

Testing AlphaECP version 2.11.01

In this study we compare the results of solving problems from MINLPLib library (26.8.2020) with AlphaECP v2.10.06 (old version) and v2.11.01 (new version) in GAMS (34.3.0). The program is used on a laptop computer with Windows 10, 16GB RAM and 2.2GHz i7-8750H processor. We only consider MINLP problems and, thus, NLP problems are omitted. There are 432 convex MINLP problems in the MINLP library that we tried to solve. When solving the convex problems, we use the parameter settings ECPmaster=1 and reslim=1000. Otherwise the default parameters are used. To show the effect of parameter choice ECPmaster=1 we also solved the problems with ECPmaster=0. The results are presented in Table 1. The first row corresponds to the parameter choice ECPmaster=0 and it turned out to be less efficient than choice ECPmaster=1 (second row), as expected. On the third row, when using the new version there were 78 problems where the relative termination criterion stopped the algorithm before the constraint tolerance was met. Note that most of the total time is consumed in the problems where the algorithm could not stop before the 1000 second time limit. For example with the new version the time used in these problems are $85 * 1000/60 \approx 1417$ minutes being 85 % of the total time.

Table 1: Results on how many convex MINLP problems were solved in 1000 seconds.

Version	<0.01% from the best	<0.1% from the best	<10% from the best	time limit break	total time (minutes)
v2.10.06d	351	362	393	107	2082
v2.10.06	362	376	402	88	1708
v2.11.01	362	377	402	85	1665

On table 2 different versions are compared by listing how many problems were solved in certain amount of time.

In the new version there is option MIPoptimaliter which defines the frequency to solve the MIP problems to optimum. Solving the current MIP problem to optimum will give a tight lower bound for it which may

be used to check the relative stopping criterion. Using this option basically gives a different solution sequence if solving goes beyond MIPoptimaliter. When comparing default MIPoptimaliter=0 (the option is not used) and MIPoptimaliter=50 with the new version and ECPmaster=1 on the convex MINLP problems some problems were solved faster or to a better solution but some were not. It is notable to mention that for problems p_ball_10b_5p_3d_h.gms, slay09m.gms and unitcommit1.gms AlphaECP terminated with a solution over 200 seconds faster.

Table 2: Results on how many convex MINLP problems were solved after a certain time.

time (s.)	v2.10.06d	v2.10.06	v2.11.01
3	147	193	197
5	171	222	225
10	213	250	254
50	264	292	293
100	287	306	308
500	313	338	340
900	323	343	346

The results for nonconvex problems are presented in Table 3. We set `reslim=1000` and the other parameters have default values. There are in total 697 nonconvex MINLP problems in the MINLP library we used.

Table 3: Results when solving nonconvex MINLP problems.

Version	<0.01% from the best	<0.1% from the best	<10% from the best	time limit break	total time (minutes)
v2.10.06	195	205	409	195	4071
v2.11.01	195	205	410	195	3837

Most of the time difference is explained by improved efficiency in certain parts of the code which results in that in some problems the algorithm does not run over time limit. There are 5 problems that are solved with the old version significantly over time limit (> 60 s). These increase the total time by 232 minutes. In addition, the improvement reduced the solving time of a single problem by 75 seconds. If this problem and the aforementioned 5 problems are omitted the total times are essentially the same for both versions of the algorithm.

Names of the considered problems are:

MINLPLib-Convex

alan.gms
ball_mk2_10.gms
ball_mk2_30.gms
ball_mk3_10.gms
ball_mk3_20.gms
ball_mk3_30.gms
ball_mk4_05.gms
ball_mk4_10.gms
ball_mk4_15.gms
batch.gms
batch0812.gms
batchdes.gms
batchs101006m.gms
batchs121208m.gms
batchs151208m.gms
batchs201210m.gms
clay0203h.gms
clay0203hfsg.gms
clay0203m.gms
clay0204h.gms
clay0204hfsg.gms
clay0204m.gms
clay0205h.gms
clay0205hfsg.gms
clay0205m.gms
clay0303h.gms
clay0303hfsg.gms
clay0303m.gms
clay0304h.gms
clay0304hfsg.gms
clay0304m.gms
clay0305h.gms
clay0305hfsg.gms
clay0305m.gms
color_lab2_4x0.gms
color_lab6b_4x20.gms
cvxnonsep_normcon20.gms
cvxnonsep_normcon20r.gms
cvxnonsep_normcon30.gms
cvxnonsep_normcon30r.gms
cvxnonsep_normcon40.gms
cvxnonsep_normcon40r.gms
cvxnonsep_nsig20.gms
cvxnonsep_nsig20r.gms
cvxnonsep_nsig30.gms

cvxnonsep_nsig30r.gms
cvxnonsep_nsig40.gms
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cvxnonsep_pcon40r.gms
cvxnonsep_psig20.gms
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cvxnonsep_psig40r.gms
du-opt.gms
du-opt5.gms
enpro48pb.gms
enpro56pb.gms
ex1223.gms
ex1223a.gms
ex1223b.gms
ex4.gms
fac1.gms
fac2.gms
fac3.gms
flay02h.gms
flay02m.gms
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fo7_2.gms
fo7_ar25_1.gms
fo7_ar2_1.gms
fo7_ar3_1.gms
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fo7_ar5_1.gms
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hybriddynamic_fixed.gms
ibs2.gms
jit1.gms
m3.gms
m6.gms
m7.gms
m7_ar25_1.gms
m7_ar2_1.gms
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m7_ar5_1.gms
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meanvarxsc.gms
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netmod_kar1.gms
netmod_kar2.gms
no7_ar25_1.gms
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pedigree_ex485_2.gms
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unitcommit_200_100_2_mod_8.gms
unitcommit_50_20_2_mod_8.gms
watercontamination0202.gms

watercontamination0202r.gms
watercontamination0303.gms
watercontamination0303r.gms

MINLPLib-Nonconvex

4stufen.gms
autocorr_bern20-03.gms
autocorr_bern20-05.gms
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chimera_rfr-01.gms
chimera_rfr-02.gms
chimera_selby-c16-01.gms
chimera_selby-c16-02.gms
chimera_selby-c8-onc8-01.gms
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crudeoil_li11.gms
crudeoil_li21.gms
crudeoil_pooling_ct1.gms
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deb6.gms
deb7.gms
deb8.gms
deb9.gms
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dosemin3d.gms
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edgexcross10-030.gms
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