718881	21.734878	505.000000
f_6	-34.067716	3.298125	-37.123928	-24.397806	-35.419311	647.000000
f_7	36.881829	7.000339	31.140025	61.945373	34.125460	680.000000
f_8	102.409541	93.662633	9.469256	380.937519	71.496338	633.000000
f_9	265.324849	92.006488	158.185662	519.898534	238.343391	729.000000
f_{10}	-4061.647119	8.814570	-4062.533017	-3973.943250	-4062.533017	792.000000
f_{11}	-3263.006265	0.000000	-3263.006265	-3263.006265	-3263.006265	1274.000000
f_{12}	8.148435	2.070307	5.911500	13.059250	7.572527	803.000000
f_{13}	-20.529418	4.917787	-25.476674	-6.631168	-22.476436	485.000000
f_{14}	-9.560542	3.833319	-14.371235	-1.424232	-10.224454	711.000000
f_{15}	290932674.188802	562130309.739425	23360405.323908	3248645044.838321	107413915.719984	366.000000
f_{16}	36.752613	42.592141	8.498573	213.847252	18.186334	585.000000
f_{17}	8007.307736	12345.491633	816.227210	55994.170429	2609.511573	365.000000
f_{18}	158.601545	132.494285	48.515832	582.609420	101.466167	358.000000

Table 2.3: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 1				
Function	Average	Standard Deviation	Range (min)	Range (max)	Median
f_1	-70160063329583415296.0000	338796336349079863296.0000	-2828996736259508404224.0000	9605.7214	-346887445138.1177
f_2	32360.9473	5458.2474	24595.4958	45513.8851	32079.8898
f_3	9911178164.1295	4290127237.6218	5506304808.9057	17431538699.4560	12070071297.9988
f_4	943295.8857	215136.7037	771931.4260	1492962.8634	864234.0474
f_5	229.9209	54.9386	173.5944	404.7392	212.2509
f_6	-28.2853	0.7963	-28.5804	-25.2905	-28.5802
f_7	64.1402	5.0137	57.2752	70.1448	64.8845
f_8	300.4383	54.4317	221.5066	431.2873	283.7795
f_9	442.8658	38.8048	399.5467	535.5281	422.6628
f_10	-8511620636520033.0000	33420893181013952.0000	-206961802287932352.0000	-4807.4612	-8482616272.8420
f_11	-1737783077265.1670	6952450370159.6992	-49853881275563.4297	-3126.1185	-16200528.4046
f_12	12.4371	0.3483	12.1728	13.3698	12.2401
f_13	-10.3469	1.4539	-12.4668	-7.4618	-10.6608
f_14	-2.5835	0.7725	-4.0134	-1.2178	-2.2568
f_15	2357735531.7113	490215279.5770	1725969295.4471	4043500368.6030	2265000603.6953
f_16	191.2140	35.2849	158.7167	287.8251	184.5890
f_17	35411.9656	5985.9020	29426.4340	47893.1815	31357.1362
f_18	463.9560	54.2899	424.9534	620.1344	430.7901

Table 2.4: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 2					
Function	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	-12386921291.6504	36535931167.7053	-257829209977.9994	8273.9433	-14473430.6218	448.0000
f_2	43210.0585	7403.9836	34600.7841	62659.8525	45319.0626	278.0000
f_3	13704900995.3950	1558562849.2379	12270397874.2038	18341870239.8221	12943298915.8215	300.0000
f_4	1094278.9188	197649.0482	833464.7883	1448295.3124	1095425.9730	275.0000
f_5	233.9955	55.5974	179.3440	339.0815	245.8857	345.0000
f_6	-26.2601	0.6202	-27.4810	-25.3131	-26.3895	400.0000
f_7	63.8115	2.1962	61.8261	71.1065	62.7049	486.0000
f_8	326.2904	35.2383	287.5697	400.9464	308.9525	537.0000
f_9	457.8249	34.3647	396.5331	504.5365	463.6322	523.0000
f_10	-5002382991.7126	14603199508.7455	-93688761775.9193	-4265.6336	-8534404.0979	572.0000
f_11	-397813276.1222	949190412.9325	-4648443484.4279	-2663.0966	-3868024.6919	861.0000
f_12	12.9201	0.1913	12.4897	13.0627	12.9923	566.0000
f_13	-10.2004	0.9283	-11.4868	-7.9446	-10.6653	313.0000
f_14	-1.7897	0.5348	-2.3752	-0.8065	-1.5362	504.0000
f_15	2416812184.8860	230778512.2867	2247272872.9017	2787802853.4538	2271623352.6933	258.0000
f_16	175.4832	16.9723	140.7453	228.7137	171.6437	356.0000
f_17	36370.2043	6298.0847	29229.1043	50169.4103	34566.9073	253.0000
f_18	461.8914	58.8370	420.3843	633.1107	420.7410	255.0000

Table 2.5: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 3		
Function	Average	Standard Deviation	Range (min)
f_1	-126168487905155999493820495839801376768.0000	832389794243488364670270267584841515008.0000	-779088538212091070134514507
f_2	40892.5487	4369.5462	34157.2063
f_3	17412900977.2503	2650650053.5031	11240020399.69
f_4	1214337.5070	109122.7620	947970.4222
f_5	280.8506	41.8432	226.0439
f_6	-26.1772	0.8050	-27.2193
f_7	68.3460	1.7104	65.5090
f_8	329.0588	22.4164	308.8319
f_9	480.6428	24.8416	449.8254
f_10	-533716650715415396638597463408640000	337773410438378103103770750615552.0000	-31879856727877605841111610
f_11	-45377544837125320737993005203456.0000	26013151551582198290365528041062400000	-24225526253077412865547140
f_12	12.9961	0.2294	12.7448
f_13	-8.9025	0.5954	-9.4724
f_14	-1.2360	0.1495	-1.3541
f_15	3165642058.0599	153613420.9980	2907962763.670
f_16	239.1586	28.3547	209.6231
f_17	46489.5931	6071.1380	36871.1313
f_18	465.1974	33.9217	435.0607

Table 2.6: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 4			
Function	Average	Standard Deviation	Range (min)	Range (max
f_1	-2948008969743321925806981120.0000	164201733744831860514614149 12.0000	-14110915768308663449633056 3584.0000	8669.4044
f_2	42441.8995	4432.5936	35550.1897	52655.4993
f_3	15472830938.6980	3534171624.2991	10277143166.2546	22696718423.9
f_4	1127461.7528	128110.6829	863551.9262	1415938.415
f_5	203.3430	26.0818	157.9483	246.8323
f_6	-26.9875	1.1641	-28.2276	-24.8834
f_7	64.7118	2.1538	63.1273	70.3944
f_8	362.0552	24.1579	339.3921	438.3229
f_9	480.2044	21.9731	458.0957	536.3020
f_10	-1232196446640420956405 76.0000	6368276279641698310553 60.0000	-5437035755064285925998592.0000	-5328.4175
f_11	-1488875890993504085606 4.0000	6717612195110307705651 2.0000	-5728493363805465734021 12.0000	-3565.1934
f_12	12.7765	0.2044	12.3169	13.2319
f_13	-9.4110	0.9875	-10.2215	-7.1916
f_14	-1.3644	0.2465	-1.6400	-1.0298
f_15	2840232226.2526	293749765.7724	2323565559.0685	3723595910.64
f_16	165.1670	27.6755	130.7243	239.8203
f_17	34982.2088	4020.6623	31339.6477	47916.2142
f_18	452.8061	75.2120	375.1127	581.9792

Table 2.7: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 5					
Function	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	-1092181062444375.5000	3891226715006459.5000	-26808964003779188.0000	9103.4875	-12233553178.7448	430.0000
f_2	45307.5503	6979.5579	38032.8089	58612.9527	46609.0739	273.0000
f_3	14297606328.9140	2046505049.7395	12873746734.7486	19674837504.3222	12899567108.7768	314.0000
f_4	1024191.1247	83184.3819	920758.1225	1181392.9278	1035870.8670	285.0000
f_5	236.4887	20.5599	208.8663	275.6020	235.7904	374.0000
f_6	-27.3430	0.6100	-27.8398	-25.5487	-27.4762	468.0000
f_7	66.6386	1.1879	66.3521	72.1491	66.3521	448.0000
f_8	352.6664	35.2650	307.4970	417.7815	357.8907	510.0000
f_9	488.7027	21.2374	462.7983	531.3271	483.4695	525.0000
f_10	-1178244727058979.2500	5246605657047394.0000	-35504804751063028.0000	-5250.8024	-7472878086.6659	692.0000
f_11	-876017300093621.5000	3036563798490315.5000	-18023020099699336.0000	-3704.5063	-4078593248.3864	874.0000
f_12	12.8292	0.1466	12.6508	13.1601	12.8575	554.0000
f_13	-8.0209	0.4349	-8.6838	-6.9695	-8.0868	333.0000
f_14	-1.3988	0.2229	-1.7024	-1.2236	-1.2430	551.0000
f_15	3600228480.6534	907649775.3889	1878159358.3329	4311471836.2297	4162850682.8866	266.0000
f_16	185.0294	20.6545	166.9869	234.3169	173.9348	362.0000
f_17	45647.1327	5644.7706	38204.2949	56431.8349	44349.0313	293.0000
f_18	527.0436	38.1978	460.9553	604.3145	515.4123	278.0000

Table 2.8: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 6					
Function	Average	Standard Deviation	Range (min)	Range (max)	Median	Ti
f_1	-8845609696330839040.0000	39823825445249048576.0000	-318317436176414801920.0000	6660.5906	-50576279487.5328	46
f_2	3150.9548	8754.3945	0.0578	53543.2960	45.4665	30
f_3	1389541540.5593	4038130857.0591	303.9762	22066348241.8350	105081.3921	38
f_4	104850.2571	265038.7464	-15082.6974	1475554.7802	-4477.9523	32
f_5	35.5024	78.7051	0.2145	337.6325	1.4083	38
f_6	-29.5957	1.5936	-30.8654	-24.3154	-30.8654	43
f_7	58.7183	3.8402	55.9091	69.3691	57.5069	45
f_8	44.9778	92.2174	-53.3558	370.0740	19.3581	50
f_9	188.0087	158.7645	6.9973	504.2157	124.5710	54
f_10	-20764864113979604992.0000	9364475929227232870 4.0000	-744262830978316500992.0000	-5203.3673	-98469615402.6325	62
f_11	-1449712641291293440.0000	6201517781740625920.0000	-46661890407869505536.0000	-3564.9973	-46248315331.1766	88
f_12	12.6901	0.1749	12.4805	12.8838	12.8248	57
f_13	-9.6921	0.8837	-10.4104	-7.4596	-10.0445	36
f_14	-2.9661	0.4066	-3.6364	-1.7873	-2.8949	54
f_15	122292580.0261	333388458.9773	0.1005	1851836153.0449	10906.1086	31
f_16	27.2759	42.0404	3.8182	226.8900	5.8716	42
f_17	4637.5037	10199.0832	9.0867	52823.5575	123.1986	30
f_18	255.3328	120.4922	125.2345	605.8961	252.0457	29

Table 2.9: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 7					
Function	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	-97828000.0406	296297483.7846	-1624940139.2796	7601.5340	-657935.9637	451.0000
f_2	40457.6053	10434.5670	22442.8086	53963.7791	40090.9408	328.0000
f_3	13925208401.5832	2601622056.3554	7741439520.6593	17030205489.5993	13268794793.1622	341.0000
f_4	1093193.9564	187570.2432	840195.3875	1440411.6710	1144579.9647	315.0000
f_5	237.9598	80.5682	162.6165	401.1570	183.2671	401.0000
f_6	-25.9290	0.6645	-27.5089	-24.4336	-25.8530	469.0000
f_7	66.7151	0.8842	66.4979	73.2450	66.4979	471.0000
f_8	344.3330	45.9768	267.7963	438.4889	344.1889	500.0000
f_9	494.8486	11.5146	486.9644	517.0532	486.9644	526.0000
f_10	-17729828.9690	48014166.8215	-279671680.4621	-5844.2787	-407569.1823	610.0000
f_11	-86265658.4394	236448454.2671	-1376355674.0067	-4705.0562	-422811.5942	857.0000
f_12	13.1933	0.0649	13.1518	13.4851	13.1552	590.0000
f_13	-8.7012	1.0174	-9.5844	-7.0119	-9.5844	350.0000
f_14	-1.6661	0.4340	-2.2571	-1.1597	-1.4198	554.0000
f_15	2187769896.0990	964553749.9273	1400555996.9301	3510439985.3536	1400555996.9301	309.0000
f_16	207.7173	34.0281	163.3056	246.6125	183.7227	412.0000
f_17	42966.2168	10502.1567	31255.2728	57010.3935	34790.1144	294.0000
f_18	448.6853	68.4643	393.4001	582.0812	406.8031	291.0000

Table 2.10: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 8		
Function	Average	Standard Deviation	Range (min
f_1	-2054106650366171390886152198457340723 20.0000	1322008869799091572005594251626664689664.0000	-1227825902379289924726006 59
f_2	51382.1906	8811.8887	43271.0524
f_3	20539043770.8880	413021237.7586	19657501671.5
f_4	1504930.1717	38588.0858	1451166.893
f_5	350.2273	16.1899	325.9111
f_6	-25.3834	0.4485	-25.9686
f_7	63.7917	1.9821	62.6192
f_8	429.8388	11.4362	407.8824
f_9	495.3828	6.0358	492.4444
f_10	-1134696306597242190264823412319846 4.0000	6669553864261989346069363139018752 0.0000	-5878407623239427188690455
f_11	-2468742162988033375705283187179 52.0000	1357718687224161910937300200587264.0000	-1156017174247141275893 18
f_12	12.8991	0.0476	12.8943
f_13	-7.5732	0.3938	-7.8769
f_14	-1.5277	0.1424	-1.6244
f_15	3037863267.9912	36180469.7141	3017531599.23
f_16	202.0400	0.9694	201.2648
f_17	51481.0988	2438.6653	43818.5178
f_18	611.5367	34.9113	556.0360

Table 2.11: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 9			
Function	Average	Standard Deviation	Range (min)	Range (r
f_1	-19561789256890501332570472448.0000	116385134336608515542852042752.0000	-10757901382867792124141507706880000	8799.98
f_2	47380.7746	9370.0246	35882.8611	61805.3
f_3	21705852479.7448	2600674491.9708	17784763546.2411	286449219
f_4	1151635.5079	240180.3827	775900.1064	1688536.
f_5	277.5559	67.4726	190.3773	364.58
f_6	-25.7222	0.6455	-26.8742	-25.11
f_7	65.2750	2.0904	64.3627	70.06
f_8	386.0274	20.0644	356.2842	415.43
f_9	502.8782	0.5577	502.7252	504.91
f_10	-28029962173607824822640836608.0000	16206477939572910566476139724800000	-139301230451144150875047670579200000	-5832.7
f_11	-94994067495816605970611568640000	55931062355029921751254433792.0000	-49031282880836636474478061158400000	-4092.4
f_12	13.0825	0.0234	13.0761	13.168
f_13	-8.3803	0.3389	-8.4869	-7.302
f_14	-1.9033	0.3463	-2.1719	-0.922
f_15	1386964442.2893	21850731.9087	1291719310.0570	139197734
f_16	200.3548	28.9188	175.8972	243.82
f_17	30764.5388	8620.4173	25583.4475	53284.5
f_18	491.9846	57.9159	401.7075	557.33

Table 2.12: Differential Evolution Algorithm Analysis For 30 Dimensions

	Differential Evolution Algorithm - Strategy 10					
Function	Average	Standard Deviation	Range (min)	Range (max)	Median	Time (ms)
f_1	-129274890247467.5000	494283663141742.0625	-2943857435008385.5000	8497.4899	-336759984.6084	481.0000
f_2	52715.1797	0.0000	52715.1797	52715.1797	52715.1797	330.0000
f_3	15364920581.9563	0.0000	15364920581.9563	15364920581.9563	15364920581.9563	349.0000
f_4	1437951.1859	9163.2108	1422080.0393	1443241.5681	1443241.5681	371.0000
f_5	396.6155	0.0000	396.6155	396.6155	396.6155	430.0000
f_6	-25.7459	0.0000	-25.7459	-25.7459	-25.7459	434.0000
f_7	68.1617	1.4993	67.5363	73.5912	67.8962	456.0000
f_8	392.6834	0.0000	392.6834	392.6834	392.6834	509.0000
f_9	518.2755	3.1115	515.8910	522.3356	515.8910	536.0000
f_10	-16509048463618.9102	57661568547237.7656	-353973460429774.5625	-7898.7723	-366750389.0830	609.0000
f_11	-947244068293.7382	3114469876482.4214	-18247938334704.1172	-6508.0106	-79558511.9955	885.0000
f_12	12.9269	0.1747	12.8098	13.1875	12.8098	584.0000
f_13	-7.7812	0.4478	-8.2567	-7.3595	-7.3595	391.0000
f_14	-1.3425	0.0703	-1.3800	-0.8401	-1.3800	591.0000
f_15	4222657670.0728	0.0000	4222657670.0728	4222657670.0728	4222657670.0728	298.0000
f_16	250.7865	0.0000	250.7865	250.7865	250.7865	396.0000
f_17	51938.3388	0.0000	51938.3388	51938.3388	51938.3388	298.0000
f_18	577.4733	23.1425	547.8799	608.9379	564.4645	299.0000

3 Analysis

Looking at the Genetic Algorithm, I can see that out of all the functions used, the worst one is Function 11 - Rana. Not only did it run the longest but it also had 0 standard deviation. There was no improvement for the function from start to finish. Function 18 - Alpine was the fastest function for this test and it got really close to its global best fitness of 0, but it wasn't the best in terms of average. Function 3 - Rosenbrock was the function that showed the most improvement. Its standard deviation is the largest in the results but it is the worst in terms of average. Function 12 - Pathologial was the closes function to get to its global best fitness, however, it was also one of the slowest.

Differential Evolution Algorithm, each function performed better depending on which of the DE Strategies was used. All functions completed execution of the Differential Evolution within a range of 200 to 1000 milliseconds. For Function 1 - Schwefel, strategy 8 produced the best outcome with a medium speed of 500 ms. For Function 2 - 1st De Jong, strategy 1 produced the best results, and was the fastest function that completed execution within 250 ms. For functions 3, 4, 5, and 6, strategy 6 produced the optimal results, where all functions completed execution within 450 ms. Although function 6 showed little improvement with a 1.59 standard deviation. For Function 7 - Stretched V Sine Wave, strategy 3 gave the best results but the population showed very little improvement throughout its evolution with a standard deviation of 1. For functions 8 and 9, strategy 6 showed the best results where the populations for both functions improved at about the same rate, with a standard deviation between 100 - 150, giver or take. For function 10 and 11, the best strategy was 8. Both of these functions have the highest sign of improvement (highest standard deviation) but both performed poorly in terms of speed. Just like in the Genetic Algorithm, Function 11 - Rana ended up being the slowest out of the best results that were gathered for this Project (referring to ResultsSummary.csv). For Function 12 - Pathological, the best strategy was 6, but just like in the Genetic Algorithm, it showed little to no improvement over the course of the populations evolution, with a standard deviation of 0.2. For functions 14 through 18, the best strategy was 6 again. And just like in the Genetic Algorithm, the fastest results were produced by Function 18 - Alpine.

Comparing these results with what I got from Project 2's Iterative Local Search, I can see that function 11 was slow for all the algorithms used. In the evolutionary algorithms, functions 4, 6, 12, 13, and 16 all showed improvement, as apposed to no improvement in the Iterative Local Search. Both function 6 and 12 were pretty close to almost no improvement in both the evolutionary algorithms and the Iterative Local Search. Function 18 seems to perform the fastest in both of the evolutionary algorithms as well as the Iterative Local Search.

4 Conclusion

Out of all the functions for the Genetic Algorithm, with the set of parameters listed in section **Results**, I'd have to say that Function 18 - Alpine produced the best results based on

time and how close it got to its global best fitness.
Out of the 10 strategies used for the Differential Evolution Algorithm, with the set of parameters listed in section **Results**, the best overall strategy was DE Strategy 6, with the notation **DE/best/1/bin**. The best function for this algorithm seems to be function 18. Not only did it perform faster than the other functions in the algorithms analyzed for this project, but it showed a steady rate of improvement, not too dramatic or to minuscule.

The overall worst function for all algorithms analyzed would be Function 11 - Rana.
The overall best function for all algorithms analyzed would be Function 18 - Alpine.

5 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