CS471 Project3

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1 INTRODUCTION

Project 3 is aiming to get optimized solutions for 18 functions through the Genetic Algorithm(GA) and Differential Evolution Algorithm(DE). Experiment is ongoing with 200 population, 30 chromosomes, and 100 generations. Genetic Algorithm has 3 steps in order of selection, crossover, and mutation. For the selection step, parents will be selected by fitness value. There are 5 algorithms to select parents: Tournament selection, Roulette wheel selection, Proportionate selection, Rank selection, and Steady state selection. However, project 3 i used only 2 selection algorithms, which are Tournament selection and Roulette wheel selection. Experiment requires 2 kinds of crossover: one point crossover and two points crossover. Crossover probability sets between 0.8 and 0.95. Generate random double value if it is between 0.8 and 0.95, process crossover. Mutation step processes with 0.005 of mutation probability, 0.1 mutation range,and [1,5] mutation precision. One significant part of Genetic Algorithm is Elitism.The Purpose of Elitism is to prevent the best solution's loss from crossover and mutation. For each generation GA iterates those steps until reach user set generation. Differential Evolution Algorithm's process is different. DE's processing order is different from GA's processing. Mutation and recombine and selection. Mutation step and Crossover step are combined for the DE. Through the experiment i got result of table about 10 strategies of mutation and recombine strategies.For the 10 strategies F which controls the amplification of the differential variations is set 1.1. and Lambda is set 1.3.

2 ANALYSIS

According to result, Schwefel function has the best(Smallest) average value with Differential Algorithm's tenth strategy. 1.2 is set for constant F value. DeJong function doesn't perform with all three Algorithm because all the average results are above 40 thousand. For the DeJong Function, Genetic Algorithm with tournament and 2 points of crossover has the best average. Rosenbrock function has the largest average and standard deviation value overall the 18 functions. Rosenbrock function's shape is similar as valley which means global minimum could be found at the narrow area. Because experiment processes with random values, it is hard to converge to minimum value. Result for the Rastrigin functions was not optimized through the 3 Algorithms(GA, DE, and Iterative Local Search). Average result for Griewank function has value between -700 and +700. Because Griewank function has many local minimum and local maximum, the standard deviation is small. Sine envelope function got the best average value with Differential Evolution Algorithm with 6th strategy. I got interesting result for Stretched function. All the average values are 53.4. with all algorithms. Through the result the shape of StretchedV function exists with flat shape between -50 and 50. Ackely 1 function has better average values compare to Ackely 2 function. However Ackely 2 function has smaller standard deviation which means the solution values for Ackely2 are more converged. I assume that if the domain for Ackely is increase, Ackely2. will perform better than Ackely1. EggHolder has pretty far solution average from global minima because EggHolder function has many local minima. Rana function didn't get significantly optimized average solutions through the three algorithms. Pathological has below 20 average solution value. but we still need optimize to get 0 average value. For the Michalewicz,Masters'Cosine Wave,Quartic,Levy,Step, and Alpine still need optimize to get global minima.

3 CONCLUSION

In conclusion, I assume that stretchedV function has flat area in [-30,30] because all the algorithms' average are same with standard deviation 0 which means all the result for random float number between -30,30 are the same. To get more optimized values, we need to modulate constant values like Crossover probability, mutation range, mutation precision, elitism rate, F, and lambda. For example, raise crossover probability and mutation rate to get smaller values.However, if we have higher crossover probability and mutation, standard deviation will be increase because we can get not only minimum value but also higher value from mutation and crossover. If we have more cross over point, we can get better average solutions for every functions however, standard deviation will be increase. F value also influence the best solution, which means if we increase F value higher, probability of getting lower solution will increase but probability of getting higher solution also increase. Standard deviation will be bigger if we have higher F value. So if we have to choose F value between 1 and 2, 1.5 will give you the ideal result. Previous best solution will be kept for new generation matrix. Statistically, If we have more values,we can get higher probability to get best solution. The best way to improve solution of GE and DE required huge

number of generation because GE and DE. Ideally, solution for each generation should be improved by GA and DE. For Iterative Local Search, Genetic Algorithm, and Differential Algorithm, I cannot decide which Algorithm can get more optimized value without specific data because the result is depend on the luck. If three algorithms execute with same number of iteration or generation, I will pick the fastest algorithm because one precise way to improve solution value is more iteration. The speed rank in order are GA, DE, and Iterative Local Search. When we have to choose algorithm to optimize value we should consider not only average but also standard deviation because standard deviation shows how precise is the algorithm which means if standard deviation is lower that means The algorithm is precise.

Table 3.1: GA with tournament selection.

	crossover1		crossover2	
	AVERAGE	STD	AVERAGE	STD
f(x1)	291.78	191.80	-88.44	17301.73
f(x2)	63662.73	90032.70	48319.48	68313.36
f(x3)	15538347218.95	20957340296.89	26179315541.59	37023143051.55
f(x4)	1651995.04	2251034.27	-7838690.08	14073180.80
f(x5)	355.45	501.27	416.80	588.02
f(x6)	-701.15	857.75	-1212.29	472.50
f(x7)	53.40	0.00	53.40	0.00
f(x8)	306.87	288.41	339.37	361.47
f(x9)	294.70	416.77	294.39	416.34
f(x10)	-43945.64	10301.57	-113051.33	46991.14
f(x11)	-1440.11	1987.05	-1845.10	2628.02
f(x12)	8.09	8.91	6.78	9.59
f(x13)	-324.16	341.57	-150.37	212.66
f(x14)	-2462.21	3102.27	-4592.89	1658.67
f(x15)	5417426143.88	7661397525.84	3102540138.51	4387651196.19
f(x16)	284.74	393.66	275.48	381.03
f(x17)	47481.23	67125.01	43137.08	60994.43
f(x18)	466.65	645.92	520.13	718.79

Table 3.2: GA with Roulette selection.

CROSSOVER 1	AVERAGE	STDEV	CROSSOVER 1	AVERAGE	STDEV
f(x1)	-67741.83	113699.07	f(x1)	13742.46	577.44
f(x2)	99040.19	20395.68	f(x2)	121120.44	16009.48
f(x3)	22696399645	25183879175	f(x3)	92858399086	45780438680
f(x4)	1499933.68	1173406.7	f(x4)	2684199.97	907146.68
f(x5)	759.2	82.65	f(x5)	542.6	18.53
f(x6)	-170.21	241.36	f(x6)	-1044.46	89.31
f(x7)	53.4	0	f(x7)	53.4	0
f(x8)	567.92	98.72	f(x8)	586.04	90.9
f(x9)	499.68	114.92	f(x9)	591.66	9.79
f(x10)	-210907.75	224720.63	f(x10)	-68031.34	100593.47
f(x11)	488.84	248.01	f(x11)	993.8	779.61
f(x12)	13.21	0.47	f(x12)	13.93	0.93
f(x13)	-226.18	293.66	f(x13)	-200.11	68.6
f(x14)	-1061.34	29.49	f(x14)	-3120.03	826.24
f(x15)	4069172796	5532375924	f(x15)	11611682006	1909745621
f(x16)	336.45	303.07	f(x16)	554.57	209.98
f(x17)	65263.75	43424.82	f(x17)	113104.82	42495.06
f(x18)	601.95	249.32	f(x18)	1073.42	133.46

Table 3.3: DE with STRATEGY 1 and 6

EXP	STRATEGY1		BIONOMIAL	STRATEGY1	
	AVERAGE	STDEV		AVERAGE	STDEV
f(x1)	13812.15493	1829.723128	f(x1)	17090.5694	553.4152075
f(x2)	76454.10531	0	f(x2)	96667.5494	0
f(x3)	45055998275	0	f(x3)	78530708389	0
f(x4)	3185616.344	0	f(x4)	2026301.733	0
f(x5)	669.9265662	0	f(x5)	638.9817119	0
f(x6)	-2.131786044	5.839171174	f(x6)	-55.47050767	75.31794377
f(x7)	53.40265856	0	f(x7)	53.40265856	0
f(x8)	605.5100159	0	f(x8)	700.032739	0
f(x9)	581.0893729	0	f(x9)	556.4089435	0
f(x10)	-90688.21519	0	f(x10)	-50475.44845	2013.449888
f(x11)	-254521.9555	388395.5013	f(x11)	-1.22355E+26	1.73036E+26
f(x12)	14.56742807	0	f(x12)	13.383028	0
f(x13)	-368.5749842	522.9926633	f(x13)	5.562432621	0
f(x14)	-71.81713348	102.9904217	f(x14)	-7.571349706	0.231395503
f(x15)	4595143401	0	f(x15)	3826064758	0
f(x16)	444.4016286	0	f(x16)	474.8756038	0
f(x17)	99290.47963	0	f(x17)	99541.34142	0
f(x18)	644.1896933	0	f(x18)	1060.400483	0

Table 3.4: DE with strategy 2 and 7

EXP 2	AVERAGE	STDEV	BIN2	AVERAGE	STDEV
f(x1)	-9100000.00	12659449.04	f(x1)	17100.00	553.42
f(x2)	135000.00	0.00	f(x2)	96700.00	0.00
f(x3)	56700000000.00	0.00	f(x3)	78500000000.00	0.00
f(x4)	2660000.00	0.00	f(x4)	2030000.00	0.00
f(x5)	723.00	0.00	f(x5)	639.00	0.00
f(x6)	-190.00	278.80	f(x6)	-55.50	75.32
f(x7)	53.40	0.00	f(x7)	53.40	0.00
f(x8)	522.00	0.00	f(x8)	700.00	0.00
f(x9)	588.00	0.00	f(x9)	556.00	0.00
f(x10)	-151000.00	0.00	f(x10)	-50500.00	2013.45
f(x11)	5220.00	7224.47	f(x11)	-1220000.00	1730360000.00
f(x12)	12.70	0.00	f(x12)	13.40	0.00
f(x13)	-356.00	500.33	f(x13)	5.56	0.00
f(x14)	-4.31	3.12	f(x14)	-7.57	0.23
f(x15)	2210000000.00	0.00	f(x15)	3830000000.00	0.00
f(x16)	324.00	0.00	f(x16)	475.00	0.00
f(x17)	110000.00	0.00	f(x17)	99500.00	0.00
f(x18)	879.00	0.00	f(x18)	1060.00	0.00

Table 3.5: DE with strategy 3 and 8

EXP 3	AVERAGE	STDEV	BIN 3	AVERAGE	STEDEV
f(x1)	-6160000.00	7876992.51	f(x1)	-195000.00	292767.18
f(x2)	91400.00	0.00	f(x2)	105000.00	0.00
f(x3)	27300000000.00	0.00	f(x3)	43500000000.00	0.00
f(x4)	2380000.00	0.00	f(x4)	3090000.00	0.00
f(x5)	569.00	0.00	f(x5)	537.00	0.00
f(x6)	-81.10	118.52	f(x6)	2.97	0.99
f(x7)	53.40	0.00	f(x7)	53.40	0.00
f(x8)	621.00	0.00	f(x8)	609.00	0.00
f(x9)	592.00	0.00	f(x9)	574.00	0.00
f(x10)	-2470.00	1494.94	f(x10)	-70900.00	0.00
f(x11)	-229000.00	330761.06	f(x11)	-13200000.00	18423571.72
f(x12)	13.40	0.00	f(x12)	12.20	0.00
f(x13)	-578.00	12.40	f(x13)	-72.70	90.79
f(x14)	-379.00	518.24	f(x14)	-39.30	62.03
f(x15)	8670000000.00	0.00	f(x15)	7110000000.00	0.00
f(x16)	534.00	0.00	f(x16)	479.00	0.00
f(x17)	107000.00	0.00	f(x17)	108000.00	0.00
f(x18)	689.00	0.00	f(x18)	941.00	0.00

Table 3.6: DE with strategy 4 and 9

EXP 4	AVERAGE	STDEV	BIN 4	AVERAGE	STDEV
f(x1)	-55688.45	96330.78	f(x1)	-216535.64	316974.86
f(x2)	59252.38	0.00	f(x2)	118523.93	0.00
f(x3)	60791403452.00	0.00	f(x3)	29734449421.00	0.00
f(x4)	3053891.07	0.00	f(x4)	2507143.97	0.00
f(x5)	771.50	0.00	f(x5)	658.65	0.00
f(x6)	-0.47	0.00	f(x6)	-15.47	24.06
f(x7)	53.40	0.00	f(x7)	53.40	0.00
f(x8)	522.59	0.00	f(x8)	614.88	0.00
f(x9)	597.70	0.00	f(x9)	572.24	0.00
f(x10)	-53204.51	0.00	f(x10)	-181553.25	0.00
f(x11)	-44717.05	50675.92	f(x11)	-353399000000000000000000.00	499781000000000000000000.00
f(x12)	13.60	0.00	f(x12)	13.34	0.00
f(x13)	-535.23	358.09	f(x13)	-369.79	498.03
f(x14)	6.02	0.00	f(x14)	3.32	2.64
f(x15)	8150363035.00	0.00	f(x15)	11574499576.00	0.00
f(x16)	481.38	0.00	f(x16)	406.10	0.00
f(x17)	132899.59	0.00	f(x17)	88820.83	0.00
f(x18)	937.82	0.00	f(x18)	729.15	0.00

Table 3.7: DE with strategy 5 and 10

EXP5	AVERAGE	STDEV	BIN5	AVERAGE	STDEV
f(x1)	11572.84683	0	f(x1)	114560.8391	424640.7735
f(x2)	84785.63384	0	f(x2)	95148.54795	0
f(x3)	57008924122	0	f(x3)	73745404782	0
f(x4)	2560739.404	0	f(x4)	2603131.899	0
f(x5)	552.3057615	0	f(x5)	564.2149254	0
f(x6)	-72.81068256	103.7013023	f(x6)	-105.9174817	132.7301812
f(x7)	53.40265856	0	f(x7)	53.40265856	0
f(x8)	626.0035643	0	f(x8)	529.6915314	0
f(x9)	577.3142059	0	f(x9)	612.3690833	0
f(x10)	-40803.90361	0	f(x10)	-2799.053644	0
f(x11)	-14690.10432	16350.09508	f(x11)	-34032503868	48129228895
f(x12)	14.46450804	0	f(x12)	14.46312879	0
f(x13)	3.387598296	1.027063196	f(x13)	-376.9371742	533.991509
f(x14)	-2029.326897	2871.029166	f(x14)	-252.0486158	366.0526684
f(x15)	9918187892	0	f(x15)	7634626666	0
f(x16)	336.1774897	0	f(x16)	383.3941007	0
f(x17)	68075.10761	0	f(x17)	66801.23486	0
f(x18)	1064.877415	0	f(x18)	1138.155483	0

Table 3.8: 30 Iterative Local Search

Iterative Local Search		
	AVERAGE	STD
f(x1)	1773.799933	2499.320194
f(x2)	68373.95886	6890.778111
f(x3)	31477898420	4562417362
f(x4)	1850107.229	199640.0562
f(x5)	422.3739281	44.44749498
f(x6)	-19.68457596	3.985320156
f(x7)	53.40265856	2.17E-14
f(x8)	458.689725	21.48658974
f(x9)	544.0829099	11.05573653
f(x10)	-18477.88311	3615.615765
f(x11)	-11903.39601	3236.624579
f(x12)	11.11437085	0.858799848
f(x13)	-110.8109424	2.874312657
f(x14)	-39.7190528	8.916369963
f(x15)	3759873867	653859006.5
f(x16)	23234.2925	3282.564703
f(x17)	69575.8267	6966.140452
f(x18)	688.5272243	61.46736134

Table 3.9: Compare GA and DE

	GA (1 point crossover)			DE (best strategy)			
	Average	StdDev	Time(msec)	Average	StdDev	Time(msec)	DE strategy (1-10)
F1	-182386.9311	103593.8656	2139.22319	-1.28247E+21	1.81369E+21	8233.30205	10
F2	51279.31144	72210.04113	803.53023	94668.23477	0	2056.86144	10
F3	56911172348	15568379046	637.78725	63760191389	0	2082.81636	10
F4	2512923.937	100458.502	1286.98124	3401363.592	0	3254.85814	1
F5	342.3107375	480.9613263	1107.85301	521.7658631	0	3447.97575	1
F6	-292.7268663	334.8678148	1201.53464	-577.6752035	817.6807632	14069.68182	1
F7	53.40265856	0	3900.4651	53.40265856	0	7337.55141	2
F8	633.3885135	76.43801457	1616.14884	480.2340515	0	4617.8691	1
F9	308.5317728	385.0610778	3601.43601	554.8934409	0	6674.60594	9
F10	-301277.4322	212045.0277	1629.70022	-172108.2509	0	8618.37431	10
F11	-52349.30306	74065.08597	2709.23088	1325.056408	0	6772.91672	10
F12	13.4730384	0.718310053	1210.50597	13.69710411	0	34856.18693	10
F13	-526.6797975	170.4478829	3322.66037	-270.496782	378.434199	4584.95913	10
F14	-274.033647	385.4542466	2288.59049	-441.344316	628.138655	23755.5344	10
F15	6459534513	9135161315	1775.66551	5673081766	0	3689.93724	10
F16	421.7531383	85.36967337	1609.49208	313.9493037	0	4671.77257	10
F17	105887.7192	26333.64914	573.86655	97616.33759	0	1780.83837	10
F18	1036.096738	23.03868979	1125.69749	835.1672377	0	3267.29566	4