Evolutionary Computation

Assignment 2: TTP Problem

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1 Algorithms for Exercise 2

In the Exercise 1, we implemented Complex-Heuristic-1 which combines the greedy heuristic and bit-flip random local search to improve both time efficiency and result accuracy. We found out that the greedy heuristic is able to construct a initial good result before conducting random local search. This design gives Complex-Heuristic-1 a great advantage to avoid useless tries and quickly gets close to the optimal solution.

For the Exercise 2, we reconsidered the (1+1)EA and computation time distribution. In the complex-Heuristic-1, once we finished Bit-flip Random Local Search, the result will be close to the optimal solution. However, this might take long time to approach or exceed the optimal solution. By applying (1+1)EA, we extremely increase the overall number of mutation during each iteration and it may help the Complex-Heuristic-2 to quickly reach the optimal solution. On the other hand, if there are multiple potential combinations of the packing plan that can generate optimal solution. The (1+1)EA gives a great chance to "jump" between those potential solutions. Hence, we defined our best performance algorithm Complex-Heuristic-2 as following sequence:

- Run Greedy Heuristic with 20% of the total time
- Run Bit-flip Random Local Search with 40% of the total time
- Run (1+1)EA with 40% of the total time

And the detail pseudo code are shown below:

Algorithm 1: ComplexHeuristic-2

compute penalty score for each of the items $I_m \in \mathcal{M}$
sort the items of $\mathcal{M}$ in descending order based on the penalty score
set current packing plan $P = \emptyset$ and $\mathcal{W}' = 0$
set phase-1-time = Max-Time-Limit $*$ 0.2
set phase-2-time = Max-Time-Limit $*$ 0.4
set phase-3-time = Max-Time-Limit $*$ 0.4
while *size of* $P < M$ *and loop-Time* $<$ *phase-1-time* **do**
    if $\mathcal{W}'+$ *weight of* I_m $<=$ *instance's capacity and penalty value of* $I_m > 0$ **then**
        $\mathcal{W}'+=$ weight of I_m add I_m to packing plan P
    end
end
using P as new packing plan and perform Bit-flip Random Local Search until phase-2-time is up
using the result from Bit-flip Random Local Search and perform $(1+1)$EA until phase-3-time is up
return results;

2 Dynamic Item Benchmarks for Exercise 2

In order to generate dynamic items for exercise 2, the following class and methods were created:

- TTPDynamicItems: The class contains all associated methods for dynamic item generation.
- TTPDynamicItems.generateDynamicItem: This method uses original items and total generation number to generate dynamic items.
- TTPDynamicItems.readDynamicItem: This method reads previous generated dynamic items and store them in the memory.
- TTPDynamicItems.updateCurrentItems:This method will update item status in instance.items based on the current generation.
- TTPDynamicItems.validateCurrentItems: This method will check the new solution item status in order to void picking unavailable items.

We generated 2 dynamic benchmarks for each of the nine benchmarks where each dynamic benchmark consists of 100,000 generations.

3 Benchmark Results for Exercise 2

The configuration parameters used for each benchmark are listed below:

- Number of Evaluation without Improvement = 10,000 times
- Time Limit = 10,000 ms
- Total Generations = 100,000
- Total Runs = 10

Figure 1, 2, 3 and 4 show average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of a280_n279_bounded-strongly-corr-01, a280_n1395_uncorr-similar-weights_05, a280_n2790_uncorr_10 and fnl4461_n4460_bounded-strongly-corr_01. According to these figures, results of Exercise 2 designed ComplexHeuristic-2 are the same as Exercise 1 best algorithm ComplexHeuristic-1.

Figure 5, 6, 7 and 8 show average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of fnl4461_n22300_uncorr-similar-weights_05, fnl4461_n44600_uncorr_10, pla33810_n169045_uncorr-similar-weights_05 and pla33810_n338090_uncorr_10. According to figures, results of Exercise 2 designed ComplexHeuristic-2 are better than Exercise 1 best algorithm ComplexHeuristic-1.

In conclusion, figure 10 shows the average scaled performance for 4 algorithms on all 9 instances. Exercise 2 designed ComplexHeuristic-2 has 93.91% and outperform all algorithms from Exercise 1.

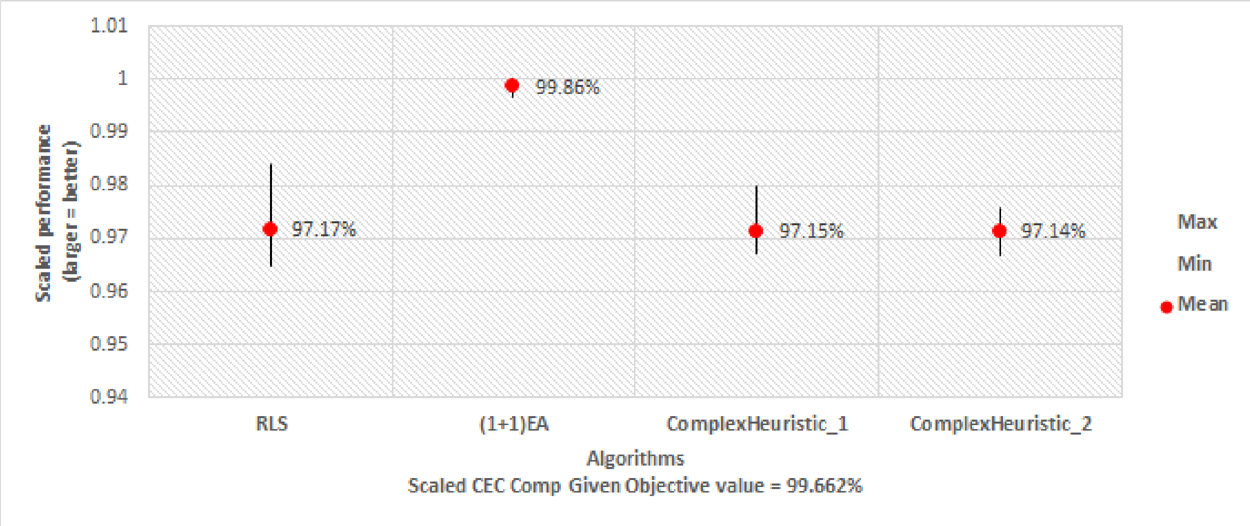

Figure 1: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of a280_n279_bounded-strongly-corr-01 instances. The scaled CEC Competition given objective value is 99.662%. Only $(1+1)$EA is larger than the CEC value.

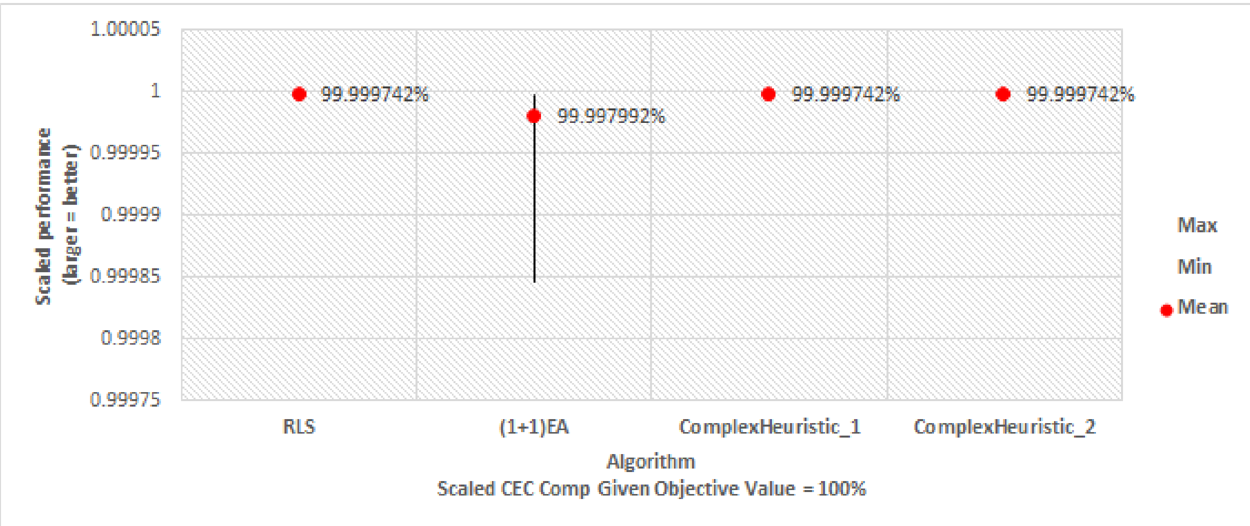

Figure 2: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of a280_n1395_uncorr-similar-weights_05 instances. The scaled CEC Competition given objective value is 100%.

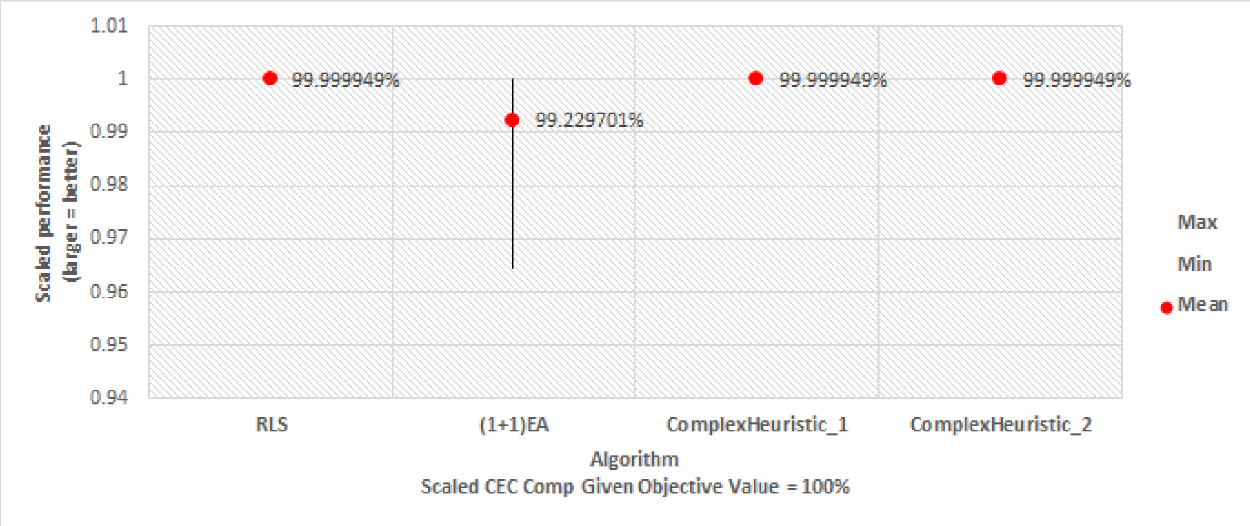

Figure 3: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of a280_n2790_uncorr_10 instances. The scaled CEC Competition given objective value is 100%.

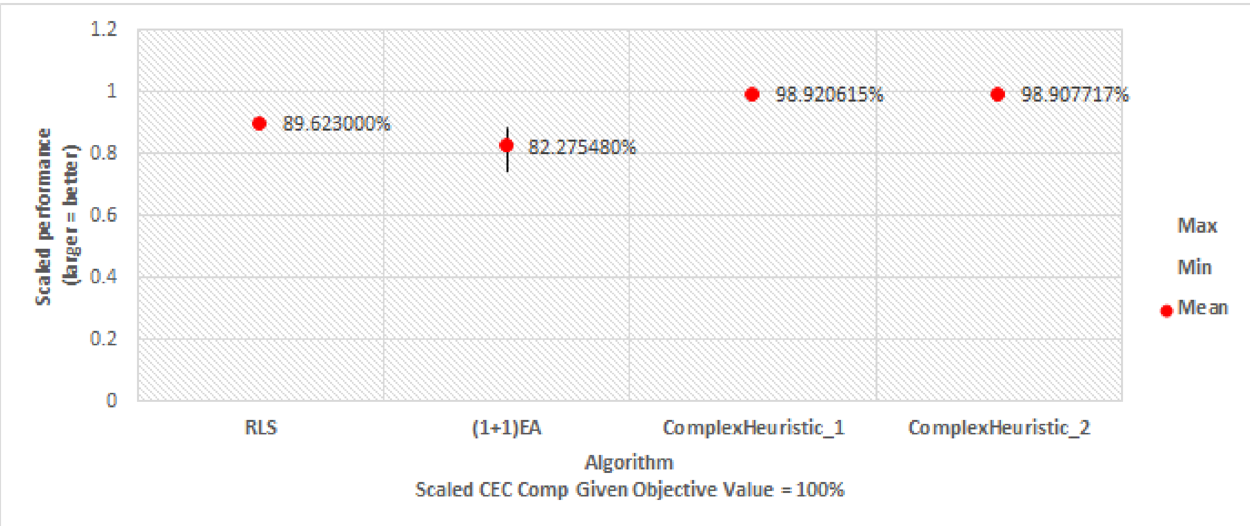

Figure 4: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of fnl4461_n4460_bounded-strongly-corr_01 instances. The scaled CEC Competition given objective value is 100%.

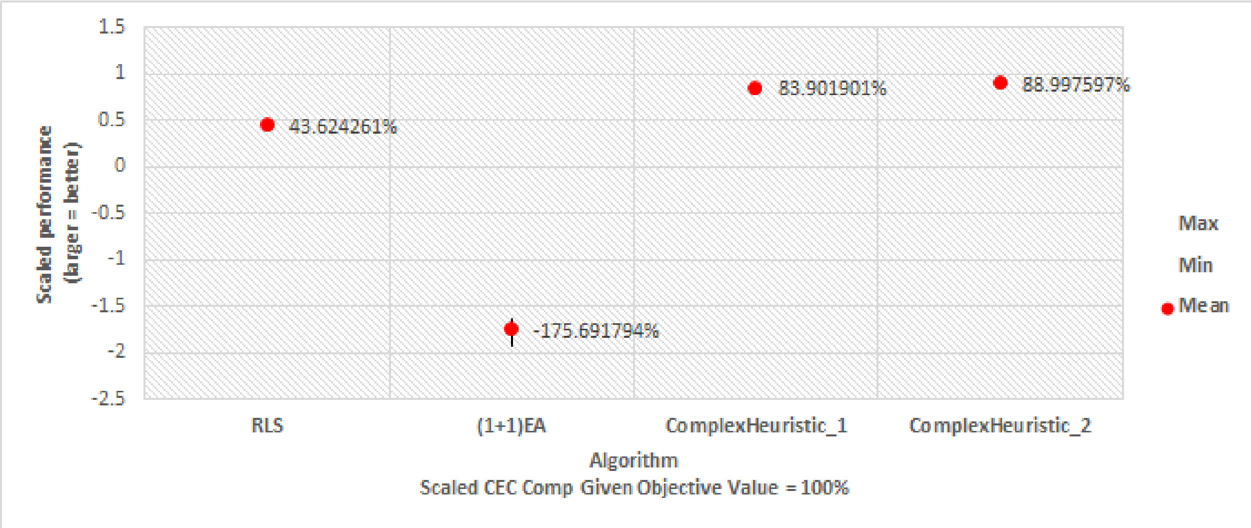

Figure 5: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of fnl4461_n22300_uncorr-similar-weights_05 instances. The scaled CEC Competition given objective value is 100%.

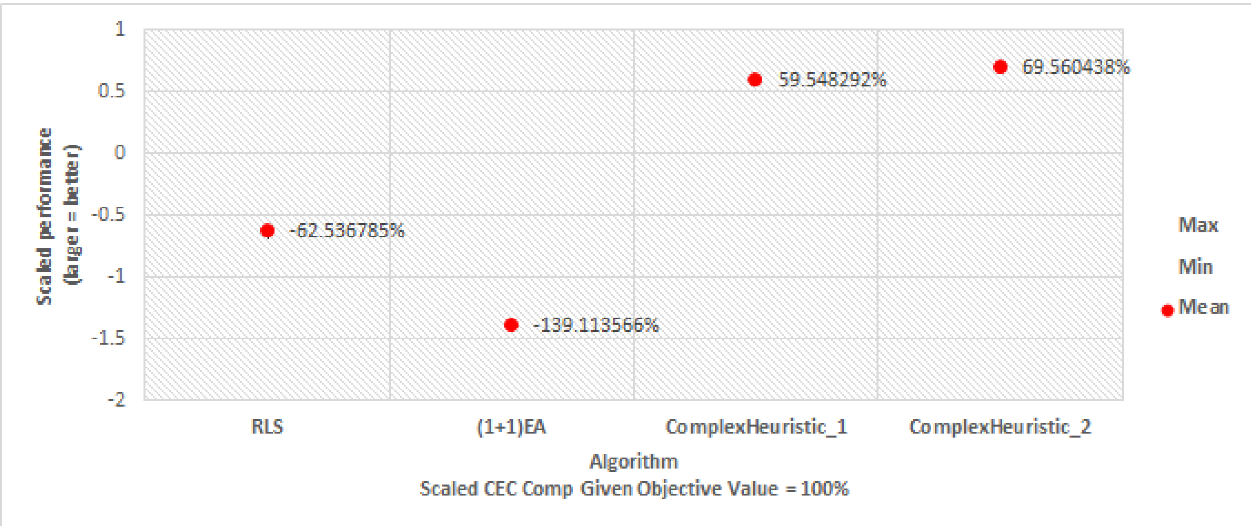

Figure 6: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of fnl4461_n44600_uncorr_10 instances. The scaled CEC Competition given objective value is 100%.

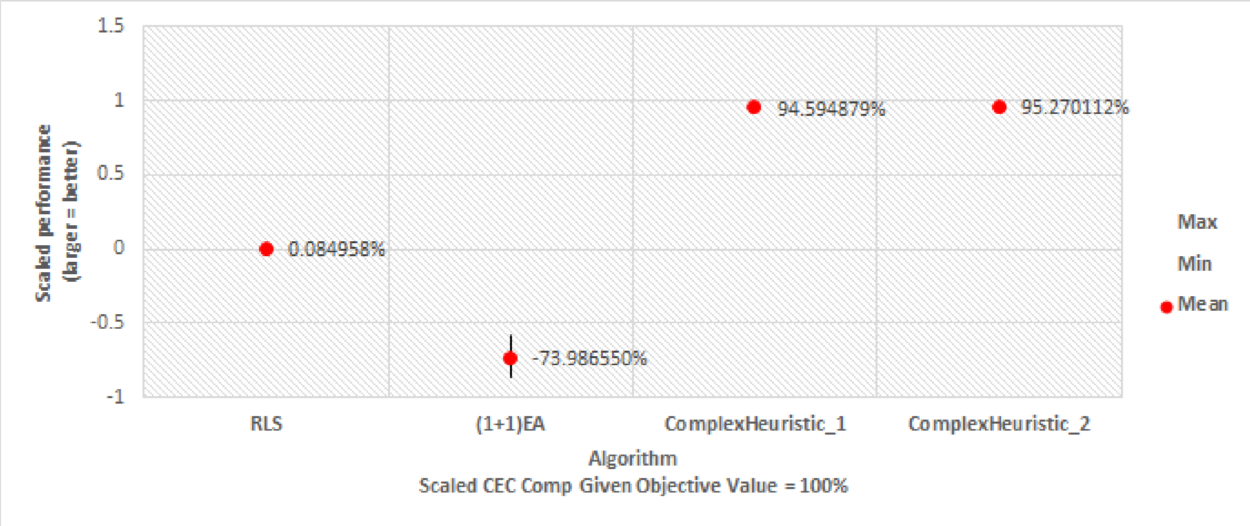

Figure 7: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of pla33810_n33809_bounded-strongly-corr_01 instances. The scaled CEC Competition given objective value is 100%.

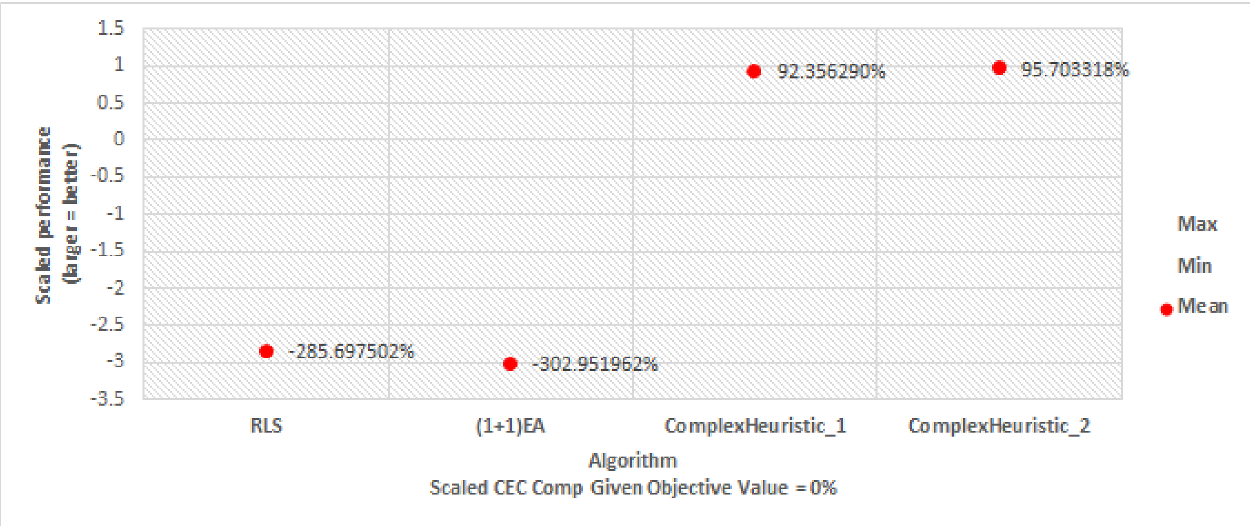

Figure 8: Average scaled performance of RLS, $(1+1)$EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of pla33810_n169045_uncorr-similar-weights_05 instances. The scaled CEC Competition given objective value is 0%. CH-1 and CH-2 are larger than the CEC value.

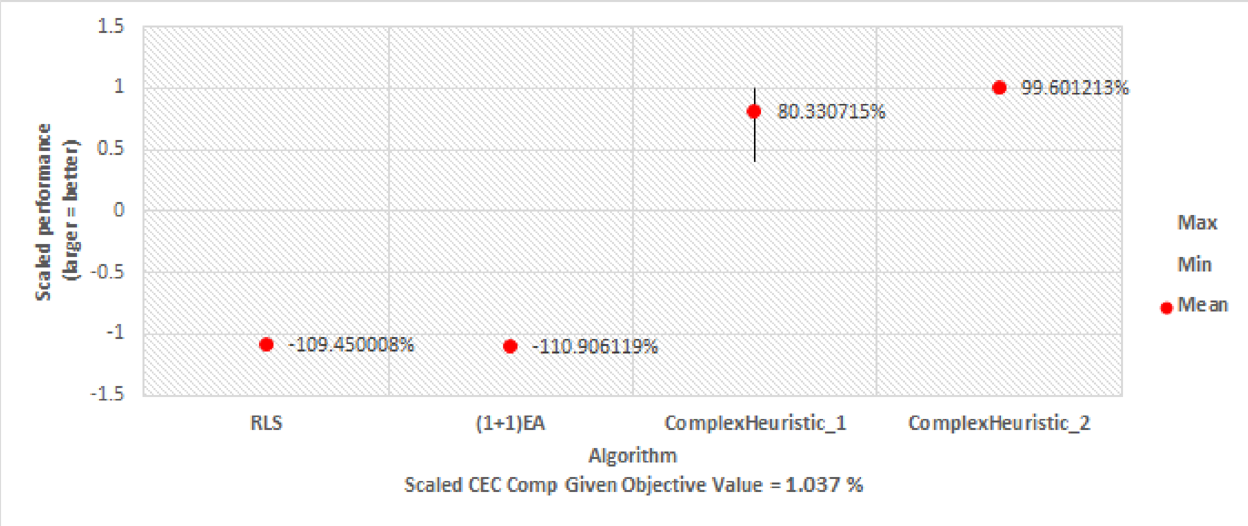

Figure 9: Average scaled performance of RLS, (1 + 1)EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of pla33810_n338090_uncorr_10 instances. The scaled CEC Competition given objective value is 1.037%. CH-1 and CH-2 are larger than the CEC value.

	RLS	(1+1)EA	ComplexHeuristic_1	ComplexHeuristic_2
Average_Max	0.490328648	0.255876583	0.926495231	0.948060144
Average_Min	0.470485904	0.4114514	0.845250012	0.932956984
Average_Mean	0.478340638	0.423739284	0.896443818	0.939091316

Algorithms

Figure 10: Average scaled performance of RLS, (1 + 1)EA, CH-1 and CH-2 algorithms on benchmark 1 and benchmark 2 of all instances.

Appendix

Table 1: Best Objective Value Per Run
a280_n279_bounded-strongly-corr_01-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	15759.18543	16120.79919	15686.85768	15663.99383
2	15660.64536	16111.18701	15831.07603	15619.21507
3	15692.26983	16119.87637	15690.91935	15636.77974
4	15670.33887	16153.62567	15666.445	15675.21834
5	15603.66277	16138.1199	15693.12251	15693.22553
6	15767.86101	16098.9215	15792.1323	15690.31698
7	15789.40254	16123.28164	15670.0122	15747.9032
8	15583.45924	16132.8008	15680.23049	15671.27968
9	15661.79881	16141.84634	15752.52403	15706.777
10	15732.31696	16128.42782	15674.28146	15686.15936

Table 2: Best Objective Value Per Run
a280_n279_bounded-strongly-corr_01-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	15734.70911	16141.65952	15677.44527	15687.10708
2	15703.1521	16142.55742	15660.91261	15654.45908
3	15897.18054	16124.81875	15650.48874	15749.10598
4	15618.64304	16149.25517	15697.2609	15711.57859
5	15672.28551	16147.55763	15623.99427	15708.43734
6	15769.24547	16116.00727	15699.26682	15702.32275
7	15596.18255	16120.89619	15698.37605	15648.49201
8	15613.39283	16132.51986	15690.30314	15723.4267
9	15705.65199	16145.38274	15672.38447	15701.20184
10	15713.2466	16137.72446	15647.39279	15762.42338

Table 3: Best Objective Value Per Run
a280_n1395_uncorr-similar-weights_05-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	104365.7309	104359.8519	104365.7309	104365.7309
2	104365.7309	104365.7309	104365.7309	104365.7309
3	104365.7309	104365.7309	104365.7309	104365.7309
4	104365.7309	104365.7309	104365.7309	104365.7309
5	104365.7309	104365.7309	104365.7309	104365.7309
6	104365.7309	104363.0173	104365.7309	104365.7309
7	104365.7309	104365.7309	104365.7309	104365.7309
8	104365.7309	104365.7309	104365.7309	104365.7309
9	104365.7309	104365.7309	104365.7309	104365.7309
10	104365.7309	104365.7309	104365.7309	104365.7309

Table 4: Best Objective Value Per Run
a280_n1395_uncorr-similar-weights_05-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	104365.7309	104365.7309	104365.7309	104365.7309
2	104365.7309	104362.9502	104365.7309	104365.7309
3	104365.7309	104365.7309	104365.7309	104365.7309
4	104365.7309	104365.7309	104365.7309	104365.7309
5	104365.7309	104362.6538	104365.7309	104365.7309
6	104365.7309	104363.0173	104365.7309	104365.7309
7	104365.7309	104362.1336	104365.7309	104365.7309
8	104365.7309	104365.7309	104365.7309	104365.7309
9	104365.7309	104349.9651	104365.7309	104365.7309
10	104365.7309	104365.7309	104365.7309	104365.7309

Table 5: Best Objective Value Per Run
a280_n2790_uncorr_10-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	411714.7896	409374.2309	411714.7896	411714.7896
2	411714.7896	407375.5613	411714.7896	411714.7896
3	411714.7896	409273.7463	411714.7896	411714.7896
4	411714.7896	411328.8618	411714.7896	411714.7896
5	411714.7896	407500.251	411714.7896	411714.7896
6	411714.7896	401899.6027	411714.7896	411714.7896
1	411714.7896	411616.4882	411714.7896	411714.7896
1	411714.7896	404464.7438	411714.7896	411714.7896
1	411714.7896	410266.1054	411714.7896	411714.7896
1	411714.7896	408226.0176	411714.7896	411714.7896

Table 6: Best Objective Value Per Run
a280_n2790_uncorr_10-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	411714.7896	411697.036	411714.7896	411714.7896
2	411714.7896	407638.7894	411714.7896	411714.7896
3	411714.7896	409737.0735	411714.7896	411714.7896
4	411714.7896	411405.1638	411714.7896	411714.7896
5	411714.7896	411453.5965	411714.7896	411714.7896
6	411714.7896	405936.2546	411714.7896	411714.7896
7	411714.7896	397065.9721	411714.7896	411714.7896
8	411714.7896	411663.2445	411714.7896	411714.7896
9	411714.7896	411481.0937	411714.7896	411714.7896
10	411714.7896	411467.4068	411714.7896	411714.7896

Table 7: Best Objective Value Per Run
fnl4461_n4460_bounded-strongly-corr_01-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	211328.397	201995.9862	233457.6599	233591.9065
2	213585.4166	195199.6884	233793.9912	233884.1652
3	214263.1813	199213.5339	233703.195	233473.523
4	213771.5719	199325.4926	233499.4025	233366.0615
5	214739.5154	195919.2901	233333.3262	233384.3808
6	212050.1106	194666.0987	233523.7263	233319.2609
7	212422.0057	200742.5644	233428.752	233687.2825
8	212261.1728	196225.3246	233559.0431	233755.6031
9	213171.8128	201103.763	233715.0912	233438.0244
10	213425.5401	197989.2594	233465.9779	233895.5421

Table 8: Best Objective Value Per Run
fnl4461_n4460_bounded-strongly-corr_01-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	209513.2678	184095.429	233371.4758	232648.562
2	209488.0876	175048.3712	232750.2131	233026.0454
3	210571.9524	175205.8253	232757.1474	232949.4937
4	212415.1874	197439.6771	233169.5381	233040.2343
5	209923.5364	207166.4877	233028.3376	233313.3816
6	207447.3796	184839.0956	233071.4285	232819.2442
7	209683.9618	188199.6278	233121.5473	233162.1483
8	208507.1577	182166.614	233210.988	233116.4269
9	208414.2254	196367.6603	232963.4724	232841.3637
10	210640.9573	208123.32	233279.8053	232883.0366

Table 9: Best Objective Value Per Run
fnl4461_n22300_uncorr-similar-weights_05-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	652230.8951	-2562516.403	1240556.306	1319417.63
2	678677.1822	-2434657.564	1248012.319	1316753.543
3	734699.0709	-2429330.706	1247868.297	1317864.292
4	670857.9199	-2415322.471	1238793.555	1316704.316
5	661395.881	-2449421.517	1246989.122	1316405.537
6	647778.0663	-2571757.234	1248943.84	1318956.773
7	691662.0112	-2541820.902	1255358.573	1319916.479
8	681130.8587	-2552480.359	1241915.351	1320051.125
9	683854.593	-2453217.754	1241165.316	1318667.392
10	668328.8356	-2451234.673	1241327.498	1321561.088

Table 10: Best Objective Value Per Run
fnl4461_n22300_uncorr-similar-weights_05-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	576975.2149	-2674349.374	1236996.127	1312504.222
2	602474.8239	-2754452.569	1230014.508	1308376.668
3	622720.9284	-2667218.709	1234276.159	1326923.286
4	647009.9485	-2601573.593	1231224.463	1313671.89
5	646033.8657	-2720171.605	1254778.683	1311877.73
6	611657.1487	-2841978.898	1233543.641	1315172.735
7	595261.1536	-2789487.897	1238828.013	1316493.575
8	634655.9504	-2754699.148	1241784.354	1314696.362
9	614242.498	-2730525.619	1228258.928	1309919.888
10	582077.9997	-2572080.287	1236909.67	1308878.27

Table 11: Best Objective Value Per Run
fnl4461_n44600_uncorr_10-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-3699217.793	-8695552.481	3770278.244	4395381.959
2	-3772576.21	-8694547.139	3821558.192	4373461.219
3	-3692987.863	-8655862.063	3723697.396	4391589.671
4	-3808297.423	-8664235.502	3783457.131	4380205.465
5	-3696611.475	-8670277.792	3747363.45	4440514.498
6	-3828425.161	-8681524.612	3752145.837	4404081.089
7	-3743227.504	-8721670.481	3744233.226	4388082.249
8	-3799979.969	-8717938.237	3797715.483	4379094.499
9	-3799979.969	-8717938.237	3797715.483	4379094.499
10	-3731195.021	-8675330.919	3772772.631	4399073.028

Table 12: Best Objective Value Per Run
fnl4461_n44600_uncorr_10-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-3928278.93	-8792848.616	3695741.269	4311053.991
2	-4079802.431	-8822746.249	3671907.64	4327650.854
3	-4315152.857	-8682447.005	3630780.621	4285982.655
4	-4065881.637	-8575558.63	3682613.782	4334308.03
5	-4104793.943	-8786239.095	3683187.453	4287351.745
6	-4123120.177	-8828897.807	3704814.708	4317831.494
7	-3823070.651	-8532500.895	3686340.89	4287647.601
8	-4059025.807	-8699870.531	3747272.581	4326806.382
9	-4104412.403	-8644873.369	3675396.956	4299594.798
10	-4072489.596	-8803598.972	3620211.51	4327996.485

Table 13: Best Objective Value Per Run
pla33810_n33809_bounded-strongly-corr_01-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	14032.52127	-1028927.51	1554358.988	1570328.386
2	5787.46491	-1111834.025	1555927.892	1568163.177
3	35404.00294	-949774.7176	1550070.577	1567387.503
4	26576.01446	-1035618.584	1552330.576	1565223.712
5	31211.92793	-1121772.643	1558363.05	1564334.032
6	24528.48335	-1168409.452	1554776.751	1566301.019
7	5433.37961	-1233342.22	1553630.654	1562313.524
8	31165.82353	-1198920.942	1552199.077	1564423.785
9	26886.11792	-1137408.549	1552246.235	1567526.695
10	12782.35607	-1217705.828	1552624.889	1563716.247

Table 14: Best Objective Value Per Run
pla33810_n33809_bounded-strongly-corr_01-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-25367.97888	-1347827.163	1549274.428	1557970.128
2	-20135.09675	-1281962.374	1548304.498	1561584.185
3	8428.709279	-1366931.919	1545596.113	1553098.841
4	-17585.49924	-1293080.235	1543260.338	1559780.935
5	-21100.94248	-1189139.236	1550111.369	1557180.668
6	-37859.19586	-1411739.951	1545400.455	1554828.344
7	-16826.38523	-1400165.817	1549122.76	1558708.65
8	-30516.84953	-1239287.064	1543650.296	1554088.279
9	-13057.41321	-1288331.593	1547891.546	1558699.753
10	-11938.02951	-1230729.728	1549212.227	1554037.211

Table 15: Best Objective Value Per Run
pla33810_n169045_uncorr-similar-weights_05-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-2.04E+07	-2.17E+07	6670891.217	6808311.875
2	-2.03E+07	-2.17E+07	6726629.542	6864207.708
3	-2.04E+07	-2.17E+07	6656787.812	6830617.977
4	-2.03E+07	-2.16E+07	6748795.994	6960090.559
5	-2.03E+07	-2.15E+07	6672321.387	6823192.787
6	-2.02E+07	-2.14E+07	6834868.417	7137979.406
7	-2.04E+07	-2.16E+07	6702073.991	6845835.858
8	-2.04E+07	-2.17E+07	6660440.653	6874738.72
9	-2.04E+07	-2.17E+07	6693469.535	6838674.006
10	-2.04E+07	-2.17E+07	6693933.898	6845572.071

Table 16: Best Objective Value Per Run
pla33810_n169045_uncorr-similar-weights_05-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-2.05E+07	-2.17E+07	6500873.151	6760161.919
2	-2.04E+07	-2.16E+07	6501721.145	6773709.678
3	-2.05E+07	-2.17E+07	6514977.726	6767690.015
4	-2.04E+07	-2.16E+07	6441880.801	6868974.825
5	-2.05E+07	-2.17E+07	6458108.694	6781606.681
6	-2.04E+07	-2.17E+07	6452981.248	6768231.407
7	-2.04E+07	-2.16E+07	6507603.771	6749815.489
8	-2.04E+07	-2.16E+07	6455955.09	6768593.883
9	-2.05E+07	-2.16E+07	6480841.73	6777586.718
10	-2.04E+07	-2.16E+07	6472303.2	6780070.359

Table 17: Best Objective Value Per Run
pla33810_n338090_uncorr_10-benchmark-1

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-6.11E+07	-6.20E+07	5.59E+07	5.60E+07
2	-6.12E+07	-6.20E+07	5.59E+07	5.60E+07
3	-6.11E+07	-6.20E+07	5.60E+07	5.60E+07
4	-6.11E+07	-6.20E+07	5.58E+07	5.60E+07
5	-6.12E+07	-6.20E+07	5.60E+07	5.60E+07
6	-6.14E+07	-6.22E+07	5.58E+07	5.56E+07
7	-6.14E+07	-6.22E+07	5.53E+07	5.60E+07
8	-6.14E+07	-6.21E+07	5.06E+07	5.58E+07
9	-6.13E+07	-6.20E+07	4.80E+07	5.59E+07
10	-6.14E+07	-6.22E+07	4.61E+07	5.59E+07

Table 18: Best Objective Value Per Run
pla33810_n338090_uncorr_10-benchmark-2

Run	OB-Ref-RLS	OB-Ref-11EA	OB-ComplexHeuristic-1	OB-ComplexHeuristic-2
1	-6.12E+07	-6.21E+07	4.66E+07	5.53E+07
2	-6.13E+07	-6.21E+07	5.42E+07	5.60E+07
3	-6.14E+07	-6.22E+07	5.51E+07	5.59E+07
4	-6.14E+07	-6.21E+07	4.60E+07	5.59E+07
5	-6.14E+07	-6.22E+07	5.02E+07	5.60E+07
6	-6.13E+07	-6.21E+07	2.24E+07	5.56E+07
7	-6.14E+07	-6.21E+07	2.24E+07	5.60E+07
8	-6.14E+07	-6.22E+07	2.24E+07	5.59E+07
9	-6.12E+07	-6.22E+07	2.25E+07	5.49E+07
10	-6.13E+07	-6.22E+07	2.25E+07	5.50E+07