A Note on Bound Constraints Handling for the CEC'13 Benchmark Problems: the case of NBIPOP-aCMA-ES and NIPOP-aCMA-ES

Ilya Loshchilov

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1 Performance of NBIPOP-aCMA-ES and NIPOP-aCMA-ES with boundary handling

In the report of the CEC'2013 Special Session & Competition on Real-Parameter Single Objective Optimization [Liang et al., 2013] it is mentioned

" **Search Range**: $[-100, 100]^D$
Initialization: Uniform random initialization within the search space. Random seed is based on time, Matlab users can use rand('state', sum(100*clock)).
Global Optimum: All problems have the global optimum within the given bounds and there is no need to perform search outside of the given bounds for these problems.
"

It leaves room for interpretation how bound constraints are defined and should be handled.

[Liao et al., 2014] noted that there are three most common situations how bound constraints are defined:

" **S1** Bound constraints are defined and are to be enforced at any stage of the search process - solutions outside the bounds are invalid.

S2 Bound constraints are defined and are enforced for the final reported solutions; however, solutions outside the bounds may be evaluated and used to drive the search process.

S3 No bound constraints are defined but bounds may be indicated to provide an initialization range.

”

[Liao et al., 2014] noted that often due to ambiguous definitions of benchmark problems, optimization algorithms launched on the same problems consider different bound constraint situations. The latter may lead to a misinterpretation when different algorithms are compared.

In a personal communication, Ryoji Tanabe mentioned that bound constraints handling is of high importance for the CEC'14 testbed which has multiple local optima outside the search range [Tanabe and Fukunaga, 2014]. The latter affects the performance of NBIPOP-aCMA-ES on the CEC'14 problems (NBIPOP-aCMA-ES participated in 2013 but not in 2014). On the CEC'13 problems, the algorithm considered **S3** scenario as well as for the BBOB framework problems on which it was initially tested [Loshchilov et al., 2012].

We decided to re-run NBIPOP-aCMA-ES and NIPOP-aCMA-ES on the CEC'13 problems with a procedure of bound constraints handing, thus considering **S1** scenario. The only modification of the source code required is to set 'defopts.LBounds = -100' and 'defopts.UBounds = 100' in cmaes_initialize.m file. The resulting algorithms are called NBIPOP-aCMA-ESbh and NIPOP-aCMA-ESbh.

The results are given in Table 1 and Figure 1. The results suggest that the ranking of NBIPOP-aCMA-EShb is the same as for the NIPOP-aCMA-ES, however, NIPOP-aCMA-EShb performs slightly better NIPOP-aCMA-ES.

As well as for the original algorithms, we don't considered the difference in performance of NBIPOP-aCMA-ES and iCMAES-ILS to be statistically significant to select the best algorithm. Indeed, the results for particular problems and dimensions may reveal that one algorithm performs better than the other.

Rank	Algorithm Name	Mean Ranking
1	NBIPOPaCMAbh	0.27570
2	icmaesils	0.28361
3	NIPOPaCMAbh	0.30421
4	DRMA-LSCh-CMA	0.30916
5	SHADE	0.33419
6	mvmo	0.36457
7	SMADE	0.45925
8	TLBSaDE	0.46998
9	DEcfbLS	0.47501
10	b6e6rl	0.48087
11	SPSRDEMMS	0.49761
12	CMAES-RIS	0.50623
13	SPSOABC	0.52293
14	jande	0.53309
15	DE_APC	0.57666
16	fk-PSO	0.58162
17	TPC-GA	0.61019
18	PVADE	0.63780
19	CDASA	0.68685
20	SPSO2011	0.75591
21	PLES	0.83455

Table 1: The Table gives the mean aggregated rank of **all the 21 algorithms** ($N = 21$) across all problems and all dimensions from the CEC 2013 Special Session & Competition on Real-Parameter Single Objective Optimization after the maximum available number of function evaluations was used.

2 Acknowledges

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References

[Liang et al., 2013] Liang, J., Qu, B., Suganthan, P., and Hernández-Dıaz, A. G. (2013). Problem definitions and evaluation criteria for the cec 2013 special session on real-parameter optimization. *Computational Intelligence*

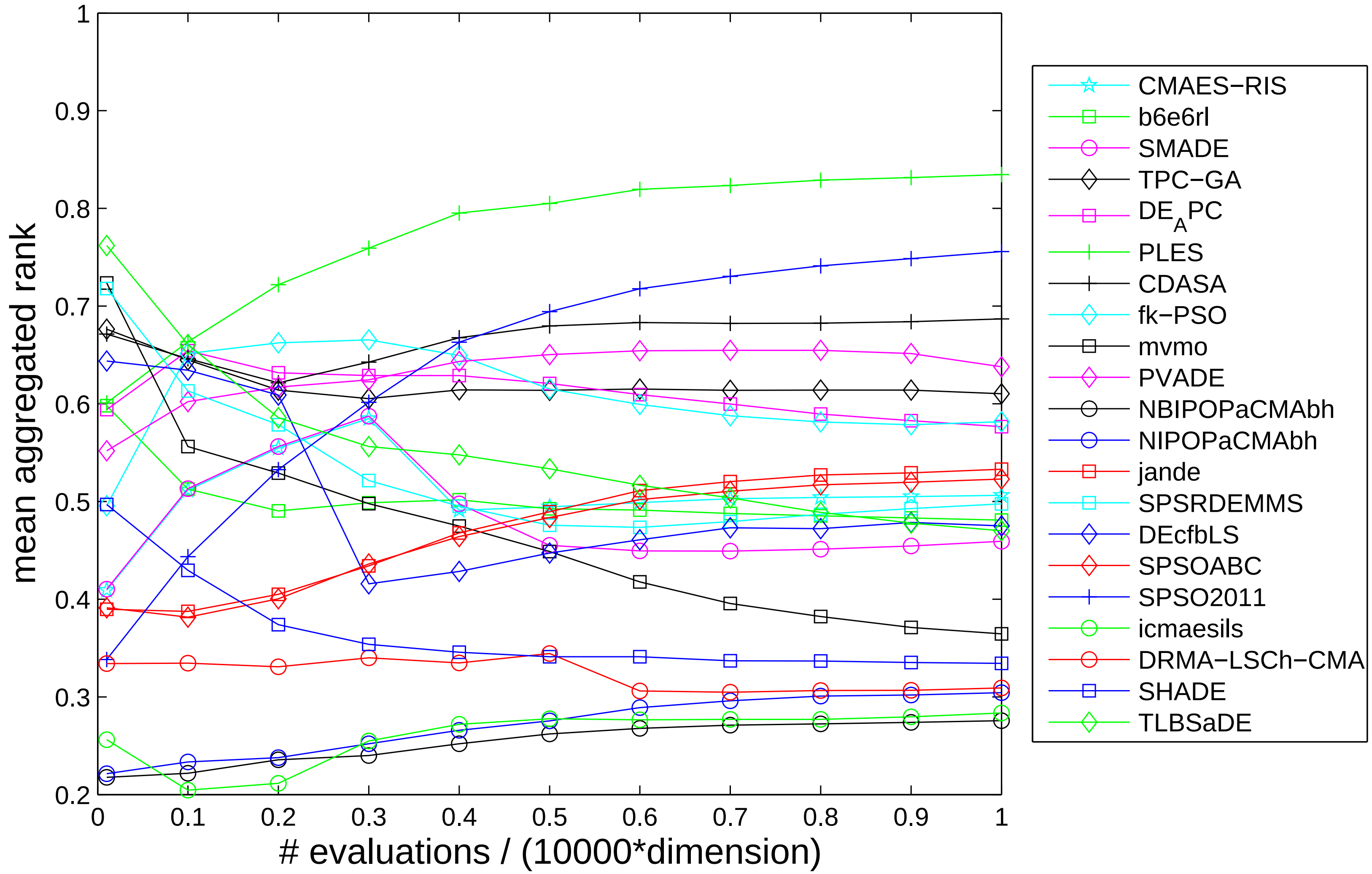

Figure 1: The Figure gives the mean aggregated rank of **all the 21 algorithms** ($N = 21$) across all problems and all dimensions from the CEC 2013 Special Session & Competition on Real-Parameter Single Objective Optimization. The mean aggregated rank is given in dependence of the computational budget as measured by the fraction of the number of function evaluations with respect to the maximum available number of function evaluations.

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