Comparison Tables: BBOB 2013 Testbed in 2-D (Expensive Setting)

The BBOBies

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Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2013 with a focus on benchmarking black-box algorithms for small function evaluation budgets ("expensive setting"), see `http://coco.gforge.inria.fr/doku.php?id=bbob-2013`. About 30 algorithms have been tested on 24 benchmark functions in dimensions between 2 and 40. A description of the used objective functions can be found in [6, 4]. The experimental set-up is described in [5].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm in BBOB-2009 (see [2]) if an algorithm from BBOB-2009 reached the given target function value. The ERT value is given otherwise ($\mathrm{ERT}_{\mathrm{best}}$ is noted as infinite). See [5] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values. Table 1 gives an overview on all algorithms submitted to the noise-free testbed in 2013.

Table 1: Names and references of all algorithms submitted for the noise-free testbed

algorithm short name	paper	reference
BIPOP-aCMA-STEP los	BI-Population CMA-ES Algorithms with Surrogate Models and Line Searches (Page 1177)	[11]
BIPOP-saACM-k los	BI-Population CMA-ES Algorithms with Surrogate Models and Line Searches (Page 1177)	[11]
CMAES hut	An Evaluation of Sequential Model-Based Optimization for Expensive Blackbox Functions (Page 1209)	[8]
DE pal	Benchmarking a Hybrid Multi Level Single Linkage Algorithm on the BBOB Noiseless Testbed	[12]
HCMA los	BI-Population CMA-ES Algorithms with Surrogate Models and Line Searches (Page 1177)	[11]
HMLSL pal	Benchmarking a Hybrid Multi Level Single Linkage Algorithm on the BBOB Noiseless Testbed	[12]
IPOP-10DDr lia	Bounding the Population Size of IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 1161)	[9]
IPOP-500 lia	Bounding the Population Size of IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 1161)	[9]
IPOP-tany lia	Testing the Impact of Parameter Tuning on a Variant of IPOP-CMA-ES with a Bounded Maximum Population Size on the Noiseless BBOB Testbed (Page 1169)	[10]
IPOP-texp lia	Testing the Impact of Parameter Tuning on a Variant of IPOP-CMA-ES with a Bounded Maximum Population Size on the Noiseless BBOB Testbed (Page 1169)	[10]
IPOP lia	Bounding the Population Size of IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 1161)	[9]
	Testing the Impact of Parameter Tuning on a Variant of IPOP-CMA-ES with a Bounded Maximum Population Size on the Noiseless BBOB Testbed (Page 1169)	[10]
MLSL pal	Benchmarking a Hybrid Multi Level Single Linkage Algorithm on the BBOB Noiseless Testbed	[12]
OQNLP pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]
P-DCN tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
P-zero tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
SMAC hut	An Evaluation of Sequential Model-Based Optimization for Expensive Blackbox Functions (Page 1209)	[8]
U-DCN tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
U-zero tra	Multiobjectivization with NSGA-II on the Noiseless BBOB Testbed (Page 1217)	[15]
fmincon pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]
fminunc pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]
ga100 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
grid100 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
grid16 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
hill hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
lmmCMA aug	Benchmarking the Local Metamodel CMA-ES on the Noiseless BBOB'2013 Test Bed (Page 1225)	[1]
memPSODE vog	Adapt-MEMPSODE: A Memetic Algorithm with Adaptive Selection of Local Searches (Page 1137)	[16]
prcga saw	Benchmarking Projection-Based Real Coded Genetic Algorithm on BBOB-2013 Noiseless Function Testbed (Page 1193)	[14]
ring100 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
ring16 hol	Benchmarking Cellular Genetic Algorithms on the BBOB Noiseless Testbed (Page 1201)	[7]
simplex pal	Comparison of Multistart Global Optimization Algorithms on the BBOB Noiseless Testbed (Page 1153)	[13]

Table 2: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_1 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f1	*1.6e+1*:1.2	*4.0e+0*:2.6	*2.5e-2*:6.2	*1.0e-8*:6.2	*1.0e-8*:6.2	15/15
BIPOP-aCMA	**2.4**(1)	4.1(3)	5.2(1.0)	11(0.5)	11(0.5)	15/15
BIPOP-saAC	5.8(5)	6.5(6)	10(4)	21(2)	21(2)	15/15
CMAES hut	4.4(9)	4.1(5)	11(4)	166(150)	166(166)	3/15
DE pal	**2.4**(2)	**2.1**(2)	14(11)	76(9)	76(9)	15/15
HCMA los	3.3(2)	**2.2**(0)	**0.97**(0)$^{\star 4}$	**0.97**(0)$^{\star 4}$	**0.97**(0)$^{\star 4}$	15/15
HMLSL pal	**1.5**(1)	**1.5**(1)	**1.8**(0.5)	**3.1**(0.5)	**3.1**(0.5)	15/15
IPOP-10DDr	**1.7**(0.8)	**2.9**(2)	9.3(3)	36(3)	36(3)	15/15
IPOP-500 l	**1.7**(0.8)	**2.9**(2)	9.3(3)	36(3)	36(3)	15/15
IPOP-tany	**1.7**(0.8)	**2.7**(2)	10(2)	33(3)	33(3)	15/15
IPOP-texp	4.3(7)	4.8(5)	7.4(4)	35(5)	35(5)	15/15
IPOP lia	**1.7**(0.8)	**2.9**(2)	9.3(3)	36(3)	36(3)	15/15
MLSL pal	**1.5**(1)	**1.5**(1)	**1.8**(0.5)	**3.1**(0.5)	**3.1**(0.5)	15/15
OQNLP pal	3.3(5)	3.8(2)	**2.8**(0.6)	3.2(0.7)	3.2(0.7)	15/15
P-DCN tra	**1.3**(0.8)	3.5(3)	22(14)	281(150)	281(150)	15/15
P-zero tra	**1.3**(0.8)	3.3(4)	16(12)	1404(1414)	1404(1414)	15/15
SMAC hut	**1.6**(1)	**1.9**(1)	**2.4**(0.6)	∞	∞ *200*	0/15
U-DCN tra	**1.3**(0.8)	3.3(5)	29(26)	3261(4538)	3261(4538)	15/15
U-zero tra	**1.3**(0.8)	**2.2**(2)	32(31)	5.5e4(4e4)	5.5e4(4e4)	15/15
fmincon pa	**1.5**(1)	**1.5**(1)	**1.8**(0.5)	**3.1**(0.5)	**3.1**(0.5)	15/15
fminunc pa	**1.5**(1)	**2.0**(1)	**1.1**(0)	**1.1**(0)	**1.1**(0)	15/15
ga100 hol	**2.6**(3)	**2.8**(3)	65(48)	2.3e5(2e5)	2.3e5(3e5)	1/15
grid100 ho	**2.6**(2)	**2.5**(2)	103(80)	2.4e5(3e5)	2.4e5(2e5)	1/15
grid16 hol	**2.3**(2)	3.7(2)	44(32)	7.3e4(8e4)	7.3e4(8e4)	3/15
hill hol	6.5(8)	4.6(4)	18(12)	2.9e4(3e4)	2.9e4(3e4)	7/15
lmmCMA aug	**1.8**(2)	**2.9**(3)	3.6(0.9)	8.8(0.8)	8.8(0.8)	15/15
memPSODE v	3.2(3)	3.3(2)	18(8)	78(27)	78(27)	15/15
prcga saw	**1.9**(1)	**2.3**(2)	31(35)	247(165)	247(165)	15/15
ring100 ho	**2.1**(2)	**2.7**(3)	77(70)	7.5e4(8e4)	7.5e4(9e4)	3/15
ring16 hol	**1.9**(2)	**2.4**(3)	45(24)	5.5e4(6e4)	5.5e4(6e4)	4/15
simplex pa	8.0(13)	13(14)	12(4)	20(3)	20(3)	15/15

Table 3: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_2 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f2	*1.0e+7*:1.4	*1.6e+6*:2.7	*1.0e+5*:6.1	*6.3e-1*:20	*1.0e-8*:30	15/15
BIPOP-aCMA	**1.7**(1)	3.4(3)	**2.7**(1)	**2.8**(0.4)	**3.7**(0.7)	15/15
BIPOP-saAC	**1.7**(1)	**2.5**(2)	**2.5**(3)	6.9(2)	7.5(2)	15/15
CMAES hut	**1.6**(1)	**2.1**(3)	3.1(3)	36(36)	∞ *206*	0/15
DE pal	**1.2**(0.4)	**1.4**(1)	**1.4**(1)	12(4)	23(4)	15/15
HCMA los	**2.4**(2)	**1.8**(0.9)	**0.98**(0.6)	4.2(4)	6.3(3)	15/15
HMLSL pal	**1.4**(1)	3.1(3)	**2.0**(1)	**1.4**(0.5)	**2.8**(0.6)	15/15
IPOP-10DDr	**1.1**(1)	**2.2**(1)	**2.8**(2)	27(2)	28(1)	15/15
IPOP-500 l	**1.1**(1)	**2.2**(1)	**2.8**(2)	27(2)	28(1)	15/15
IPOP-tany	**1.2**(1)	**2.3**(1)	**1.9**(1)	22(10)	27(1)	15/15
IPOP-texp	**1.4**(2)	**2.8**(2)	**2.0**(0.9)	20(11)	26(3)	15/15
IPOP lia	**1.1**(1)	**2.2**(1)	**2.8**(2)	27(2)	28(1)	15/15
MLSL pal	**1.4**(1)	3.1(3)	**2.0**(1)	**1.4**(0.5)	**2.8**(0.6)	15/15
OQNLP pal	**2.9**(4)	4.0(2)	**2.6**(2)	3.5(1)	103(118)	6/15
P-DCN tra	**0.95**(0.4)	**1.3**(0.9)	**3.0**(5)	17(15)	1575(357)	15/15
P-zero tra	**0.95**(0.4)	**1.6**(0.9)	3.2(4)	27(20)	1.0e5(1e5)	7/15
SMAC hut	**1.4**(1)	**1.4**(1)	**1.1**(0.7)	32(33)	∞ *200*	0/15
U-DCN tra	**0.95**(0.4)	**1.2**(0.9)	**1.8**(2)	177(238)	2.8e4(4e4)	11/15
U-zero tra	**0.95**(0.4)	**1.2**(0.9)	**1.9**(2)	1214(824)	∞ *2e6*	0/15
fmincon pa	**1.4**(1)	3.1(3)	**2.0**(1)	**1.4**(0.5)	**2.8**(0.6)	15/15
fminunc pa	**1.4**(1)	**2.4**(2)	**1.5**(0.7)	**2.9**(2)	**4.0**(0.8)	15/15
ga100 hol	**1.6**(1)	**1.5**(1)	**2.9**(3)	269(350)	∞ *1e5*	0/15
grid100 ho	**1.4**(2)	**2.0**(2)	3.6(4)	291(145)	∞ *1e5*	0/15
grid16 hol	**1.3**(0.7)	**1.6**(1)	3.9(5)	463(338)	∞ *1e5*	0/15
hill hol	5.0(4)	4.5(4)	3.8(3)	247(370)	∞ *1e5*	0/15
lmmCMA aug	**1.4**(1)	**2.3**(3)	**1.8**(1)	4.8(1)	5.3(0.6)	15/15
memPSODE v	**1.5**(1)	**2.6**(5)	**2.6**(2)	63(51)	58(21)	15/15
prcga saw	**1.8**(2)	**1.9**(2)	7.4(13)	18(7)	111(130)	15/15
ring100 ho	**1.3**(1)	**1.5**(1)	4.9(5)	657(1063)	∞ *1e5*	0/15
ring16 hol	**1.0**(0.7)	**1.3**(1)	6.8(10)	355(490)	∞ *1e5*	0/15
simplex pa	6.8(11)	10(7)	5.5(1.0)	4.8(2)	5.7(0.6)	15/15

Table 4: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_3 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f3	*1.0e+2*:1.4	*4.0e+1*:4.1	*2.5e+1*:6.6	*6.3e+0*:26	*2.5e+0*:112	15/15
BIPOP-aCMA	**2.1**(2)	**2.5**(2)	**2.3**(1)	**1.9**(1)	**1.7**(3)	15/15
BIPOP-saAC	3.0(4)	**2.7**(3)	10(26)	5.6(7)	**2.8**(2)	15/15
CMAES hut	3.6(4)	3.4(5)	4.3(4)	3.4(3)	3.6(4)	6/15
DE pal	**2.3**(1)	**1.7**(2)	**2.3**(2)	**3.0**(2)	**1.3**(0.9)	15/15
HCMA los	**2.0**(2)	**2.3**(1)	**2.1**(2)	**1.7**(1)	**0.82**(0.5)	15/15
HMLSL pal	8.1(18)	6.0(7)	5.1(5)	4.5(3)	**2.0**(1)	15/15
IPOP-10DDr	**2.2**(2)	**1.7**(2)	**1.8**(1)	6.3(14)	4.7(4)	15/15
IPOP-500 l	**2.2**(2)	**1.7**(2)	**1.8**(1)	6.3(14)	4.7(4)	15/15
IPOP-tany	**2.2**(2)	**1.5**(2)	**2.4**(3)	**2.2**(2)	3.3(4)	15/15
IPOP-texp	**2.4**(2)	**1.8**(2)	**2.0**(2)	7.9(13)	5.2(3)	15/15
IPOP lia	**2.2**(2)	**1.7**(2)	**1.8**(1)	6.3(14)	4.7(4)	15/15
MLSL pal	8.2(17)	5.9(8)	5.3(6)	5.8(5)	**2.7**(2)	15/15
OQNLP pal	28(49)	19(18)	13(11)	10(3)	3.6(3)	15/15
P-DCN tra	**1.6**(1)	**1.5**(2)	**2.3**(2)	543(62)	297(477)	15/15
P-zero tra	**1.6**(1)	**1.4**(2)	**2.6**(2)	524(1632)	434(709)	15/15
SMAC hut	**1.5**(2)	**1.2**(1)	**1.7**(1)	**2.4**(2)	**1.7**(1)	11/15
U-DCN tra	**1.6**(1)	**1.4**(1)	**2.6**(2)	3.9(4)	**2.5**(2)	15/15
U-zero tra	**1.6**(1)	**1.4**(2)	3.4(3)	3.3(2)	**1.8**(2)	15/15
fmincon pa	8.2(17)	6.0(7)	5.2(4)	4.6(4)	**2.1**(2)	15/15
fminunc pa	6.7(12)	4.3(6)	6.3(8)	4.4(4)	**2.9**(3)	15/15
ga100 hol	**1.6**(1)	**2.0**(3)	**2.9**(2)	7.9(8)	3.5(3)	15/15
grid100 ho	**1.7**(1)	**2.5**(3)	4.4(6)	14(15)	10(5)	15/15
grid16 hol	**1.7**(2)	**1.5**(2)	3.6(4)	4.6(4)	**2.1**(2)	15/15
hill hol	4.1(6)	3.1(2)	**2.5**(2)	**2.2**(2)	**1.4**(0.9)	15/15
lmmCMA aug	**1.2**(1)	**1.8**(1)	**1.8**(0.9)	**2.8**(4)	**2.3**(2)	15/15
memPSODE v	**2.2**(1)	**1.7**(1)	**2.2**(3)	8.8(15)	3.4(5)	15/15
prcga saw	**1.4**(1)	**2.2**(2)	**2.9**(5)	**2.9**(3)	**1.9**(1)	15/15
ring100 ho	**1.4**(1)	**1.4**(0.7)	**2.7**(3)	15(16)	6.1(5)	15/15
ring16 hol	**1.2**(1)	**0.90**(0.9)	**1.3**(1.0)	6.2(6)	**2.5**(2)	15/15
simplex pa	45(54)	24(20)	18(11)	11(3)	4.4(4)	15/15

Table 5: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_4 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f4	*6.3e+1*:2.4	*4.0e+1*:5.2	*2.5e+1*:8.5	*1.0e+1*:22	*2.5e+0*:120	5/5
BIPOP-aCMA	3.0(3)	**2.4**(2)	**2.6**(2)	**1.8**(1)	**1.8**(0.6)	15/15
BIPOP-saAC	**2.8**(2)	**1.7**(2)	**2.3**(2)	**2.7**(2)	4.5(4)	15/15
CMAES hut	3.6(5)	**2.8**(3)	**2.7**(3)	**2.2**(2)	4.4(5)	5/15
DE pal	**1**(0.6)	**1.3**(2)	**2.2**(2)	3.2(3)	**1.5**(0.8)	15/15
HCMA los	**2.4**(1)	**2.1**(0.8)	**2.0**(2)	**2.0**(1)	**1.2**(0.6)	15/15
HMLSL pal	5.6(11)	4.4(5)	3.4(3)	4.7(4)	**2.2**(2)	15/15
IPOP-10DDr	**1.6**(2)	**1.8**(2)	3.1(3)	10(16)	8.8(8)	15/15
IPOP-500 l	**1.6**(2)	**1.8**(2)	3.1(3)	10(16)	8.9(8)	15/15
IPOP-tany	**1.4**(1)	**1.1**(0.9)	**1.4**(1)	4.3(3)	13(12)	15/15
IPOP-texp	**2.3**(2)	**1.5**(2)	**1.3**(1)	**1.0**(1)	11(16)	15/15
IPOP lia	**1.6**(2)	**1.8**(2)	3.1(3)	10(16)	8.9(8)	15/15
MLSL pal	5.6(10)	4.6(6)	3.5(3)	4.9(5)	**2.9**(3)	15/15
OQNLP pal	20(29)	15(15)	10(10)	8.7(6)	11(14)	12/15
P-DCN tra	**1.5**(1)	**1.3**(1)	**1.9**(2)	5.4(4)	596(865)	15/15
P-zero tra	**1.5**(1)	**1.2**(1)	**1.7**(1)	**2.5**(1)	400(1111)	15/15
SMAC hut	**0.97**(1)	**0.95**(0.8)	**1.1**(0.9)	**2.5**(3)	**2.0**(2)	9/15
U-DCN tra	**1.5**(1)	**1.0**(0.7)	**2.1**(2)	3.7(2)	**1.8**(1)	15/15
U-zero tra	**1.5**(1)	**1.1**(0.8)	**2.5**(2)	3.3(2)	**2.3**(1)	15/15
fmincon pa	5.5(11)	4.5(6)	3.4(4)	4.6(4)	4.1(4)	15/15
fminunc pa	7.1(11)	3.8(5)	3.4(3)	3.6(3)	4.9(3)	15/15
ga100 hol	**1.8**(2)	**1.7**(2)	4.5(4)	6.9(6)	6.4(2)	15/15
grid100 ho	**1.4**(0.6)	**1.8**(2)	**2.3**(2)	14(12)	13(10)	15/15
grid16 hol	**1.6**(1)	**2.1**(3)	4.7(6)	6.0(5)	4.3(4)	15/15
hill hol	**2.9**(4)	**2.2**(2)	**2.2**(2)	**1.7**(2)	**2.0**(1)	15/15
lmmCMA aug	**1.6**(2)	**1.2**(0.8)	**1.4**(1)	**2.2**(2)	4.1(7)	13/15
memPSODE v	**2.5**(2)	3.6(3)	4.7(4)	3.6(2)	5.2(9)	15/15
prcga saw	**1.4**(1)	**1.1**(0.9)	**2.6**(3)	**2.9**(2)	6.1(10)	15/15
ring100 ho	**1.7**(1)	**2.2**(3)	**2.7**(3)	12(10)	10(5)	15/15
ring16 hol	**2.7**(1)	3.1(5)	4.3(4)	5.3(5)	**2.8**(2)	15/15
simplex pa	33(34)	29(18)	19(11)	11(5)	7.4(6)	15/15

Table 6: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_5 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f5	*4.0e+1*:1.4	*1.6e+1*:3.5	*1.0e-8*:4.4	*1.0e-8*:4.4	*1.0e-8*:4.4	15/15
BIPOP-aCMA	**2.0**(1)	**1.1**(0.4)	**1.4**(0)	**1.4**(0)	**1.4**(0)	15/15
BIPOP-saAC	3.3(5)	3.1(2)	5.5(2)	5.5(2)	5.5(2)	15/15
CMAES hut	5.0(4)	3.5(3)	5.5(3)	5.5(3)	5.5(3)	15/15
DE pal	**1.9**(1)	**2.7**(3)	357(34)	357(34)	357(34)	15/15
HCMA los	**2.3**(1)	**1.2**(0.3)	**1.5**(0.2)	**1.5**(0.2)	**1.5**(0.2)	15/15
HMLSL pal	**2.9**(0)	**1.2**(0)	46(49)	46(49)	46(49)	15/15
IPOP-10DDr	3.0(1)	**1.9**(0.1)	**3.8**(0.5)	**3.8**(0.5)	**3.8**(0.5)	15/15
IPOP-500 l	3.0(1)	**1.9**(0.1)	**3.8**(0.5)	**3.8**(0.5)	**3.8**(0.5)	15/15
IPOP-tany	3.0(1)	**2.2**(0.3)	8.6(6)	8.6(6)	8.6(6)	15/15
IPOP-texp	6.7(2)	5.0(0.1)	43(27)	43(27)	43(27)	15/15
IPOP lia	3.0(1)	**1.9**(0.1)	**3.8**(0.5)	**3.8**(0.5)	**3.8**(0.5)	15/15
MLSL pal	**2.9**(0)	**1.2**(0)	26(34)	26(34)	26(34)	15/15
OQNLP pal	9.3(0)	4.3(0)	4.1(0)	4.1(0)	4.1(0)	15/15
P-DCN tra	**1.1**(0.4)	**1.3**(0.7)	226(38)	226(38)	226(38)	15/15
P-zero tra	**1.1**(0.4)	**1.3**(0.7)	115(43)	115(43)	115(43)	15/15
SMAC hut	**2.1**(0.7)	**1**(0.1)	**1.1**(0.2)	**1.1**(0.2)	**1.1**(0.2)	15/15
U-DCN tra	**1.1**(0.4)	**1.3**(0.7)	6.7e6(7e6)	6.7e6(7e6)	6.7e6(7e6)	1/15
U-zero tra	**1.1**(0.4)	**1.3**(0.7)	∞	∞	∞ *2e6*	0/15
fmincon pa	**2.9**(0)	**1.2**(0)	20(20)	20(20)	20(20)	15/15
fminunc pa	5.0(0)	**2.0**(0)	**3.0**(0)	**3.0**(0)	**3.0**(0)	15/15
ga100 hol	**2.3**(3)	**2.2**(2)	59(30)	59(30)	59(30)	15/15
grid100 ho	**1.7**(1)	**2.4**(2)	85(76)	85(76)	85(76)	15/15
grid16 hol	**2.1**(2)	**2.7**(2)	35(23)	35(23)	35(23)	15/15
hill hol	5.7(10)	3.5(4)	7.2(5)	7.2(5)	7.2(5)	15/15
lmmCMA aug	5.5(4)	3.8(2)	5.1(2)	5.1(2)	5.1(2)	15/15
memPSODE v	**2.9**(2)	**2.6**(1)	8.4(6)	8.4(6)	8.4(6)	15/15
prcga saw	**2.0**(2)	11(17)	3.6e5(4e5)	3.6e5(4e5)	3.6e5(4e5)	1/15
ring100 ho	**1.9**(1)	**2.0**(2)	78(40)	78(40)	78(40)	15/15
ring16 hol	**1.8**(2)	3.2(4)	33(20)	33(20)	33(20)	15/15
simplex pa	25(0)	11(0.1)	37(41)	37(41)	37(41)	15/15

Table 7: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_6 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f6	*6.3e+4*:1.4	*1.0e+2*:2.8	*1.6e+1*:10	*1.0e+0*:23	*2.5e-6*:103	15/15
BIPOP-aCMA	**1**(0.7)	**2.6**(2)	4.3(5)	4.7(3)	4.4(0.8)	15/15
BIPOP-saAC	3.5(4)	3.4(6)	**2.3**(4)	4.0(4)	4.3(3)	15/15
CMAES hut	3.1(6)	3.5(4)	**2.7**(2)	3.5(2)	∞ *206*	0/15
DE pal	**1.3**(0.7)	**2.9**(4)	**1.6**(1)	3.5(2)	10(3)	15/15
HCMA los	**1.4**(1)	**2.4**(2)	**3.0**(3)	5.9(3)	5.0(2)	15/15
HMLSL pal	**1.3**(1)	3.3(4)	**1.7**(1)	**1.6**(0.6)	**1.1**(0.4)	15/15
IPOP-10DDr	**1.7**(2)	**1.6**(1)	**1.2**(1)	3.8(3)	4.1(0.9)	15/15
IPOP-500 l	**1.7**(2)	**1.6**(1)	**1.2**(1)	3.8(3)	4.1(0.9)	15/15
IPOP-tany	**1.8**(2)	**1.9**(1)	**1.2**(2)	**3.0**(2)	4.2(0.7)	15/15
IPOP-texp	**2.8**(4)	3.5(3)	**2.1**(2)	3.9(3)	4.5(2)	15/15
IPOP lia	**1.7**(2)	**1.6**(1)	**1.2**(1)	3.8(3)	4.1(0.9)	15/15
MLSL pal	**1.3**(1)	3.3(4)	**1.7**(1)	**1.6**(0.6)	**1.1**(0.4)	15/15
OQNLP pal	**2.9**(5)	3.9(4)	**2.0**(1)	**2.5**(2)	**2.5**(2)	15/15
P-DCN tra	**1.0**(0.4)	4.0(2)	3.7(6)	6.7(6)	43(31)	15/15
P-zero tra	**1.0**(0.4)	6.0(3)	4.0(10)	8.2(7)	188(157)	15/15
SMAC hut	**0.90**(0.4)	**1.3**(1)	**0.98**(0.9)	9.2(9)	∞ *200*	0/15
U-DCN tra	**1.0**(0.4)	**1.3**(2)	**0.95**(0.8)	6.2(5)	6123(9749)	13/15
U-zero tra	**1.0**(0.4)	**1.2**(1)	**0.93**(1)	12(19)	2.0e4(3e4)	9/15
fmincon pa	**1.3**(1)	3.3(4)	**1.7**(1)	**1.6**(0.6)	**1.1**(0.4)	15/15
fminunc pa	**1.9**(2)	**2.9**(3)	**1.6**(1)	**2.6**(2)	**1.9**(1)	15/15
ga100 hol	**1**(0.4)	**1.5**(2)	**1.8**(2)	16(15)	∞ *1e5*	0/15
grid100 ho	**1.4**(1)	**1.9**(2)	**2.1**(3)	22(23)	∞ *1e5*	0/15
grid16 hol	**1.1**(0.7)	**2.9**(3)	**2.5**(3)	17(18)	7066(7757)	2/15
hill hol	**2.4**(3)	**2.1**(2)	**1.7**(2)	5.6(4)	7195(7757)	2/15
lmmCMA aug	**1**(1)	**1.3**(0.9)	**0.89**(0.8)	**2.6**(2)	**2.8**(0.6)	15/15
memPSODE v	**1.7**(1)	**2.0**(2)	**2.8**(2)	4.1(2)	7.3(3)	15/15
prcga saw	**1.5**(1)	**2.0**(2)	**2.0**(2)	26(43)	174(207)	15/15
ring100 ho	**1.2**(0.4)	**1.5**(2)	**2.0**(1)	13(15)	∞ *1e5*	0/15
ring16 hol	**1.3**(1)	**2.4**(2)	**2.5**(3)	13(9)	7039(7272)	2/15
simplex pa	6.7(12)	11(15)	5.1(3)	4.4(2)	**1.8**(0.5)	15/15

Table 8: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_7 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f7	*4.0e+2*:1.6	*1.0e+1*:3.2	*2.5e+0*:14	*1.6e+0*:21	*1.6e-2*:188	15/15
BIPOP-aCMA	**1.2**(0.6)	4.3(4)	**2.8**(4)	3.4(3)	**1.2**(0.7)	15/15
BIPOP-saAC	**2.5**(4)	5.4(3)	**2.8**(3)	**2.9**(4)	**1.1**(0.9)	15/15
CMAES hut	**2.5**(2)	5.9(6)	3.0(3)	**2.8**(4)	**1.3**(1)	9/15
DE pal	**0.87**(0.3)	4.6(6)	3.1(3)	**2.5**(2)	**1.5**(0.5)	15/15
HCMA los	**1.5**(1)	**2.8**(1)	**2.5**(3)	3.2(3)	**1.6**(0.8)	15/15
HMLSL pal	**1.6**(1)	3.9(5)	**2.3**(2)	**2.8**(3)	**2.2**(2)	15/15
IPOP-10DDr	**0.96**(0.6)	4.1(4)	**1.7**(2)	3.9(7)	**1.7**(2)	15/15
IPOP-500 l	**0.96**(0.6)	4.1(4)	**1.7**(2)	3.9(7)	**1.7**(2)	15/15
IPOP-tany	**1.2**(0.6)	3.6(3)	**2.8**(2)	3.8(6)	**2.0**(2)	15/15
IPOP-texp	**2.0**(3)	3.9(4)	3.5(2)	3.2(5)	**1.6**(1.0)	15/15
IPOP lia	**0.96**(0.6)	4.1(4)	**1.7**(2)	3.9(7)	**1.7**(2)	15/15
MLSL pal	**2.5**(3)	4.7(5)	3.1(4)	5.0(7)	45(57)	13/15
OQNLP pal	4.0(4)	6.4(5)	**2.7**(2)	**2.5**(3)	**1.5**(0.5)	15/15
P-DCN tra	**1.9**(0.6)	22(30)	6610(97)	1.5e4(5e4)	1643(5312)	13/15
P-zero tra	**1.3**(0.6)	10(17)	1.0e4(313)	1.5e4(5e4)	1686(5316)	13/15
SMAC hut	**1.6**(1)	**2.0**(2)	**0.86**(0.8)	**0.89**(0.5)	**2.0**(2)	6/15
U-DCN tra	**1.5**(0.6)	5.6(7)	3.2(3)	3.6(3)	72(167)	15/15
U-zero tra	**1.3**(0.6)	5.0(5)	3.8(6)	**3.0**(4)	43(49)	15/15
fmincon pa	**1.8**(2)	3.9(5)	3.4(4)	4.3(4)	33(50)	14/15
fminunc pa	**1.9**(2)	4.9(5)	4.0(6)	3.7(4)	38(49)	14/15
ga100 hol	**1.1**(0.9)	**2.4**(2)	**2.2**(2)	**2.2**(2)	10(10)	15/15
grid100 ho	**1.2**(2)	6.4(7)	3.8(2)	4.4(6)	41(32)	15/15
grid16 hol	**1.0**(0.6)	4.2(4)	**1.9**(3)	**2.4**(3)	7.3(9)	15/15
hill hol	3.5(8)	6.2(10)	4.2(8)	4.6(6)	30(46)	15/15
lmmCMA aug	**1.9**(2)	**3.5**(3)	**2.5**(4)	**2.1**(3)	**0.56**(0.7)	15/15
memPSODE v	**1.5**(0.9)	5.5(8)	13(27)	16(23)	10(8)	15/15
prcga saw	**1.5**(2)	**3.5**(2)	**1.4**(1)	**2.2**(2)	3.8(5)	15/15
ring100 ho	**1.3**(0.6)	4.1(5)	**3.0**(4)	3.5(4)	15(12)	15/15
ring16 hol	**1.5**(2)	7.0(9)	4.5(4)	3.8(4)	10(10)	15/15
simplex pa	**1.9**(2)	5.5(6)	3.4(3)	3.6(2)	5.7(8)	15/15

Table 9: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_8 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f8	*2.5e+3*:1.2	*1.0e+2*:3.2	*6.3e+0*:7.0	*1.6e-1*:27	*1.6e-6*:100	15/15
BIPOP-aCMA	**2.3**(2)	3.3(4)	7.7(5)	11(9)	5.5(3)	15/15
BIPOP-saAC	**1.7**(1)	3.1(3)	3.9(3)	6.5(6)	3.3(2)	15/15
CMAES hut	**2.8**(4)	3.4(3)	10(15)	13(12)	∞ *206*	0/15
DE pal	**1.9**(2)	**2.9**(3)	6.5(5)	12(8)	11(2)	15/15
HCMA los	**1.8**(0.8)	**2.0**(2)	**1.8**(2)	9.0(6)	4.2(2)	15/15
HMLSL pal	**1.8**(1)	**1.6**(2)	**2.8**(3)	**2.5**(2)	**1.0**(0.5)	15/15
IPOP-10DDr	**2.4**(0.8)	3.8(3)	**2.6**(2)	11(7)	6.2(1)	15/15
IPOP-500 l	**2.4**(0.8)	3.8(3)	**2.6**(2)	11(7)	6.2(1)	15/15
IPOP-tany	3.7(4)	3.4(2)	4.4(3)	10(3)	6.0(0.9)	15/15
IPOP-texp	7.8(10)	5.2(4)	4.6(3)	7.7(6)	5.9(0.9)	15/15
IPOP lia	**2.4**(0.8)	3.8(3)	**2.6**(2)	11(7)	6.2(1)	15/15
MLSL pal	**1.8**(1)	**1.6**(2)	**2.8**(3)	**2.5**(2)	**1.0**(0.5)	15/15
OQNLP pal	3.3(5)	**2.9**(3)	**2.2**(2)	**2.2**(2)	**1.1**(0.6)	15/15
P-DCN tra	**1.3**(0.8)	8.8(14)	11(8)	51(61)	383(370)	15/15
P-zero tra	**1.3**(0.8)	4.3(7)	79(222)	74(123)	927(1121)	15/15
SMAC hut	**1.7**(2)	**1.6**(1)	3.3(3)	10(11)	∞ *200*	0/15
U-DCN tra	**1.3**(0.8)	**2.6**(2)	8.4(5)	35(55)	∞ *2e6*	0/15
U-zero tra	**1.3**(0.8)	**2.7**(2)	6.1(4)	82(133)	∞ *2e6*	0/15
fmincon pa	**1.8**(1)	**1.6**(2)	**2.8**(3)	**2.5**(2)	**1.0**(0.5)	15/15
fminunc pa	**1.7**(1)	**1.9**(2)	**1.8**(2)	**1.9**(2)	**0.91**(0.4)	15/15
ga100 hol	**2.3**(2)	3.1(3)	7.9(7)	32(32)	∞ *1e5*	0/15
grid100 ho	**2.4**(2)	3.9(4)	5.6(4)	68(28)	∞ *1e5*	0/15
grid16 hol	**2.3**(2)	5.9(8)	13(18)	69(109)	∞ *1e5*	0/15
hill hol	4.0(6)	4.3(5)	14(22)	49(69)	∞ *1e5*	0/15
lmmCMA aug	**2.1**(3)	**1.7**(2)	**2.4**(1)	3.3(2)	**1.6**(0.5)	15/15
memPSODE v	3.7(3)	6.9(8)	14(25)	29(34)	18(6)	15/15
prcga saw	**1.6**(0.8)	**2.0**(3)	4.0(4)	55(146)	170(151)	15/15
ring100 ho	**1.7**(2)	**2.7**(2)	8.7(10)	54(41)	∞ *1e5*	0/15
ring16 hol	**2.2**(2)	4.7(6)	10(9)	47(24)	1.4e4(2e4)	1/15
simplex pa	7.5(13)	6.8(5)	6.0(6)	3.7(3)	**1.6**(0.7)	15/15

Table 10: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_9 for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f9	*6.3e+0*:13	*4.0e+0*:15	*2.5e+0*:15	*2.5e-1*:21	*1.0e-8*:94	15/15
BIPOP-aCMA	**2.9**(3)	3.5(3)	4.9(7)	12(10)	6.6(3)	15/15
BIPOP-saAC	**2.4**(3)	**2.5**(3)	4.3(4)	8.8(6)	4.0(2)	15/15
CMAES hut	**2.9**(3)	4.1(5)	5.8(8)	13(15)	∞ *206*	0/15
DE pal	4.3(4)	4.1(4)	4.1(4)	9.0(8)	15(3)	15/15
HCMA los	**2.6**(3)	**2.7**(3)	3.1(4)	7.3(8)	3.6(1)	15/15
HMLSL pal	**0.87**(0)	**0.74**(0)	**0.74**(0)	**0.53**(0)	**0.62**(0.0)	15/15
IPOP-10DDr	**2.7**(1)	3.9(2)	4.9(3)	11(11)	7.4(3)	15/15
IPOP-500 l	**2.7**(1)	3.9(2)	4.9(3)	11(11)	7.4(3)	15/15
IPOP-tany	**2.2**(2)	**2.0**(1)	3.4(3)	7.3(8)	7.1(2)	15/15
IPOP-texp	**1.2**(0.4)	**1.1**(0.4)	**1.6**(1)	6.8(6)	6.6(2)	15/15
IPOP lia	**2.7**(1)	3.9(2)	4.9(3)	11(11)	7.4(3)	15/15
MLSL pal	**0.87**(0)	**0.74**(0)	**0.74**(0)	**0.53**(0)	**0.62**(0.0)	15/15
OQNLP pal	**0.63**(0)	**0.54**(0)	**0.61**(0)	**0.56**(0.0)	**1.4**(2)	15/15
P-DCN tra	16(5)	20(6)	25(21)	89(116)	1.2e4(2e4)	10/15
P-zero tra	27(75)	48(121)	57(128)	96(96)	5.2e4(6e4)	5/15
SMAC hut	**2.2**(2)	**2.6**(2)	3.6(2)	33(32)	∞ *200*	0/15
U-DCN tra	**1.6**(2)	**1.9**(2)	**2.0**(2)	46(76)	3.0e5(3e5)	1/15
U-zero tra	**2.1**(2)	**2.9**(2)	3.4(2)	95(213)	∞ *2e6*	0/15
fmincon pa	**0.87**(0)	**0.74**(0)	**0.74**(0)	**0.53**(0)	**0.62**(0.0)	15/15
fminunc pa	**0.56**(0)	**0.47**(0)*	**0.47**(0)*	**0.34**(0)$^{\star 3}$	**0.68**(0.0)	15/15
ga100 hol	4.1(4)	5.6(8)	9.1(9)	20(17)	∞ *1e5*	0/15
grid100 ho	7.5(7)	11(14)	13(15)	40(27)	∞ *1e5*	0/15
grid16 hol	4.4(4)	4.6(4)	10(6)	33(26)	∞ *1e5*	0/15
hill hol	4.6(6)	4.6(5)	5.4(6)	36(43)	∞ *1e5*	0/15
lmmCMA aug	**1.5**(1)	**1.7**(0.6)	**1.9**(0.9)	3.1(2)	**1.8**(0.5)	15/15
memPSODE v	10(13)	10(11)	12(11)	24(37)	19(7)	15/15
prcga saw	**2.9**(2)	**2.8**(2)	3.1(2)	47(59)	193(124)	15/15
ring100 ho	3.5(3)	6.0(6)	9.0(10)	37(27)	∞ *1e5*	0/15
ring16 hol	4.2(4)	4.6(4)	5.2(5)	25(16)	∞ *1e5*	0/15
simplex pa	**0.88**(0.1)	**1.4**(0.1)	**1.6**(0.1)	**1.3**(0.2)	**1.5**(0.1)	15/15

Table 11: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{10} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f10	*1.6e+6*:2.0	*4.0e+5*:3.2	*6.3e+2*:8.8	*1.0e+1*:30	*2.5e-8*:101	15/15
BIPOP-aCMA	**2.4**(4)	**1.9**(2)	6.6(5)	8.0(5)	**5.8**(0.7)	15/15
BIPOP-saAC	**2.8**(3)	**2.2**(4)	5.8(4)	3.8(2)	**2.2**(0.3)	15/15
CMAES hut	4.8(5)	3.8(5)	6.5(6)	10(8)	∞ *206*	0/15
DE pal	**2.4**(3)	**2.4**(3)	12(7)	11(4)	15(2)	15/15
HCMA los	**2.4**(2)	**2.0**(1)	**1.4**(0.5)	3.6(2)	**2.6**(0.5)	15/15
HMLSL pal	**2.8**(3)	**2.2**(2)	**1.8**(0.6)	**0.71**(0.2)	38(38)	15/15
IPOP-10DDr	**1.4**(0.8)	**2.1**(3)	6.1(4)	12(8)	8.0(0.7)	15/15
IPOP-500 l	**1.4**(0.8)	**2.1**(3)	6.1(4)	12(8)	8.0(0.7)	15/15
IPOP-tany	**1.8**(2)	**2.0**(1)	5.4(4)	8.9(8)	7.9(0.6)	15/15
IPOP-texp	**1.9**(2)	**2.1**(2)	5.1(3)	9.4(6)	7.5(0.5)	15/15
IPOP lia	**1.4**(0.8)	**2.1**(3)	6.1(4)	12(8)	8.0(0.7)	15/15
MLSL pal	**2.8**(3)	**2.2**(2)	**1.8**(0.6)	**0.71**(0.2)	181(314)	10/15
OQNLP pal	4.3(3)	3.1(2)	**2.6**(2)	**1.2**(0.7)	61(64)	7/15
P-DCN tra	**2.3**(4)	4.3(7)	7.3(7)	392(597)	2.8e5(3e5)	1/15
P-zero tra	**2.5**(2)	3.6(6)	5.7(3)	385(880)	3.0e5(3e5)	1/15
SMAC hut	**1.5**(1)	**1.1**(0.8)	**1.8**(0.7)	**1.3**(1)	∞ *200*	0/15
U-DCN tra	**2.1**(2)	**2.8**(4)	13(9)	164(243)	∞ *2e6*	0/15
U-zero tra	**1.9**(2)	**2.2**(2)	12(12)	269(456)	∞ *2e6*	0/15
fmincon pa	**2.8**(3)	**2.2**(2)	**1.8**(0.6)	**0.71**(0.2)	141(190)	11/15
fminunc pa	**2.4**(2)	**1.8**(1)	**1.4**(0.7)	**1.1**(1.0)	303(387)	8/15
ga100 hol	**2.3**(2)	**2.0**(2)	29(23)	386(725)	∞ *1e5*	0/15
grid100 ho	**1.8**(2)	**2.7**(3)	25(35)	311(511)	∞ *1e5*	0/15
grid16 hol	**1.6**(2)	**2.5**(2)	19(16)	45(38)	∞ *1e5*	0/15
hill hol	**2.1**(2)	**2.2**(2)	16(22)	265(433)	∞ *1e5*	0/15
lmmCMA aug	3.3(3)	**2.9**(2)	3.2(1)	**2.4**(1)	**1.6**(0.2)	15/15
memPSODE v	3.2(4)	4.7(5)	10(3)	22(35)	28(14)	15/15
prcga saw	**2.9**(4)	3.3(3)	9.4(6)	88(128)	8766(9765)	2/15
ring100 ho	**2.2**(2)	**2.4**(3)	18(29)	58(71)	∞ *1e5*	0/15
ring16 hol	**2.2**(2)	**2.4**(2)	13(9)	63(61)	∞ *1e5*	0/15
simplex pa	11(9)	8.0(6)	4.6(2)	**2.4**(2)	**1.7**(0.2)	15/15

Table 12: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{11} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f11	*1.0e+7*:1.1	*1.6e+6*:3.2	*1.0e+4*:6.6	*4.0e+1*:23	*4.0e-8*:100	15/15
BIPOP-aCMA	**1.9**(1)	**2.2**(2)	5.4(4)	6.2(6)	**5.7**(0.6)	15/15
BIPOP-saAC	3.8(5)	**2.8**(3)	4.1(3)	3.5(1)	**2.2**(0.4)	15/15
CMAES hut	**1.9**(2)	**2.1**(3)	4.2(4)	5.6(5)	∞ *206*	0/15
DE pal	**1.8**(0.9)	**1.2**(0.8)	6.2(5)	8.7(4)	14(1)	15/15
HCMA los	**2.0**(1)	**2.0**(1)	**1.5**(0.5)	**2.2**(3)	**2.6**(0.5)	15/15
HMLSL pal	**1.7**(1)	**2.3**(2)	**2.0**(1)	**0.84**(0.4)	19(27)	15/15
IPOP-10DDr	**1.6**(0.9)	**1.6**(1)	4.5(2)	6.5(10)	8.2(0.5)	15/15
IPOP-500 l	**1.6**(0.9)	**1.6**(1)	4.5(2)	6.5(10)	8.2(0.5)	15/15
IPOP-tany	**1.6**(0.9)	**2.3**(1)	4.6(3)	5.3(2)	8.1(0.6)	15/15
IPOP-texp	3.2(5)	3.7(3)	4.0(3)	4.5(2)	8.1(1.0)	15/15
IPOP lia	**1.6**(0.9)	**1.6**(1)	4.5(2)	6.5(10)	8.2(0.5)	15/15
MLSL pal	**1.7**(1)	**2.3**(2)	**2.0**(1)	**0.84**(0.4)	97(158)	12/15
OQNLP pal	**2.9**(3)	3.1(2)	3.5(2)	**1.6**(1)	72(83)	7/15
P-DCN tra	**1.4**(0.9)	3.7(8)	10(12)	25(72)	8.6e4(1e5)	3/15
P-zero tra	**1.4**(0.9)	**2.5**(2)	6.8(7)	6.9(3)	1.4e5(1e5)	2/15
SMAC hut	**1.6**(1)	**1.2**(0.8)	**1.6**(1)	**1.4**(0.7)	∞ *200*	0/15
U-DCN tra	**1.4**(0.9)	**1.8**(2)	5.8(7)	13(12)	∞ *2e6*	0/15
U-zero tra	**1.4**(0.9)	**1.8**(2)	6.3(6)	28(27)	∞ *2e6*	0/15
fmincon pa	**1.7**(1)	**2.3**(2)	**2.0**(1)	**0.84**(0.3)	115(172)	13/15
fminunc pa	**1.7**(1)	**1.9**(1)	**1.8**(0.9)	**0.84**(0.3)	66(124)	13/15
ga100 hol	**1.6**(0.9)	**1.4**(1)	13(23)	17(17)	∞ *1e5*	0/15
grid100 ho	**1.6**(0.9)	**1.4**(1)	11(8)	29(26)	∞ *1e5*	0/15
grid16 hol	**1.3**(0.5)	**1.3**(1)	10(9)	30(39)	∞ *1e5*	0/15
hill hol	4.7(6)	3.4(3)	4.2(3)	23(37)	∞ *1e5*	0/15
lmmCMA aug	**2.5**(2)	**2.0**(2)	**2.6**(1)	**1.6**(0.7)	**1.6**(0.2)	15/15
memPSODE v	**2.2**(1)	**1.7**(2)	7.4(5)	11(5)	34(25)	15/15
prcga saw	**2.1**(1)	**1.8**(1)	6.1(6)	5.5(2)	5861(6109)	3/15
ring100 ho	**1.7**(1)	**1.4**(1)	9.0(8)	33(24)	∞ *1e5*	0/15
ring16 hol	**1.4**(0.9)	**1.2**(0.9)	8.1(7)	20(16)	∞ *1e5*	0/15
simplex pa	5.9(9)	8.0(6)	5.7(1)	**2.2**(0.6)	**1.7**(0.1)	15/15

Table 13: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{12} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f12	*2.5e+8*:1.3	*6.3e+6*:2.7	*6.3e+5*:6.3	*4.0e+1*:21	*1.6e-3*:101	15/15
BIPOP-aCMA	**0.95**(0)	**1.2**(1)	**1.3**(1)	4.7(3)	5.7(1)	15/15
BIPOP-saAC	**1.5**(2)	**1.9**(2)	**1.6**(2)	5.3(2)	4.5(5)	15/15
CMAES hut	**0.75**(0)	**1.7**(3)	**1.7**(2)	9.4(10)	∞ *206*	0/15
DE pal	**1.3**(0.4)	**1**(1)	**1.7**(2)	7.0(5)	16(10)	15/15
HCMA los	**1.1**(0.8)	**1.5**(1)	**1.2**(0.8)	4.0(4)	5.3(4)	15/15
HMLSL pal	**1.1**(1)	**1.4**(2)	**1.2**(1.0)	**1.0**(0.6)	**0.99**(2)	15/15
IPOP-10DDr	**1.1**(1)	**1.5**(0.9)	**1.5**(1)	7.3(7)	14(12)	15/15
IPOP-500 l	**1.1**(1)	**1.5**(0.9)	**1.5**(1)	7.3(7)	14(12)	15/15
IPOP-tany	**1.2**(1)	**1.6**(1)	**1.2**(1)	6.2(7)	8.3(4)	15/15
IPOP-texp	**1.2**(1)	**2.6**(2)	**1.9**(1)	4.0(2)	10(10)	15/15
IPOP lia	**1.1**(1)	**1.5**(0.9)	**1.5**(1)	7.3(7)	14(12)	15/15
MLSL pal	**1.1**(1)	**1.4**(2)	**1.2**(1.0)	**1.0**(0.6)	**0.99**(2)	15/15
OQNLP pal	**1.6**(3)	3.2(2)	**1.9**(1)	**1.9**(1)	4.5(3)	15/15
P-DCN tra	**0.95**(0.4)	**0.98**(0.5)	**0.78**(1)	4.7(4)	446(428)	15/15
P-zero tra	**0.95**(0.4)	**0.98**(0.5)	**0.78**(0.6)	3.8(1)	645(376)	15/15
SMAC hut	**0.85**(0.4)	**0.73**(0.5)	**0.44**(0.3)	3.0(2)	∞ *200*	0/15
U-DCN tra	**0.95**(0.4)	**1.1**(0.5)	**0.85**(1)	12(8)	1.9e4(3e4)	8/15
U-zero tra	**0.95**(0.4)	**0.98**(0.5)	**0.83**(1)	29(26)	2.4e4(3e4)	7/15
fmincon pa	**1.1**(1)	**1.4**(2)	**1.2**(1.0)	**1.0**(0.6)	**0.99**(2)	15/15
fminunc pa	**1.1**(1)	**2.2**(2)	**1.6**(2)	**1.0**(0.7)	**1.7**(2)	15/15
ga100 hol	**0.90**(0.4)	**1.2**(0.9)	**1.6**(2)	23(25)	2233(2601)	5/15
grid100 ho	**1**(0.4)	**0.88**(0.7)	**1.4**(1)	57(52)	3375(3479)	4/15
grid16 hol	**0.95**(0.4)	**1**(0.7)	**1.5**(2)	31(30)	1.4e4(2e4)	1/15
hill hol	**1.6**(2)	**2.6**(3)	**1.8**(2)	49(57)	7062(7455)	2/15
lmmCMA aug	**0.95**(0.8)	**1.4**(2)	**1.1**(1)	**1.8**(0.5)	3.5(3)	15/15
memPSODE v	**1.3**(1)	**1.5**(1)	**1.8**(2)	24(50)	17(8)	15/15
prcga saw	**0.90**(0.4)	**1.1**(1)	4.1(2)	17(9)	712(823)	9/15
ring100 ho	**0.90**(0.4)	**1.0**(0.7)	**1.6**(2)	32(29)	3187(3479)	4/15
ring16 hol	**0.75**(0)	**0.90**(0.5)	**1.3**(1)	16(11)	1.4e4(2e4)	1/15
simplex pa	**2.7**(5)	8.2(7)	5.6(4)	**3.0**(1)	**2.1**(2)	15/15

Table 14: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{13} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f13	*4.0e+2*:1.6	*2.5e+2*:3.1	*6.3e+1*:8.7	*1.0e+1*:23	*4.0e-6*:100	15/15
BIPOP-aCMA	3.2(3)	**1.9**(2)	3.2(3)	3.9(2)	**6.0**(0.8)	15/15
BIPOP-saAC	**2.4**(2)	**1.9**(2)	3.2(5)	3.3(2)	**2.7**(0.6)	15/15
CMAES hut	**2.6**(3)	**1.9**(2)	**2.4**(2)	3.2(2)	∞ *206*	0/15
DE pal	**2.3**(2)	**2.0**(2)	**3.0**(2)	4.9(2)	14(2)	15/15
HCMA los	**2.7**(2)	**1.7**(1)	**2.9**(5)	**2.9**(3)	**3.2**(0.8)	15/15
HMLSL pal	**1.5**(1)	**1.2**(0.8)	**1.2**(0.6)	**0.77**(0.3)	31(24)	15/15
IPOP-10DDr	**2.4**(3)	**2.0**(2)	3.3(2)	4.3(7)	8.7(2)	15/15
IPOP-500 l	**2.4**(3)	**2.0**(2)	3.3(2)	4.3(7)	8.7(2)	15/15
IPOP-tany	**2.7**(3)	**1.9**(2)	**3.0**(2)	5.9(8)	8.4(0.7)	15/15
IPOP-texp	3.5(5)	**2.4**(3)	**2.6**(2)	7.4(10)	8.1(0.8)	15/15
IPOP lia	**2.4**(3)	**2.0**(2)	3.3(2)	4.3(7)	8.7(2)	15/15
MLSL pal	**1.5**(1)	**1.2**(0.8)	**1.2**(0.6)	**0.77**(0.3)	360(456)	6/15
OQNLP pal	3.5(4)	**2.7**(2)	**1.7**(0.5)	**1.2**(0.6)	19(17)	10/15
P-DCN tra	**1.9**(2)	**2.1**(3)	4.2(4)	21(30)	∞ *2e6*	0/15
P-zero tra	**1.9**(2)	**1.9**(2)	4.0(3)	37(102)	∞ *2e6*	0/15
SMAC hut	**1.5**(2)	**1.0**(1)	**1.3**(1.0)	**1.6**(1)	∞ *200*	0/15
U-DCN tra	**1.9**(2)	**1.8**(2)	3.2(4)	10(10)	∞ *2e6*	0/15
U-zero tra	**1.9**(2)	**1.6**(2)	**2.0**(2)	11(11)	∞ *2e6*	0/15
fmincon pa	**1.5**(1)	**1.2**(0.8)	**1.2**(0.6)	**0.77**(0.3)	172(237)	9/15
fminunc pa	**1.4**(0.9)	**1.7**(1)	**1.4**(0.9)	5.2(5)	∞ *2e4*	0/15
ga100 hol	**2.5**(4)	**2.1**(2)	3.5(3)	11(12)	∞ *1e5*	0/15
grid100 ho	**2.0**(2)	**1.4**(0.8)	**2.3**(2)	24(21)	∞ *1e5*	0/15
grid16 hol	**1.7**(0.9)	**1.9**(2)	4.0(5)	15(25)	∞ *1e5*	0/15
hill hol	4.6(5)	**2.8**(3)	10(9)	13(18)	∞ *1e5*	0/15
lmmCMA aug	**1.5**(1)	**1.1**(1)	**1.4**(0.9)	**2.0**(2)	**3.0**(0.7)	15/15
memPSODE v	4.1(2)	3.5(2)	3.2(3)	12(19)	15(7)	15/15
prcga saw	**1.9**(1)	**1.4**(0.8)	**2.0**(2)	33(63)	∞ *1e5*	0/15
ring100 ho	**1.9**(2)	**2.0**(2)	3.5(4)	15(17)	∞ *1e5*	0/15
ring16 hol	**2.5**(2)	**2.3**(2)	4.0(4)	10(8)	∞ *1e5*	0/15
simplex pa	8.3(10)	7.0(5)	5.5(4)	4.1(2)	**2.2**(0.5)	15/15

Table 15: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{14} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f14	*1.6e+1*:1.4	*2.5e+0*:4.2	*1.0e+0*:7.4	*2.5e-2*:21	*1.0e-8*:101	15/15
BIPOP-aCMA	**2.1**(2)	4.7(7)	4.8(6)	5.4(2)	**6.5**(1)	15/15
BIPOP-saAC	**1.9**(2)	**3.0**(5)	3.4(4)	3.5(2)	**2.9**(0.3)	15/15
CMAES hut	**1.2**(0.7)	**2.0**(2)	**2.5**(3)	4.2(2)	∞ *206*	0/15
DE pal	**1.5**(1)	**1.8**(2)	3.7(3)	7.7(3)	14(2)	15/15
HCMA los	**1.4**(1)	3.6(3)	3.0(5)	4.9(4)	**3.2**(0.5)	15/15
HMLSL pal	**1.8**(2)	**1.3**(1)	**1.1**(0.8)	**1.0**(0.4)	39(14)	15/15
IPOP-10DDr	**1**(0.7)	**1.4**(2)	**1.9**(2)	3.6(1)	8.2(0.7)	15/15
IPOP-500 l	**1**(0.7)	**1.4**(2)	**1.9**(2)	3.6(1)	8.2(0.7)	15/15
IPOP-tany	**1**(0.7)	**1.7**(2)	**2.0**(2)	3.7(1)	8.2(1.0)	15/15
IPOP-texp	**1.9**(2)	**2.3**(3)	**2.5**(2)	3.4(1)	7.9(0.9)	15/15
IPOP lia	**1**(0.7)	**1.4**(2)	**1.9**(2)	3.6(1)	8.2(0.7)	15/15
MLSL pal	**1.8**(2)	**1.3**(1)	**1.1**(0.8)	**1.0**(0.4)	629(757)	4/15
OQNLP pal	3.2(4)	**2.6**(3)	**2.1**(2)	**1.5**(0.7)	100(98)	5/15
P-DCN tra	**1.1**(0.7)	4.2(3)	6.2(7)	8.0(4)	2.7e4(3e4)	7/15
P-zero tra	**1.1**(0.7)	**2.4**(2)	5.8(9)	6.2(4)	2.9e5(3e5)	1/15
SMAC hut	**0.76**(0)	**1.1**(1.0)	**1.8**(1)	3.9(1)	∞ *200*	0/15
U-DCN tra	**1.1**(0.7)	**1.8**(3)	3.0(3)	23(14)	∞ *2e6*	0/15
U-zero tra	**1.1**(0.7)	**1.3**(2)	**2.4**(2)	31(42)	∞ *2e6*	0/15
fmincon pa	**1.8**(2)	**1.3**(1)	**1.1**(0.8)	**1.0**(0.4)	2964(3028)	1/15
fminunc pa	**1.4**(1)	**1.6**(2)	**1.7**(2)	**1.5**(1)	526(595)	5/15
ga100 hol	**1.9**(1)	**2.1**(2)	**2.3**(2)	41(13)	∞ *1e5*	0/15
grid100 ho	**1**(0.4)	**1.4**(2)	3.2(2)	50(44)	∞ *1e5*	0/15
grid16 hol	**1.2**(0.4)	**2.0**(3)	4.5(8)	37(23)	∞ *1e5*	0/15
hill hol	3.6(4)	3.5(4)	**2.5**(2)	21(38)	∞ *1e5*	0/15
lmmCMA aug	**0.95**(0)	**1.4**(1)	**1.8**(2)	**1.9**(0.6)	**2.4**(0.4)	15/15
memPSODE v	**1.7**(1)	3.0(2)	3.5(3)	5.9(3)	34(32)	15/15
prcga saw	**1.4**(1)	**1.8**(2)	**2.3**(2)	7.4(3)	1692(1930)	7/15
ring100 ho	**1.3**(0.7)	**2.5**(2)	4.2(4)	55(30)	∞ *1e5*	0/15
ring16 hol	**2.0**(1)	**3.0**(3)	3.3(4)	21(16)	∞ *1e5*	0/15
simplex pa	7.6(11)	6.9(9)	7.9(6)	4.4(1)	**1.7**(0.2)$^{\star 3}$	15/15

Table 16: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{15} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f15	*1.6e+2*:1.2	*4.0e+1*:4.7	*2.5e+1*:10	*1.0e+1*:37	*2.5e+0*:118	5/5
BIPOP-aCMA	**1.2**(0.4)	**1.2**(1)	**1.8**(2)	**1.4**(2)	**2.0**(3)	15/15
BIPOP-saAC	**1.7**(2)	**1.5**(2)	**1.3**(1)	**1.1**(0.7)	**1.4**(2)	15/15
CMAES hut	**2.6**(2)	**1.7**(2)	**1.2**(1)	**0.98**(0.8)	**1.9**(2)	9/15
DE pal	**1.7**(1)	**0.77**(0.5)	**0.78**(0.9)	**1.6**(1)	**1.9**(1)	15/15
HCMA los	**2.3**(2)	**1.9**(1)	**1.5**(1)	**1.1**(0.8)	**1.7**(2)	15/15
HMLSL pal	4.7(1)	5.3(6)	4.8(4)	3.0(2)	**2.0**(1)	15/15
IPOP-10DDr	**2.4**(2)	**2.0**(2)	**1.6**(2)	**1.1**(0.7)	**2.2**(4)	15/15
IPOP-500 l	**2.4**(2)	**2.0**(2)	**1.6**(2)	**1.1**(0.7)	**2.2**(4)	15/15
IPOP-tany	**2.4**(2)	**1.7**(1.0)	**1.3**(0.8)	**0.91**(0.6)	**2.6**(3)	15/15
IPOP-texp	3.9(4)	3.2(2)	**2.0**(2)	**1.1**(0.9)	3.7(6)	15/15
IPOP lia	**2.4**(2)	**2.0**(2)	**1.6**(2)	**1.1**(0.7)	**2.2**(4)	15/15
MLSL pal	4.7(1)	6.0(7)	4.9(4)	**2.6**(2)	**2.7**(3)	15/15
OQNLP pal	25(58)	22(17)	11(8)	4.6(4)	**2.6**(1)	15/15
P-DCN tra	**1.2**(0.4)	**1.1**(1.0)	**1.1**(0.9)	5.7(13)	3109(8446)	13/15
P-zero tra	**1.2**(0.4)	**1.1**(1.0)	**1.3**(2)	4.9(6)	1847(5461)	15/15
SMAC hut	**1.7**(2)	**1.2**(1)	**0.93**(0.9)	**1.4**(1)	**2.4**(2)	9/15
U-DCN tra	**1.2**(0.4)	**1**(1)	**0.92**(0.7)	**2.0**(3)	5.5(7)	15/15
U-zero tra	**1.2**(0.4)	**1.0**(1)	**1.3**(1)	**1.3**(1)	8.9(13)	15/15
fmincon pa	4.3(1)	5.2(6)	4.9(4)	3.3(2)	**2.6**(1)	15/15
fminunc pa	3.5(1)	7.6(9)	5.2(5)	**3.0**(2)	**2.2**(2)	15/15
ga100 hol	**1.8**(2)	**2.4**(2)	**1.8**(2)	**2.7**(3)	5.6(5)	15/15
grid100 ho	**1.7**(0.8)	**1.5**(2)	**0.78**(1)	**2.7**(4)	12(9)	15/15
grid16 hol	**1.3**(0.8)	**1.5**(1.0)	**1.5**(2)	4.7(5)	5.2(6)	15/15
hill hol	3.6(5)	3.4(5)	**2.7**(3)	**2.6**(2)	4.5(5)	15/15
lmmCMA aug	**1.6**(2)	**1.5**(1)	**1.1**(0.8)	**0.74**(0.5)	**1.0**(1)	15/15
memPSODE v	**2.3**(2)	**1.4**(1)	**1.3**(2)	**1.6**(1)	4.5(7)	15/15
prcga saw	**1.9**(2)	**1.2**(1)	**1.4**(1)	**1.3**(1)	**1.5**(0.8)	15/15
ring100 ho	**1.3**(0.8)	**1.5**(1)	**1.8**(2)	3.1(5)	5.8(5)	15/15
ring16 hol	**1.7**(0.8)	**2.0**(2)	**1.9**(3)	3.1(2)	3.7(3)	15/15
simplex pa	32(61)	25(17)	13(8)	4.8(3)	5.0(4)	15/15

Table 17: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{16} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f16	*1.0e+2*:1.1	*2.5e+1*:3.9	*1.6e+1*:6.5	*4.0e+0*:31	*2.5e-1*:127	5/5
BIPOP-aCMA	**1.5**(0.9)	**2.2**(3)	**2.3**(2)	3.5(2)	3.3(4)	15/15
BIPOP-saAC	**1.4**(0.4)	**2.5**(4)	**2.2**(2)	**1.5**(2)	**1.6**(0.9)	15/15
CMAES hut	**1.4**(0.4)	**1.7**(1)	**2.8**(3)	3.5(3)	**2.5**(2)	8/15
DE pal	**1.6**(0.9)	**2.3**(2)	3.4(5)	**2.5**(3)	5.3(4)	15/15
HCMA los	5.1(9)	3.9(2)	**2.7**(2)	**2.7**(2)	5.7(5)	15/15
HMLSL pal	**2.0**(3)	6.0(8)	8.0(7)	3.1(3)	5.4(8)	15/15
IPOP-10DDr	**1.5**(0.9)	**2.0**(3)	**1.8**(2)	**1.6**(2)	**2.3**(4)	15/15
IPOP-500 l	**1.5**(0.9)	**2.0**(3)	**1.8**(2)	**1.6**(2)	**2.3**(4)	15/15
IPOP-tany	**1.8**(0.9)	**2.1**(2)	**1.6**(2)	**1.7**(1)	**1.5**(0.8)	15/15
IPOP-texp	**1.5**(0.9)	**1.8**(2)	**2.1**(2)	**1.7**(1)	3.2(4)	15/15
IPOP lia	**1.5**(0.9)	**2.0**(3)	**1.8**(2)	**1.6**(2)	**2.3**(4)	15/15
MLSL pal	**2.0**(3)	6.4(9)	8.5(7)	4.6(4)	7.1(8)	15/15
OQNLP pal	**2.6**(3)	20(22)	21(19)	6.4(4)	8.5(6)	14/15
P-DCN tra	**1.5**(0.9)	**1.3**(1)	**1.6**(1)	4583(20)	1126(5)	14/15
P-zero tra	**1.5**(0.9)	**1.3**(1)	**1.5**(2)	7370(2e4)	1836(4792)	14/15
SMAC hut	**1.2**(0.4)	**1.8**(2)	**1.6**(1)	**0.88**(0.7)	**1.8**(2)	9/15
U-DCN tra	**1.5**(0.9)	**1.4**(0.9)	**1.6**(2)	**1.9**(2)	6.3(13)	15/15
U-zero tra	**1.5**(0.9)	**1.3**(1)	**1.3**(1)	**1.8**(2)	11(13)	15/15
fmincon pa	**2.0**(3)	6.2(8)	8.7(9)	4.6(6)	7.6(9)	15/15
fminunc pa	**1.6**(1)	13(17)	14(12)	4.1(3)	17(14)	15/15
ga100 hol	**1.3**(0.9)	**2.2**(2)	**1.8**(1)	3.3(5)	10(7)	15/15
grid100 ho	**1.3**(0.9)	**2.3**(2)	**1.9**(2)	**2.4**(2)	11(12)	15/15
grid16 hol	**1.5**(0.4)	**1.5**(2)	**2.0**(2)	**2.8**(5)	24(32)	15/15
hill hol	**1.5**(0.9)	3.2(7)	**2.8**(4)	**2.1**(2)	18(45)	15/15
lmmCMA aug	**1.6**(0.9)	**2.1**(2)	**2.1**(3)	**1.4**(1)	**2.2**(2)	14/15
memPSODE v	**1.5**(0.9)	**2.1**(2)	**2.5**(2)	4.3(5)	5.9(7)	15/15
prcga saw	**1.5**(0.9)	**1.5**(1)	**1.2**(1)	**2.3**(2)	4.3(2)	15/15
ring100 ho	**1.4**(0.9)	**2.6**(3)	**2.0**(2)	3.3(6)	13(17)	15/15
ring16 hol	**1.2**(0.4)	**0.97**(1)	**2.0**(3)	**2.3**(3)	8.5(7)	15/15
simplex pa	23(56)	33(8)	21(6)	5.5(2)	**2.7**(2)	15/15

Table 18: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{17} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f17	*4.0e+1*:1.2	*1.0e+1*:2.7	*4.0e+0*:10	*2.5e+0*:28	*1.6e-1*:119	5/5
BIPOP-aCMA	**1.7**(0.4)	3.8(2)	6.1(3)	**2.4**(1)	**1.6**(0.9)	15/15
BIPOP-saAC	**1.8**(2)	10(8)	4.6(3)	**1.8**(1)	**1.5**(0.9)	15/15
CMAES hut	**2.0**(3)	3.2(5)	**2.2**(3)	**0.98**(1)	**1.0**(0.6)	14/15
DE pal	**1.8**(1)	**2.9**(3)	**2.1**(2)	**1.2**(0.9)	**2.1**(0.5)	15/15
HCMA los	**1.7**(2)	**2.4**(2)	4.9(2)	**2.5**(2)	**2.4**(2)	15/15
HMLSL pal	**2.3**(2)	12(17)	10(15)	4.6(6)	17(18)	15/15
IPOP-10DDr	**1.5**(0.8)	**2.4**(2)	**1.6**(1)	**2.4**(0.6)	3.5(4)	15/15
IPOP-500 l	**1.5**(0.8)	**2.4**(2)	**1.6**(1)	**2.4**(0.6)	3.5(4)	15/15
IPOP-tany	**1.9**(0.8)	3.0(4)	**1.6**(0.9)	**0.88**(0.7)	**2.6**(3)	15/15
IPOP-texp	4.6(10)	29(70)	16(25)	7.2(10)	6.1(6)	15/15
IPOP lia	**1.5**(0.8)	**2.4**(2)	**1.6**(1)	**2.4**(0.6)	3.5(4)	15/15
MLSL pal	**2.3**(2)	12(16)	10(17)	4.7(6)	59(49)	15/15
OQNLP pal	11(4)	25(27)	13(2)	5.5(2)	4.8(3)	15/15
P-DCN tra	**1.3**(0.8)	7.0(6)	18(33)	9.2(15)	6.0(7)	15/15
P-zero tra	**1.3**(0.8)	**2.6**(2)	5.8(7)	3.2(6)	16(32)	15/15
SMAC hut	**1.1**(0.4)	**1.5**(0.9)	**1.2**(2)	**0.74**(0.5)	24(28)	1/15
U-DCN tra	**1.3**(0.8)	**2.9**(3)	**2.6**(2)	**1.2**(0.9)	6.3(7)	15/15
U-zero tra	**1.3**(0.8)	**2.6**(3)	**1.9**(1)	**1.0**(0.8)	9.1(11)	15/15
fmincon pa	**2.3**(2)	12(17)	7.9(11)	3.6(4)	59(49)	15/15
fminunc pa	**2.3**(2)	5.3(5)	4.8(4)	**2.4**(2)	23(30)	15/15
ga100 hol	**1.4**(0.8)	**1.7**(2)	**1.8**(2)	**1.4**(1)	10(5)	15/15
grid100 ho	**1.2**(0.8)	**1.9**(2)	**2.2**(2)	**2.2**(2)	21(17)	15/15
grid16 hol	**1.8**(0.8)	**1.9**(2)	3.4(4)	**2.2**(2)	10(11)	15/15
hill hol	**1.7**(0.8)	4.1(8)	**2.2**(3)	**0.97**(1.0)	11(16)	15/15
lmmCMA aug	**1.3**(0.8)	**2.6**(2)	**1.4**(2)	**0.80**(0.6)	**1.2**(1)	15/15
memPSODE v	**2.3**(1)	**2.4**(2)	**2.5**(2)	**1.8**(2)	6.2(14)	15/15
prcga saw	**1.1**(0.4)	**1.6**(2)	**1.4**(1)	**0.84**(0.9)	3.6(6)	15/15
ring100 ho	**1.2**(0.4)	**3.0**(3)	**2.3**(2)	**2.6**(4)	20(14)	15/15
ring16 hol	**1.1**(0.4)	**2.5**(3)	3.5(3)	**2.2**(1)	9.0(5)	15/15
simplex pa	10(10)	18(18)	11(2)	4.6(1)	13(11)	15/15

Table 19: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{18} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f18	*4.0e+2*:1.2	*1.0e+2*:3.2	*4.0e+1*:7.2	*6.3e+0*:32	*1.6e+0*:104	5/5
BIPOP-aCMA	**1.3**(0.8)	**1.6**(2)	**1.7**(1)	**1.6**(1)	**2.5**(4)	15/15
BIPOP-saAC	3.2(3)	4.1(5)	**2.4**(3)	3.9(7)	4.6(3)	15/15
CMAES hut	**1.4**(0.4)	**1.7**(2)	**1.1**(1)	**1.2**(2)	**1.4**(2)	11/15
DE pal	**1.4**(0.8)	**1.2**(1)	**1.5**(2)	**1.5**(1)	**1.7**(0.7)	15/15
HCMA los	**1.6**(2)	3.7(4)	**2.2**(2)	**3.0**(2)	3.4(3)	15/15
HMLSL pal	9.4(1)	12(23)	11(14)	11(12)	17(22)	15/15
IPOP-10DDr	**1.5**(0.8)	**1.9**(1)	**1.5**(2)	3.4(3)	6.7(11)	15/15
IPOP-500 l	**1.5**(0.8)	**1.9**(1)	**1.5**(2)	3.4(3)	6.7(11)	15/15
IPOP-tany	**1.8**(1)	**2.2**(2)	**1.6**(2)	**3.0**(2)	6.2(8)	15/15
IPOP-texp	9.4(2)	18(14)	18(46)	7.1(16)	6.5(8)	15/15
IPOP lia	**1.5**(0.8)	**1.9**(1)	**1.5**(2)	3.4(3)	6.7(11)	15/15
MLSL pal	9.4(1)	12(23)	11(13)	25(29)	30(34)	15/15
OQNLP pal	9.2(4)	19(21)	15(10)	5.7(2)	**2.9**(1)	15/15
P-DCN tra	**1.2**(0.4)	**1.8**(2)	8.8(11)	4.4(5)	276(148)	15/15
P-zero tra	**1.2**(0.4)	**1.7**(1)	3.7(7)	3.2(4)	2654(5128)	14/15
SMAC hut	**1.3**(1)	**1.7**(2)	**1.6**(2)	**1.2**(1)	3.1(3)	7/15
U-DCN tra	**1.2**(0.4)	**2.0**(3)	**2.2**(2)	**2.3**(2)	8.5(16)	15/15
U-zero tra	**1.2**(0.4)	**1.4**(1)	**1.2**(0.8)	**2.4**(2)	4.2(5)	15/15
fmincon pa	8.7(1)	13(21)	10(13)	14(5)	17(21)	15/15
fminunc pa	3.7(2)	4.8(6)	4.0(4)	3.3(2)	4.8(4)	15/15
ga100 hol	**1.6**(0.8)	**1.8**(0.9)	**1.5**(1)	**2.5**(4)	3.6(3)	15/15
grid100 ho	**1.1**(0.4)	**1.0**(0.6)	**1.5**(2)	5.0(6)	11(11)	15/15
grid16 hol	**1.3**(0.8)	**1.2**(0.9)	**0.87**(0.6)	**2.5**(2)	5.2(6)	15/15
hill hol	**1.1**(0.8)	**2.6**(3)	**2.0**(2)	3.9(4)	6.4(7)	15/15
lmmCMA aug	**1.4**(1)	6.9(2)	3.6(1)	**1.3**(0.5)	**1.5**(2)	15/15
memPSODE v	**2.0**(2)	**1.6**(1)	**1.3**(1)	4.0(2)	9.3(9)	15/15
prcga saw	**1.2**(0.8)	**1.5**(2)	**1.6**(1)	**1.4**(1)	**2.4**(1)	15/15
ring100 ho	**1.4**(0.8)	**1.6**(2)	**1.8**(2)	3.3(4)	7.4(7)	15/15
ring16 hol	**1.3**(0.4)	**1.7**(1)	**1.8**(2)	**3.0**(3)	3.9(4)	15/15
simplex pa	8.7(10)	16(16)	12(6)	5.6(2)	3.9(2)	15/15

Table 20: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{19} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f19	*1.6e-1*:23	*1.0e-1*:26	*6.3e-2*:38	*4.0e-2*:40	*1.0e-2*:216	15/15
BIPOP-aCMA	8.2(13)	8.9(11)	13(11)	21(32)	18(27)	15/15
BIPOP-saAC	4.0(3)	4.6(8)	5.1(6)	6.3(9)	13(18)	15/15
CMAES hut	8.3(10)	11(14)	8.6(9)	13(15)	14(15)	1/15
DE pal	8.0(6)	8.4(7)	7.3(5)	10(8)	71(95)	11/15
HCMA los	9.4(16)	10(13)	22(18)	28(30)	17(24)	15/15
HMLSL pal	**0.47**(0)	**0.64**(0)	**0.61**(0)	**0.58**(0)	**0.15**(0)	15/15
IPOP-10DDr	9.3(3)	13(31)	14(23)	16(24)	15(25)	15/15
IPOP-500 l	9.3(3)	13(31)	14(23)	16(24)	16(21)	15/15
IPOP-tany	23(19)	28(26)	25(21)	31(28)	26(35)	15/15
IPOP-texp	13(19)	21(25)	16(18)	19(25)	12(12)	15/15
IPOP lia	9.3(3)	13(31)	14(23)	16(24)	16(21)	15/15
MLSL pal	**0.47**(0)	**0.64**(0)	**0.61**(0)	**0.58**(0)	**0.15**(0)	15/15
OQNLP pal	**0.47**(0)	**0.45**(0)	**0.32**(0)	**0.30**(0)	8.7(8)	13/15
P-DCN tra	11(12)	11(10)	8.8(7)	11(11)	6.0e4(7e4)	2/15
P-zero tra	8.5(15)	10(17)	8.9(12)	13(11)	1.3e5(1e5)	1/15
SMAC hut	5.3(5)	6.5(6)	5.9(6)	8.7(9)	**6.5**(7)	2/15
U-DCN tra	10(11)	12(14)	18(28)	19(26)	53(69)	15/15
U-zero tra	11(13)	11(12)	19(28)	28(27)	117(134)	15/15
fmincon pa	**0.47**(0)	**0.64**(0)	**0.61**(0)	**0.58**(0)	**0.15**(0)	15/15
fminunc pa	**0.57**(0.1)	**0.55**(0.1)	**0.38**(0.1)	**0.37**(0.1)	8.9(10)	15/15
ga100 hol	13(12)	15(13)	16(14)	27(28)	20(15)	15/15
grid100 ho	17(18)	22(21)	25(18)	33(33)	22(17)	15/15
grid16 hol	11(10)	10(12)	11(8)	13(10)	24(53)	15/15
hill hol	7.0(8)	10(8)	11(11)	19(21)	32(40)	15/15
lmmCMA aug	5.2(11)	5.1(10)	6.1(8)	5.8(8)	**6.1**(7)	11/15
memPSODE v	14(11)	14(11)	17(40)	17(38)	47(106)	15/15
prcga saw	**2.4**(2)	**2.9**(3)	**2.3**(2)	4.5(4)	11(14)	15/15
ring100 ho	13(13)	18(21)	25(24)	35(25)	19(18)	15/15
ring16 hol	10(10)	12(11)	12(9)	24(33)	20(24)	15/15
simplex pa	**0.30**(0.0)$^{\star}_{\downarrow 4}$	**0.33**(0.0)$^{\star}_{\downarrow 4}$	**0.26**(0.0)$^{\star 2}_{\downarrow 4}$	**0.26**(0.0)$^{\star 2}_{\downarrow 4}$	9.2(9)	15/15

Table 21: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{20} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f20	*4.0e+3*:1.9	*2.5e+2*:2.8	*4.0e+0*:6.3	*2.5e+0*:21	*6.3e-1*:139	15/15
BIPOP-aCMA	**2.2**(4)	4.5(6)	4.0(3)	**2.3**(2)	6.7(12)	15/15
BIPOP-saAC	**1.8**(2)	**2.3**(3)	**2.6**(2)	**1.6**(2)	**3.2**(2)	15/15
CMAES hut	**2.4**(3)	**2.3**(2)	**2.0**(3)	**1.6**(2)	**2.5**(3)	7/15
DE pal	**1.8**(2)	**2.9**(3)	3.3(4)	3.2(2)	23(2)	14/15
HCMA los	**2.5**(2)	**2.2**(1)	**1.6**(0.6)	**1.1**(1)	3.4(3)	15/15
HMLSL pal	**2.7**(0)	**2.9**(0)	**2.2**(0)	**1.4**(0)	**2.5**(1)	15/15
IPOP-10DDr	**2.2**(2)	3.9(4)	5.5(3)	**1.9**(0.7)	10(20)	15/15
IPOP-500 l	**2.2**(2)	3.9(4)	5.5(3)	**1.9**(0.7)	7.8(13)	15/15
IPOP-tany	**1.8**(1)	**1.6**(2)	**1.2**(1)	**2.0**(1)	10(12)	15/15
IPOP-texp	**2.5**(2)	3.1(3)	**1.8**(0.9)	**1.3**(0.8)	9.3(13)	15/15
IPOP lia	**2.2**(2)	3.9(4)	5.5(3)	**1.9**(0.7)	7.8(13)	15/15
MLSL pal	**2.7**(0)	**2.9**(0)	**2.2**(0)	**1.4**(0)	**2.9**(1)	15/15
OQNLP pal	5.4(0)	4.6(0)	5.9(0)	9.2(4)	5.2(4)	15/15
P-DCN tra	**1.1**(0.8)	**1.4**(0.9)	6.1(6)	5.6(5)	8854(1e4)	12/15
P-zero tra	**1.1**(0.8)	**1.4**(0.9)	4.1(3)	**1.9**(1)	2.2e4(3e4)	6/15
SMAC hut	**1.5**(0.5)	**1.3**(0.7)	**1.9**(3)	**1.8**(2)	6.4(7)	3/15
U-DCN tra	**1.1**(0.8)	**1.4**(0.9)	4.9(4)	3.7(3)	6.5(6)	15/15
U-zero tra	**1.1**(0.8)	**1.4**(0.9)	3.1(2)	**2.4**(3)	6.4(9)	15/15
fmincon pa	**2.7**(0)	**2.9**(0)	**2.2**(0)	**1.4**(0)	**2.1**(1)	15/15
fminunc pa	**2.1**(0)	**1.4**(0)	**1.1**(0)	6.7(3)	3.5(3)	15/15
ga100 hol	**1.2**(0.8)	**2.1**(2)	**2.3**(2)	3.5(3)	6.0(4)	15/15
grid100 ho	**1.8**(1)	3.2(4)	4.5(5)	7.0(8)	13(11)	15/15
grid16 hol	**1.3**(1)	**2.4**(2)	4.0(6)	**2.3**(2)	6.7(9)	15/15
hill hol	**2.4**(3)	5.2(6)	4.0(4)	**2.3**(2)	4.3(6)	15/15
lmmCMA aug	**2.5**(0.8)	**2.1**(1)	**1.8**(1)	**1.8**(0.9)	8.6(10)	11/15
memPSODE v	**2.5**(1)	3.6(1)	3.5(3)	3.1(2)	3.8(6)	15/15
prcga saw	**1.1**(1)	**1.2**(1)	**2.2**(3)	**1.8**(2)	8.6(7)	15/15
ring100 ho	**1.1**(0.5)	**2.0**(3)	3.5(5)	5.2(5)	10(8)	15/15
ring16 hol	**0.96**(0.5)	**1.9**(2)	4.1(4)	**2.9**(3)	4.7(4)	15/15
simplex pa	14(0.3)	12(0.2)	5.6(0.5)	3.4(4)	6.3(5)	15/15

Table 22: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{21} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f21	*1.0e+1*:1.7	*6.3e+0*:2.6	*2.5e+0*:7.9	*1.6e+0*:30	*4.0e-1*:105	15/15
BIPOP-aCMA	**1.5**(0.9)	**1.6**(1)	**1.7**(2)	6.2(9)	10(18)	15/15
BIPOP-saAC	**1.5**(2)	**2.3**(3)	**1.8**(1)	5.3(7)	6.8(10)	15/15
CMAES hut	**1.2**(1)	**2.2**(3)	**1.7**(1)	**2.7**(4)	**1.6**(2)	9/15
DE pal	**2.0**(2)	**2.3**(2)	**1.1**(1)	**1.7**(2)	96(191)	12/15
HCMA los	**2.1**(2)	**2.6**(2)	**1.3**(1)	**3.0**(6)	7.8(9)	15/15
HMLSL pal	**2.3**(3)	**2.8**(2)	**1.6**(1)	**2.1**(3)	**2.1**(2)	15/15
IPOP-10DDr	**2.6**(2)	**2.6**(3)	**2.3**(2)	4.1(10)	12(14)	15/15
IPOP-500 l	**2.6**(2)	**2.6**(3)	**2.3**(2)	4.1(10)	11(14)	15/15
IPOP-tany	**2.2**(2)	**2.8**(3)	**1.9**(1)	6.5(12)	12(13)	15/15
IPOP-texp	**2.7**(2)	7.0(3)	7.2(2)	12(12)	30(41)	15/15
IPOP lia	**2.6**(2)	**2.6**(3)	**2.3**(2)	4.1(10)	11(14)	15/15
MLSL pal	**2.3**(3)	**2.8**(2)	**1.6**(1)	**1.6**(2)	**1.7**(2)	15/15
OQNLP pal	4.4(6)	7.1(4)	4.5(7)	**2.5**(2)	**1.4**(1)	15/15
P-DCN tra	**1.4**(1)	3.2(4)	1135(3)	3.3e4(7e4)	2.2e4(3e4)	7/15
P-zero tra	**1.4**(1)	**2.1**(3)	1.8e4(6)	4.4e4(7e4)	2.2e4(3e4)	7/15
SMAC hut	**0.92**(0.9)	**1.7**(2)	**1.6**(2)	**1.4**(1)	**0.74**(0.5)	15/15
U-DCN tra	**1.4**(1)	**1.8**(2)	**1.4**(0.9)	**0.85**(0.8)	**0.67**(1)	15/15
U-zero tra	**1.4**(1)	**2.0**(2)	**1.6**(2)	**1.1**(2)	**0.82**(1)	15/15
fmincon pa	**2.3**(3)	**2.8**(2)	**1.6**(1)	**1.2**(1)	**1.3**(1)	15/15
fminunc pa	**3.0**(3)	4.2(5)	**2.8**(3)	**1.7**(1)	**0.88**(0.4)	15/15
ga100 hol	**1**(0.6)	**2.3**(3)	**1.8**(2)	**1.8**(2)	**1.4**(2)	15/15
grid100 ho	**1.1**(0.9)	**1.9**(2)	**1.2**(0.9)	**1.1**(1)	**2.3**(4)	15/15
grid16 hol	**1.1**(0.6)	**1.4**(1)	**1.8**(2)	**1.9**(2)	21(22)	15/15
hill hol	**1.7**(2)	**2.9**(3)	**2.0**(2)	5.2(7)	161(476)	13/15
lmmCMA aug	**1**(0.9)	**0.92**(0.6)	**0.88**(0.9)	**2.4**(4)	4.1(8)	13/15
memPSODE v	**1.9**(2)	**2.8**(2)	**2.1**(2)	**1.8**(2)	**2.8**(4)	15/15
prcga saw	**1.6**(1)	**1.6**(1)	**1.5**(2)	**2.4**(4)	14(20)	15/15
ring100 ho	**1.8**(0.9)	**1.8**(1)	**1.3**(1)	**1.3**(2)	**1.7**(2)	15/15
ring16 hol	**1.1**(0.9)	**1.6**(1)	**0.97**(0.7)	3.3(4)	**2.6**(4)	15/15
simplex pa	15(22)	17(22)	10(9)	4.8(4)	**1.9**(0.9)	15/15

Table 23: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{22} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f22	*4.0e+1*:1.3	*1.6e+1*:3.2	*6.3e+0*:9.3	*1.6e+0*:25	*1.0e-1*:168	15/15
BIPOP-aCMA	**1.6**(2)	**2.5**(3)	**2.1**(2)	5.9(11)	4.3(4)	15/15
BIPOP-saAC	**1.5**(1)	**1.5**(2)	**1.5**(2)	10(24)	5.9(9)	15/15
CMAES hut	**1.1**(0.4)	**1.4**(2)	**1.7**(2)	8.3(12)	3.6(4)	4/15
DE pal	**1.5**(1)	**1.6**(2)	**1.1**(1)	**2.7**(3)	18(2)	14/15
HCMA los	**2.2**(2)	**2.4**(2)	**1.8**(2)	4.5(7)	3.5(5)	15/15
HMLSL pal	**3.0**(4)	**2.5**(2)	**2.2**(3)	3.5(3)	**1.2**(0.8)	15/15
IPOP-10DDr	**1.8**(2)	**1.7**(1)	**1.1**(0.8)	11(14)	10(12)	15/15
IPOP-500 l	**1.8**(2)	**1.7**(1)	**1.1**(0.8)	11(14)	8.5(10)	15/15
IPOP-tany	**1.8**(2)	**1.3**(2)	**1.1**(1)	**2.2**(1)	5.9(7)	15/15
IPOP-texp	**1.8**(1)	**2.3**(2)	4.7(2)	21(35)	11(16)	15/15
IPOP lia	**1.8**(2)	**1.7**(1)	**1.1**(0.8)	11(14)	8.5(10)	15/15
MLSL pal	**3.0**(4)	**2.5**(2)	**2.2**(3)	**2.8**(3)	**0.96**(0.8)	15/15
OQNLP pal	5.6(5)	4.5(4)	3.4(3)	4.3(5)	**1.4**(0.8)	15/15
P-DCN tra	**1.2**(0.8)	**1.7**(1)	**2.4**(5)	1.3e4(4e4)	1.1e4(1e4)	8/15
P-zero tra	**1.2**(0.8)	**1.3**(1)	1.5e4(5)	1.5e4(4e4)	1.1e4(2e4)	8/15
SMAC hut	**1.3**(0.8)	**1.3**(1)	**1.3**(1)	**0.74**(0.9)	**0.91**(0.9)	11/15
U-DCN tra	**1.2**(0.8)	**1.1**(1)	**1.3**(1)	**2.2**(3)	**1.3**(2)	15/15
U-zero tra	**1.2**(0.8)	**1.1**(1)	**0.88**(0.9)	**2.0**(2)	**2.4**(2)	15/15
fmincon pa	**3.0**(4)	**2.5**(2)	**2.5**(4)	3.9(3)	**0.87**(0.7)	15/15
fminunc pa	**2.8**(2)	**2.2**(1)	**3.0**(4)	**3.0**(2)	**0.88**(0.7)	15/15
ga100 hol	**1.5**(0.8)	**1.0**(0.5)	**1.5**(1)	**1.5**(1)	**2.3**(3)	15/15
grid100 ho	**1.7**(0.8)	**1.3**(0.9)	**0.59**(0.4)	**1.5**(2)	**2.8**(3)	15/15
grid16 hol	**1.9**(2)	**1.5**(1)	**1.6**(2)	3.0(3)	**2.0**(2)	15/15
hill hol	3.4(2)	**2.0**(2)	**1.8**(2)	287(8)	45(3)	14/15
lmmCMA aug	**1.8**(1)	**1.9**(2)	**2.0**(0.9)	**3.0**(5)	**2.5**(4)	14/15
memPSODE v	**2.4**(2)	**1.9**(2)	**2.6**(3)	**2.9**(2)	**2.3**(3)	15/15
prcga saw	**1.2**(0.8)	**0.98**(1)	**1.2**(1)	**1.8**(2)	4.3(8)	15/15
ring100 ho	**0.95**(0.4)	**1.1**(0.8)	**1.5**(1)	**2.8**(3)	**2.4**(3)	15/15
ring16 hol	**1.3**(1)	**1.7**(1)	**1.8**(2)	5.5(10)	3.3(3)	15/15
simplex pa	15(13)	16(25)	10(8)	7.2(4)	**1.5**(0.7)	15/15

Table 24: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{23} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f23	*4.0e+1*:1.5	*2.5e+1*:2.6	*1.0e+1*:7.8	*4.0e+0*:55	*2.5e+0*:103	5/5
BIPOP-aCMA	**1.3**(1)	**1.2**(1)	**1.8**(2)	4.0(6)	4.4(7)	15/15
BIPOP-saAC	**1.1**(0.7)	**1.1**(1.0)	**2.0**(2)	**1.7**(2)	**1.8**(2)	15/15
CMAES hut	**1.3**(1.0)	**1.5**(2)	**2.0**(2)	**2.5**(3)	8.4(10)	3/15
DE pal	**1.6**(1.0)	**1.6**(1)	**2.3**(2)	**1.8**(2)	**2.1**(2)	15/15
HCMA los	**1.9**(2)	**2.4**(2)	**2.4**(2)	**2.0**(2)	3.3(5)	15/15
HMLSL pal	**2.7**(2)	11(24)	4.6(8)	**2.8**(3)	**2.1**(2)	15/15
IPOP-10DDr	**1.3**(1.0)	**1.1**(0.8)	**1.8**(2)	**1.3**(2)	3.1(4)	15/15
IPOP-500 l	**1.3**(1.0)	**1.1**(0.8)	**1.8**(2)	**1.3**(2)	3.1(4)	15/15
IPOP-tany	**1.5**(1.0)	**1.4**(1)	**2.4**(2)	**1.9**(2)	**1.7**(1)	15/15
IPOP-texp	**1.7**(2)	**1.3**(1.0)	**2.1**(1)	**2.6**(3)	3.4(4)	15/15
IPOP lia	**1.3**(1.0)	**1.1**(0.8)	**1.8**(2)	**1.3**(2)	3.1(4)	15/15
MLSL pal	**2.7**(2)	11(24)	4.5(8)	**2.1**(2)	**1.6**(1)	15/15
OQNLP pal	3.3(3)	19(34)	9.1(11)	4.1(3)	**2.9**(2)	15/15
P-DCN tra	**1.3**(1.0)	**0.97**(0.8)	**1.7**(2)	**1.7**(2)	**1.4**(1)	15/15
P-zero tra	**1.3**(1.0)	**0.97**(0.8)	**1.1**(0.8)	**2.1**(3)	**1.5**(2)	15/15
SMAC hut	**1.3**(1.0)	**1.6**(2)	**2.0**(2)	**1.8**(2)	**2.5**(3)	8/15
U-DCN tra	**1.3**(1.0)	**0.97**(0.8)	**1.7**(2)	**1.5**(2)	**2.2**(2)	15/15
U-zero tra	**1.3**(1.0)	**0.97**(0.8)	**1.7**(2)	**1.1**(1)	**3.0**(3)	15/15
fmincon pa	**2.7**(2)	8.3(22)	4.5(9)	**2.2**(2)	**2.4**(2)	15/15
fminunc pa	**1.8**(2)	12(18)	5.2(8)	**2.0**(2)	**2.2**(3)	15/15
ga100 hol	**2.1**(2)	**1.9**(2)	**1.7**(2)	**1.8**(2)	**2.9**(4)	15/15
grid100 ho	**1.6**(1)	**2.8**(3)	**2.5**(3)	**1.8**(2)	**1.9**(2)	15/15
grid16 hol	**1.3**(0.7)	**1.4**(1)	**1.7**(1)	3.4(7)	3.7(5)	15/15
hill hol	**1.3**(1.0)	**1.6**(1)	3.4(3)	3.5(5)	3.3(4)	15/15
lmmCMA aug	**1.7**(1)	**1.4**(1)	**2.1**(2)	**2.8**(2)	4.3(4)	15/15
memPSODE v	**1.4**(1.0)	**1.2**(1.0)	**1.6**(2)	3.5(6)	**3.0**(3)	15/15
prcga saw	**1.6**(1.0)	**1.4**(1.0)	**2.5**(3)	**2.2**(2)	**2.3**(2)	15/15
ring100 ho	**1.5**(1.0)	**1.8**(2)	**2.3**(2)	**1.9**(2)	**2.9**(2)	15/15
ring16 hol	**1.2**(1)	**1.2**(1.0)	**2.0**(2)	**2.5**(4)	3.3(4)	15/15
simplex pa	64(84)	54(50)	23(19)	4.8(3)	**2.9**(2)	15/15

Table 25: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{24} for given run-length based budgets (0.5D, 1.2D, 3D, 10D, and 50D function evaluations). The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear for each algorithm and run-length based target, the corresponding ERT$_{\text{best 2009}}$ (preceded by the target Δf-value in *italics*) in the first row. #succ is the number of trials that reached the target value of the last column. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries with succeeding star are statistically significantly better (according to the rank-sum test) compared to all other algorithms in the table, with $p = 0.05$ or $p = 10^{-k}$ when the number k following the star is larger than 1, with Bonferroni correction by the number of instances.

#FEs/D	0.5	1.2	3	10	50	#succ
f24	*4.0e+1*:1.1	*2.5e+1*:2.7	*1.6e+1*:7.7	*6.3e+0*:44	*2.5e+0*:275	5/5
BIPOP-aCMA	**1.4**(0.9)	**2.7**(3)	**1.9**(2)	**1.6**(1)	3.0(4)	15/15
BIPOP-saAC	**1.5**(0.9)	**2.8**(4)	**1.7**(2)	**1.4**(1)	3.6(2)	15/15
CMAES hut	**2.2**(2)	**2.6**(2)	3.0(3)	**1.9**(3)	**1.2**(1)	7/15
DE pal	**1.5**(0.9)	**1.4**(1)	**1.3**(1)	**1.8**(2)	**1.8**(2)	15/15
HCMA los	**2.7**(3)	**2.1**(2)	**1.3**(1)	**1.6**(2)	**2.5**(2)	15/15
HMLSL pal	**2.1**(2)	4.3(4)	3.8(5)	**2.2**(2)	**1.7**(2)	15/15
IPOP-10DDr	**1.2**(0.9)	**0.95**(0.8)	**1.6**(2)	**1.4**(1)	6.7(7)	15/15
IPOP-500 l	**1.2**(0.9)	**0.95**(0.8)	**1.6**(2)	**1.4**(1)	6.6(7)	15/15
IPOP-tany	**1.2**(0.9)	**0.90**(0.9)	**1.1**(0.6)	**1.8**(0.8)	7.1(11)	15/15
IPOP-texp	**1.2**(0.9)	**1.0**(0.9)	**1.9**(1.0)	**1.4**(1)	5.2(7)	15/15
IPOP lia	**1.2**(0.9)	**0.95**(0.8)	**1.6**(2)	**1.4**(1)	6.6(7)	15/15
MLSL pal	**2.1**(2)	4.2(4)	3.4(4)	**2.6**(2)	**1.6**(2)	15/15
OQNLP pal	**2.8**(3)	4.0(3)	**2.3**(2)	5.1(2)	**2.6**(2)	15/15
P-DCN tra	**1.6**(0.9)	**2.3**(2)	**1.9**(2)	**2.4**(2)	26(29)	15/15
P-zero tra	**1.6**(0.9)	**2.2**(2)	**2.3**(3)	9.2(1)	42(54)	15/15
SMAC hut	**1.1**(0.5)	**1.5**(1)	**1.6**(1)	**2.1**(2)	3.6(4)	3/15
U-DCN tra	**1.6**(0.9)	**2.3**(2)	**1.9**(2)	**1.9**(3)	3.2(3)	15/15
U-zero tra	**1.6**(0.9)	**2.3**(2)	**1.5**(1.0)	**1.6**(1)	8.5(6)	15/15
fmincon pa	**2.1**(2)	4.2(4)	3.3(4)	**2.1**(2)	**1.9**(3)	15/15
fminunc pa	**2.6**(4)	3.3(3)	**2.6**(2)	**2.3**(2)	**1.9**(2)	15/15
ga100 hol	**1.6**(0.9)	**1.2**(1)	**1.1**(1)	**2.5**(3)	8.9(11)	15/15
grid100 ho	**1.5**(0.5)	**1.4**(1)	**1.6**(1)	**2.0**(1)	6.4(8)	15/15
grid16 hol	**1.8**(0.9)	**1.8**(1)	**1.5**(2)	**2.1**(2)	8.8(13)	15/15
hill hol	**1.2**(0.9)	**2.4**(3)	**2.0**(2)	**1.7**(1)	5.5(7)	15/15
lmmCMA aug	**1.2**(0.9)	**1.5**(1)	**1.2**(0.8)	**1.6**(2)	**1.2**(0.8)	15/15
memPSODE v	3.7(4)	**2.6**(2)	3.1(4)	**1.9**(1)	5.6(10)	15/15
prcga saw	**1.6**(1)	**1.7**(2)	**1.0**(0.9)	**1.8**(2)	7.8(14)	15/15
ring100 ho	**2.1**(2)	**1.6**(1)	**1.4**(1)	**2.1**(2)	5.9(6)	15/15
ring16 hol	**1.4**(0.5)	**1.1**(1)	**1.5**(2)	**2.4**(2)	3.8(6)	15/15
simplex pa	4.2(7)	9.1(10)	5.2(3)	5.0(1)	3.3(3)	15/15

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