Comparison Tables: BBOB 2013 Testbed in 5-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: 05-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	*2.5e+1*:4.8	*1.6e+1*:7.6	*1.0e-8*:12	*1.0e-8*:12	*1.0e-8*:12	15/15
BIPOP-aCMA	3.2(3)	3.5(2)	15(0.6)	15(0.6)	15(0.6)	15/15
BIPOP-saAC	4.3(3)	3.7(3)	21(2)	21(2)	21(2)	15/15
CMAES hut	**2.4**(2)	**2.1**(2)	∞	∞	∞ *506*	0/15
DE pal	**1.8**(2)	3.9(4)	180(7)	180(7)	180(7)	15/15
HCMA los	**1.9**(1)	**1.5**(0)	**0.98**(0)$^{\star 4}$	**0.98**(0)$^{\star 4}$	**0.98**(0)$^{\star 4}$	15/15
HMLSL pal	**1.0**(0.6)	**0.76**(0.4)	**4.5**(0.7)	**4.5**(0.7)	**4.5**(0.7)	15/15
IPOP-10DDr	**2.1**(2)	**2.9**(2)	58(5)	58(5)	58(5)	15/15
IPOP-500 l	**2.1**(2)	**2.9**(2)	58(5)	58(5)	58(5)	15/15
IPOP-tany	**1.4**(2)	**2.9**(3)	62(4)	62(4)	62(4)	15/15
IPOP-texp	**2.3**(3)	**2.4**(3)	62(5)	62(5)	62(5)	15/15
IPOP lia	**2.1**(2)	**2.9**(2)	58(5)	58(5)	58(5)	15/15
MLSL pal	**1.0**(0.6)	**0.76**(0.4)	**4.5**(0.7)	**4.5**(0.7)	**4.5**(0.7)	15/15
OQNLP pal	**2.5**(2)	**2.0**(1)	**2.6**(0.0)	**2.6**(0.0)	**2.6**(0.0)	15/15
P-DCN tra	**2.5**(4)	5.5(10)	712(331)	712(331)	712(331)	15/15
P-zero tra	8.7(7)	10(13)	2005(871)	2005(871)	2005(871)	15/15
SMAC hut	**0.79**(0.7)	**0.84**(0.5)	∞	∞	∞ *500*	0/15
U-DCN tra	**2.4**(2)	**2.6**(3)	3045(1610)	3045(1610)	3045(1610)	15/15
U-zero tra	**2.3**(2)	**2.3**(2)	9.8e4(6e4)	9.8e4(6e4)	9.8e4(6e4)	15/15
fmincon pa	**1.0**(0.6)	**0.76**(0.4)	**4.5**(0.7)	**4.5**(0.7)	**4.5**(0.7)	15/15
fminunc pa	**1.1**(0.6)	**1.2**(0.8)	**1.1**(0)	**1.1**(0)	**1.1**(0)	15/15
ga100 hol	**2.1**(2)	3.2(2)	∞	∞	∞ *2e5*	0/15
grid100 ho	3.6(4)	3.9(5)	∞	∞	∞ *2e5*	0/15
grid16 hol	6.2(10)	11(13)	∞	∞	∞ *2e5*	0/15
hill hol	4.8(5)	4.1(4)	∞	∞	∞ *2e5*	0/15
lmmCMA aug	**1.2**(2)	**1.5**(1)	9.1(0.6)	9.1(0.6)	9.1(0.6)	15/15
memPSODE v	4.2(5)	5.1(6)	7.6(0.2)	7.6(0.2)	7.6(0.2)	15/15
prcga saw	**1.8**(2)	**2.3**(3)	2503(3948)	2503(3948)	2503(3948)	15/15
ring100 ho	**2.3**(3)	5.7(9)	∞	∞	∞ *2e5*	0/15
ring16 hol	**2.4**(2)	4.4(4)	∞	∞	∞ *2e5*	0/15
simplex pa	12(8)	17(17)	96(12)	96(12)	96(12)	15/15

Table 3: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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	*1.6e+6*:2.9	*4.0e+5*:11	*4.0e+4*:15	*6.3e+2*:58	*1.0e-8*:95	15/15
BIPOP-aCMA	**1.9**(2)	**1.8**(1)	3.8(1)	**1.6**(0.2)	**3.0**(0.2)	15/15
BIPOP-saAC	3.6(4)	**2.3**(2)	6.1(4)	3.4(0.7)	5.6(0.7)	15/15
CMAES hut	3.7(5)	**1.9**(2)	6.1(3)	8.2(5)	∞ *506*	0/15
DE pal	**1.8**(2)	**2.2**(2)	7.2(6)	8.0(2)	32(1)	15/15
HCMA los	3.7(2)	**1.0**(0)	**0.97**(0.2)	**1.2**(0.7)	**3.8**(0.2)	15/15
HMLSL pal	10(12)	3.7(4)	5.2(5)	**2.2**(2)	10(9)	15/15
IPOP-10DDr	**2.6**(2)	**1.4**(1)	5.7(4)	9.3(5)	24(3)	15/15
IPOP-500 l	**2.6**(2)	**1.4**(1)	5.7(4)	9.3(5)	24(3)	15/15
IPOP-tany	3.3(4)	**1.6**(1)	5.3(3)	10(4)	24(1)	15/15
IPOP-texp	4.8(4)	**1.6**(1)	6.3(7)	9.4(3)	25(2)	15/15
IPOP lia	**2.6**(2)	**1.4**(1)	5.7(4)	9.3(5)	24(3)	15/15
MLSL pal	10(12)	3.7(4)	5.2(5)	**2.2**(2)	7.3(6)	15/15
OQNLP pal	5.9(3)	**1.9**(1)	**3.1**(2)	**1.3**(0.1)	456(460)	3/15
P-DCN tra	**1.1**(1)	**2.8**(4)	10(7)	11(8)	881(819)	15/15
P-zero tra	**1.1**(1)	**1.9**(2)	7.4(7)	10(8)	8.9e4(9e4)	7/15
SMAC hut	**1.0**(0.9)	**0.74**(0.7)	**1.7**(2)	8.0(7)	∞ *500*	0/15
U-DCN tra	**1.1**(1)	**1.0**(2)	6.2(6)	19(24)	1.7e4(3e4)	12/15
U-zero tra	**1.1**(1)	**1.0**(2)	7.8(8)	23(26)	∞ *5e6*	0/15
fmincon pa	10(12)	3.7(4)	4.8(5)	**2.0**(1)	**4.7**(2)	15/15
fminunc pa	5.2(4)	**2.0**(1)	**3.1**(2)	**2.7**(1)	7.7(2)	15/15
ga100 hol	**1.6**(2)	**1.4**(1)	16(16)	31(17)	∞ *2e5*	0/15
grid100 ho	**1.7**(2)	**1.4**(2)	24(31)	76(35)	∞ *2e5*	0/15
grid16 hol	**1.3**(0.9)	**1.2**(1)	11(9)	22(10)	∞ *2e5*	0/15
hill hol	8.7(9)	3.4(3)	6.1(6)	13(11)	∞ *2e5*	0/15
lmmCMA aug	**1.6**(2)	**0.83**(0.9)	**2.4**(2)	**2.5**(0.7)	**5.5**(1)	15/15
memPSODE v	**1.7**(2)	**1.3**(1)	7.4(4)	3.5(2)	**5.2**(3)	15/15
prcga saw	**1.5**(1)	**1.0**(1)	5.3(5)	8.3(2)	1122(1443)	15/15
ring100 ho	**1.1**(1)	**1.1**(0.9)	25(24)	54(21)	∞ *2e5*	0/15
ring16 hol	**1.5**(1)	**1.7**(2)	10(7)	17(12)	∞ *2e5*	0/15
simplex pa	22(13)	6.6(3)	15(16)	11(9)	28(3)	15/15

Table 4: 05-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	*1.6e+2*:4.1	*1.0e+2*:15	*6.3e+1*:23	*2.5e+1*:73	*1.0e+1*:716	15/15
BIPOP-aCMA	**2.9**(4)	**1.8**(1)	**1.8**(0.5)	**1.1**(0.6)	**0.27**(0.1)	15/15
BIPOP-saAC	4.1(2)	**2.7**(2)	**2.6**(1)	3.1(1)	**1.1**(0.9)	15/15
CMAES hut	**2.9**(3)	**1.7**(1)	**2.3**(2)	**2.6**(1)	**1.2**(0.8)	8/15
DE pal	**1.7**(2)	**1.7**(2)	4.8(3)	4.5(0.9)	**1.2**(0.4)	15/15
HCMA los	**2.6**(2)	**1.8**(2)	**1.6**(1)	**1.1**(0.6)	**0.29**(0.1)	15/15
HMLSL pal	7.1(18)	6.4(7)	11(10)	8.0(5)	**1.3**(0.2)	15/15
IPOP-10DDr	**2.5**(3)	**2.0**(1)	**2.5**(1)	**2.4**(2)	**0.99**(1)	15/15
IPOP-500 l	**2.5**(3)	**2.0**(1)	**2.5**(1)	**2.4**(2)	**0.99**(1)	15/15
IPOP-tany	**2.0**(2)	**1.5**(1)	**2.0**(1.0)	**2.3**(1)	**0.94**(1)	15/15
IPOP-texp	**1.5**(1)	**1.1**(0.9)	**1.6**(0.9)	**2.5**(2)	**1.1**(1)	15/15
IPOP lia	**2.5**(3)	**2.0**(1)	**2.5**(1)	**2.4**(2)	**0.99**(1)	15/15
MLSL pal	7.5(20)	7.7(8)	12(9)	18(20)	5.6(5)	15/15
OQNLP pal	13(26)	9.3(12)	12(9)	25(30)	8.6(12)	13/15
P-DCN tra	**0.98**(0.8)	7.3(2)	7.3(1)	7.5(11)	7.5(11)	15/15
P-zero tra	**0.98**(0.8)	**1.6**(2)	3.3(3)	42(40)	9.4(9)	15/15
SMAC hut	**0.73**(0.6)	**0.74**(1.0)	**2.6**(4)	4.4(5)	5.1(5)	2/15
U-DCN tra	**0.98**(0.8)	**1.4**(1)	**2.6**(1)	3.3(1)	**0.85**(0.5)	15/15
U-zero tra	**0.98**(0.8)	**1.3**(1)	**1.6**(0.7)	**1.5**(0.5)	**0.62**(0.5)	15/15
fmincon pa	7.4(19)	7.1(8)	9.1(9)	12(15)	5.2(6)	15/15
fminunc pa	9.1(20)	6.9(7)	9.0(6)	13(9)	5.3(5)	15/15
ga100 hol	**1.6**(2)	**0.99**(1)	5.4(6)	11(3)	**2.3**(0.6)	15/15
grid100 ho	**1.1**(1)	4.3(4)	17(13)	25(12)	5.3(4)	15/15
grid16 hol	**2.2**(2)	3.5(3)	5.3(5)	6.1(3)	**1.1**(0.5)	15/15
hill hol	7.3(5)	**2.6**(1)	**2.0**(1)	**1.5**(0.8)	**0.36**(0.2)	15/15
lmmCMA aug	**1.4**(1)	**0.92**(0.8)	**1.4**(1)	**2.4**(1)	**0.45**(0.1)	15/15
memPSODE v	3.2(3)	8.4(14)	20(18)	15(12)	3.6(3)	15/15
prcga saw	**1.6**(2)	**1.2**(1)	**2.5**(3)	5.0(2)	**1.3**(0.6)	15/15
ring100 ho	**1.6**(2)	**2.2**(2)	12(10)	20(7)	4.4(1)	15/15
ring16 hol	**2.0**(1)	3.0(3)	4.7(4)	4.6(2)	**0.98**(0.3)	15/15
simplex pa	91(112)	50(34)	43(13)	25(14)	12(7)	15/15

Table 5: 05-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	*2.5e+2*:2.6	*1.6e+2*:10	*1.0e+2*:19	*4.0e+1*:65	*1.6e+1*:434	15/15
BIPOP-aCMA	3.6(4)	**2.1**(2)	**2.6**(1)	**1.6**(0.5)	**0.38**(0.1)	15/15
BIPOP-saAC	4.3(5)	**2.2**(2)	**2.3**(3)	3.3(0.8)	**1.9**(2)	15/15
CMAES hut	4.1(4)	**2.5**(4)	**2.5**(3)	**2.5**(1)	**1.2**(0.7)	11/15
DE pal	**3.0**(3)	**2.6**(3)	3.6(2)	4.2(2)	**1.5**(0.6)	15/15
HCMA los	6.3(6)	3.2(2)	3.0(2)	**1.8**(0.4)	**0.45**(0.3)	15/15
HMLSL pal	**0.69**(0)	**0.94**(1)	5.4(11)	7.3(6)	**1.9**(1)	15/15
IPOP-10DDr	**1.0**(0.2)	**1.5**(2)	**2.6**(2)	**2.4**(1.0)	**2.9**(3)	15/15
IPOP-500 l	**1.0**(0.2)	**1.5**(2)	**2.6**(2)	**2.4**(1.0)	**2.9**(3)	15/15
IPOP-tany	**0.64**(0.2)	**1.0**(1)	**1.7**(1)	**2.5**(1)	**1.9**(3)	15/15
IPOP-texp	**0.64**(0.2)	**0.86**(1.0)	**1.3**(0.6)	**1.3**(0.6)	**2.5**(3)	15/15
IPOP lia	**1.0**(0.2)	**1.5**(2)	**2.6**(2)	**2.4**(1.0)	**2.9**(3)	15/15
MLSL pal	**0.69**(0)	**0.94**(1)	4.9(9)	18(26)	15(18)	15/15
OQNLP pal	**0.72**(0)	4.1(12)	12(11)	44(77)	34(47)	9/15
P-DCN tra	4.7(2)	3.9(3)	5.3(5)	22(38)	77(86)	15/15
P-zero tra	**1.6**(2)	**1.5**(1)	**1.7**(1)	11(13)	43(14)	15/15
SMAC hut	**0.56**(0.4)	**0.54**(0.6)	**1.8**(3)	14(13)	∞ *500*	0/15
U-DCN tra	**1.8**(2)	**1.7**(2)	**2.7**(1)	**2.7**(1)	**1.2**(0.6)	15/15
U-zero tra	**1.7**(2)	**1.3**(1)	**1.5**(0.6)	**1.8**(0.8)	**0.84**(0.4)	15/15
fmincon pa	**0.69**(0)	**0.94**(1)	4.9(9)	12(20)	13(18)	15/15
fminunc pa	**0.69**(0)	**1.6**(2)	4.6(4)	13(14)	19(20)	15/15
ga100 hol	**2.5**(3)	**2.9**(2)	6.3(5)	12(3)	3.5(0.9)	15/15
grid100 ho	4.1(5)	**2.7**(3)	8.6(8)	28(16)	10(4)	15/15
grid16 hol	**2.6**(2)	**2.9**(4)	5.6(5)	6.7(4)	**2.1**(1.0)	15/15
hill hol	7.9(8)	3.9(2)	**2.7**(2)	**1.5**(0.7)	**0.61**(0.3)	15/15
lmmCMA aug	**0.51**(0.4)	**0.79**(1)	**0.93**(1)	**2.2**(0.9)	**1.3**(1)	15/15
memPSODE v	**2.9**(2)	3.2(3)	19(16)	14(10)	4.9(3)	15/15
prcga saw	**1.6**(2)	**0.77**(1.0)	**1.6**(2)	5.2(2)	**2.0**(1)	15/15
ring100 ho	3.1(3)	**1.9**(2)	5.7(6)	20(8)	7.0(2)	15/15
ring16 hol	**1.7**(2)	**2.8**(4)	5.2(4)	5.2(2)	**1.6**(0.5)	15/15
simplex pa	**1.4**(0)	19(52)	41(32)	43(44)	29(26)	15/15

Table 6: 05-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	*6.3e+1*:4.0	*4.0e+1*:10	*1.0e-8*:10	*1.0e-8*:10	*1.0e-8*:10	15/15
BIPOP-aCMA	**1.4**(1)	**1.0**(0.3)	**1.2**(0)	**1.2**(0)	**1.2**(0)	15/15
BIPOP-saAC	3.9(4)	**2.4**(2)	6.4(2)	6.4(2)	6.4(2)	15/15
CMAES hut	3.2(2)	**1.9**(2)	5.6(1)	5.6(1)	5.6(1)	15/15
DE pal	**1.6**(2)	3.3(3)	859(45)	859(45)	859(45)	15/15
HCMA los	**2.4**(0.9)	**1.2**(0.1)	**1.5**(0.3)	**1.5**(0.3)	**1.5**(0.3)	15/15
HMLSL pal	**1.8**(0)	**0.71**(0)	503(698)	503(698)	503(698)	15/15
IPOP-10DDr	**1.7**(1)	**2.1**(1)	46(43)	46(43)	46(43)	15/15
IPOP-500 l	**1.7**(1)	**2.1**(1)	46(43)	46(43)	46(43)	15/15
IPOP-tany	**2.6**(3)	**2.3**(1)	67(60)	67(60)	67(60)	15/15
IPOP-texp	7.3(2)	4.2(1)	89(71)	89(71)	89(71)	15/15
IPOP lia	**1.7**(1)	**2.1**(1)	46(43)	46(43)	46(43)	15/15
MLSL pal	**1.8**(0)	**0.71**(0)	527(461)	527(461)	527(461)	14/15
OQNLP pal	5.0(0)	**2.1**(0)	**2.4**(0)	**2.4**(0)	**2.4**(0)	15/15
P-DCN tra	**1.5**(2)	3.2(4)	326(66)	326(66)	326(66)	15/15
P-zero tra	**1.2**(1)	4.0(9)	171(79)	171(79)	171(79)	15/15
SMAC hut	**1.3**(0.2)	**0.63**(0.2)	**0.95**(0.1)$^{\star 3}$	**0.95**(0.1)$^{\star 3}$	**0.95**(0.1)$^{\star 3}$	15/15
U-DCN tra	**1.4**(2)	**2.1**(2)	3.3e6(4e6)	3.3e6(4e6)	3.3e6(4e6)	2/15
U-zero tra	**1.3**(1)	**2.0**(3)	∞	∞	∞ *5e6*	0/15
fmincon pa	**1.8**(0)	**0.71**(0)	1250(2807)	1250(2794)	1250(2794)	13/15
fminunc pa	3.2(0)	**1.3**(0)	**3.1**(0)	**3.1**(0)	**3.1**(0)	15/15
ga100 hol	**2.3**(2)	5.0(5)	124(27)	124(27)	124(27)	15/15
grid100 ho	**2.2**(2)	4.5(4)	264(76)	264(76)	264(76)	15/15
grid16 hol	3.8(7)	10(6)	51(14)	51(14)	51(14)	15/15
hill hol	6.8(6)	4.1(2)	11(4)	11(4)	11(4)	15/15
lmmCMA aug	3.1(2)	**1.9**(0.8)	5.0(1)	5.0(1)	5.0(1)	15/15
memPSODE v	**1.8**(2)	**2.5**(1.0)	14(6)	14(6)	14(6)	15/15
prcga saw	3.5(4)	11(6)	∞	∞	∞ *3e5*	0/15
ring100 ho	**1.8**(2)	6.1(8)	201(42)	201(42)	201(42)	15/15
ring16 hol	4.6(10)	6.3(6)	48(12)	48(12)	48(12)	15/15
simplex pa	19(0.4)	12(13)	90(97)	90(97)	90(97)	15/15

Table 7: 05-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	*1.0e+5*:3.0	*2.5e+4*:8.4	*1.0e+2*:16	*2.5e+1*:54	*2.5e-1*:254	15/15
BIPOP-aCMA	3.8(6)	**2.4**(4)	5.1(4)	3.4(3)	**2.2**(0.5)	15/15
BIPOP-saAC	5.4(7)	**2.7**(2)	3.5(4)	3.1(2)	**2.5**(1.0)	15/15
CMAES hut	**2.9**(4)	**1.6**(2)	3.2(4)	**2.7**(2)	**2.4**(1)	11/15
DE pal	**2.3**(3)	**1.8**(2)	5.8(7)	3.2(2)	6.8(2)	15/15
HCMA los	3.2(1)	**1.4**(0.7)	**1.5**(1)	**2.7**(3)	**2.4**(1.0)	15/15
HMLSL pal	**2.8**(4)	**2.3**(2)	3.4(2)	**1.7**(1)	**1.2**(0.6)	15/15
IPOP-10DDr	**2.4**(2)	**2.0**(2)	3.1(3)	**2.0**(0.9)	**2.0**(0.3)	15/15
IPOP-500 l	**2.4**(2)	**2.0**(2)	3.1(3)	**2.0**(0.9)	**2.0**(0.3)	15/15
IPOP-tany	**2.6**(3)	**2.3**(3)	**2.8**(2)	**1.8**(0.9)	**2.1**(0.4)	15/15
IPOP-texp	4.1(6)	3.2(4)	3.6(2)	**1.7**(1.0)	**2.1**(0.6)	15/15
IPOP lia	**2.4**(2)	**2.0**(2)	3.1(3)	**2.0**(0.9)	**2.0**(0.3)	15/15
MLSL pal	**2.8**(4)	**2.3**(2)	3.4(2)	**1.7**(1)	**1.2**(0.6)	15/15
OQNLP pal	3.6(3)	**2.3**(2)	**2.2**(0.8)	**1.1**(0.6)	**0.98**(0.4)	15/15
P-DCN tra	**2.4**(4)	**1.9**(2)	7.7(7)	8.8(8)	8.0(4)	15/15
P-zero tra	**2.2**(3)	**2.4**(3)	10(13)	8.2(8)	7.2(7)	15/15
SMAC hut	**1.4**(1)	**1.1**(1)	**1.5**(2)	**1.9**(2)	∞ *500*	0/15
U-DCN tra	3.2(3)	**2.5**(4)	7.7(4)	6.9(10)	272(433)	15/15
U-zero tra	**2.1**(2)	**1.3**(1)	6.1(4)	3.8(3)	1830(1556)	14/15
fmincon pa	**2.8**(4)	**2.3**(2)	3.2(2)	**1.6**(0.8)	**1.2**(0.6)	15/15
fminunc pa	**2.5**(3)	**1.8**(1)	**2.4**(1)	**1.5**(1)	**2.5**(1)	15/15
ga100 hol	3.6(2)	4.1(5)	13(14)	11(7)	60(34)	15/15
grid100 ho	**2.8**(3)	**2.1**(2)	24(33)	22(18)	657(586)	12/15
grid16 hol	4.7(10)	4.4(8)	9.1(6)	8.2(8)	207(165)	14/15
hill hol	4.7(7)	**2.5**(3)	4.1(5)	3.5(2)	31(29)	15/15
lmmCMA aug	**1.6**(2)	**1.4**(1)	4.7(5)	3.8(4)	4.5(3)	15/15
memPSODE v	**2.0**(1)	**1.5**(2)	7.8(8)	5.4(4)	**2.8**(2)	15/15
prcga saw	**1.5**(2)	3.5(8)	8.3(8)	6.3(5)	218(297)	15/15
ring100 ho	**1.9**(3)	3.6(7)	10(12)	10(7)	96(50)	15/15
ring16 hol	**1.9**(2)	**2.6**(3)	7.0(8)	5.0(4)	23(14)	15/15
simplex pa	21(30)	13(13)	34(55)	22(14)	14(8)	15/15

Table 8: 05-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	*1.6e+2*:4.2	*1.0e+2*:6.2	*2.5e+1*:20	*4.0e+0*:54	*1.0e+0*:324	15/15
BIPOP-aCMA	**2.0**(2)	**2.8**(3)	4.7(3)	4.0(2)	**1.5**(1)	15/15
BIPOP-saAC	3.3(3)	3.6(3)	3.0(2)	**2.6**(0.6)	**1.2**(1)	15/15
CMAES hut	**2.5**(3)	**2.8**(3)	**2.7**(2)	3.4(2)	**1.6**(2)	10/15
DE pal	**2.0**(2)	**1.6**(2)	3.7(3)	8.3(6)	**2.8**(1)	15/15
HCMA los	**2.8**(1)	**2.2**(0.6)	**2.3**(2)	3.6(3)	**1.0**(0.3)	15/15
HMLSL pal	**1.9**(2)	**2.0**(2)	5.5(7)	10(4)	3.8(2)	15/15
IPOP-10DDr	**1.2**(1)	**1.2**(1)	**2.5**(2)	**3.3**(1)	**1.1**(0.4)	15/15
IPOP-500 l	**1.2**(1)	**1.2**(1)	**2.5**(2)	**3.3**(1)	**1.1**(0.4)	15/15
IPOP-tany	**1.2**(2)	**1.5**(2)	**1.9**(2)	**2.6**(2)	**1.7**(2)	15/15
IPOP-texp	**1.3**(1)	**1.8**(2)	**1.7**(1)	4.8(10)	**2.1**(2)	15/15
IPOP lia	**1.2**(1)	**1.2**(1)	**2.5**(2)	**3.3**(1)	**1.1**(0.4)	15/15
MLSL pal	**1.8**(2)	**2.1**(3)	14(22)	219(203)	1097(1236)	2/15
OQNLP pal	4.0(4)	7.1(12)	11(13)	29(28)	48(57)	2/15
P-DCN tra	6.0(5)	7.6(4)	46(58)	6812(560)	1695(2334)	14/15
P-zero tra	21(11)	74(40)	61(61)	6831(378)	2798(7771)	13/15
SMAC hut	**1.3**(1)	**1.1**(0.9)	**1.5**(1)	**1.6**(0.8)	**0.88**(0.9)	13/15
U-DCN tra	3.0(5)	**2.8**(3)	4.6(4)	31(28)	1132(41)	14/15
U-zero tra	3.2(3)	**3.0**(2)	3.9(3)	48(37)	1488(2964)	15/15
fmincon pa	**2.7**(3)	3.4(3)	8.8(8)	164(139)	1086(1244)	2/15
fminunc pa	**1.5**(1)	**2.6**(4)	8.1(10)	184(193)	∞ *5e4*	0/15
ga100 hol	**1.8**(2)	3.2(4)	6.9(7)	24(17)	11(10)	15/15
grid100 ho	**2.8**(4)	**2.4**(3)	9.3(10)	44(52)	74(83)	15/15
grid16 hol	**0.73**(0.6)	**2.8**(6)	7.6(6)	26(32)	97(110)	14/15
hill hol	8.6(6)	7.5(6)	5.4(3)	141(132)	117(200)	15/15
lmmCMA aug	**1.2**(1)	**1.3**(1)	**1.5**(1)	**2.3**(4)	**0.92**(1.0)	15/15
memPSODE v	3.7(4)	3.5(3)	10(14)	18(20)	7.5(6)	15/15
prcga saw	**1.4**(1.0)	**1.8**(2)	4.1(4)	9.1(5)	17(17)	15/15
ring100 ho	**1.6**(1)	**2.8**(2)	13(17)	30(19)	19(11)	15/15
ring16 hol	**2.5**(3)	3.3(4)	7.3(6)	10(8)	104(276)	15/15
simplex pa	**1.6**(2)	**2.9**(3)	11(11)	93(69)	155(137)	10/15

Table 9: 05-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	*1.0e+4*:4.6	*6.3e+3*:6.8	*1.0e+3*:18	*6.3e+1*:54	*1.6e+0*:258	15/15
BIPOP-aCMA	4.8(4)	3.8(3)	4.5(2)	4.3(2)	4.0(4)	15/15
BIPOP-saAC	**2.7**(4)	**2.4**(3)	**2.6**(2)	**2.3**(0.8)	**2.2**(2)	15/15
CMAES hut	3.7(3)	**2.8**(3)	**2.9**(2)	**2.6**(1)	3.2(2)	8/15
DE pal	3.6(3)	**2.9**(2)	4.7(2)	5.4(2)	5.7(2)	15/15
HCMA los	**1.8**(1)	**1.4**(0.9)	**0.85**(0.3)	**1.2**(2)	**2.3**(3)	15/15
HMLSL pal	**1.2**(2)	**1.1**(1)	**1.2**(1)	**0.92**(0.5)	**1.3**(2)	15/15
IPOP-10DDr	**2.9**(3)	**2.5**(2)	**2.6**(1)	**2.6**(0.9)	4.0(1)	15/15
IPOP-500 l	**2.9**(3)	**2.5**(2)	**2.6**(1)	**2.6**(0.9)	4.0(1)	15/15
IPOP-tany	**2.6**(3)	**2.5**(2)	**2.2**(1)	**2.1**(0.6)	3.3(1)	15/15
IPOP-texp	**2.9**(3)	**2.4**(2)	**2.1**(1)	**1.7**(0.5)	4.3(3)	15/15
IPOP lia	**2.9**(3)	**2.5**(2)	**2.6**(1)	**2.6**(0.9)	4.0(1)	15/15
MLSL pal	**1.2**(2)	**1.1**(1)	**1.2**(1)	**0.92**(0.5)	**1.0**(1)	15/15
OQNLP pal	**1.9**(2)	**1.6**(1)	**1.2**(0.3)	**0.84**(0.5)	**0.68**(0.3)	15/15
P-DCN tra	5.5(4)	5.5(6)	8.2(11)	27(30)	7096(9725)	11/15
P-zero tra	3.0(3)	3.9(7)	6.7(7)	22(24)	3003(9688)	13/15
SMAC hut	**0.99**(1.0)	**0.91**(1)	**1.2**(1)	3.3(2)	∞ *500*	0/15
U-DCN tra	3.7(5)	3.3(5)	3.5(3)	10(9)	279(545)	15/15
U-zero tra	**2.2**(2)	**1.9**(2)	**2.7**(2)	7.3(5)	3004(7911)	14/15
fmincon pa	**1.2**(2)	**1.1**(1)	**1.2**(1)	**0.92**(0.5)	**1.0**(1)	15/15
fminunc pa	**0.83**(0.7)	**0.79**(0.9)	**0.84**(0.5)	**1.1**(0.8)	**0.88**(0.4)	15/15
ga100 hol	3.1(3)	3.3(3)	9.4(9)	16(7)	295(493)	12/15
grid100 ho	**1.7**(2)	3.1(2)	12(13)	53(36)	426(525)	11/15
grid16 hol	4.0(6)	4.7(6)	11(8)	15(12)	504(969)	10/15
hill hol	4.4(5)	3.4(4)	**2.7**(2)	5.7(5)	250(442)	14/15
lmmCMA aug	**1.0**(1)	**0.96**(1)	**1.6**(1)	**1.5**(0.6)	**1.7**(2)	15/15
memPSODE v	3.8(5)	4.7(4)	4.8(3)	3.5(2)	3.5(5)	15/15
prcga saw	**2.1**(2)	**1.5**(2)	4.4(4)	7.5(3)	267(652)	15/15
ring100 ho	**2.8**(3)	3.2(3)	7.0(6)	28(16)	54(24)	15/15
ring16 hol	3.0(2)	3.8(4)	6.1(5)	9.1(6)	272(484)	13/15
simplex pa	7.9(7)	7.5(10)	7.6(5)	10(7)	5.1(3)	15/15

Table 10: 05-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	*2.5e+1*:20	*1.6e+1*:26	*1.0e+1*:35	*4.0e+0*:62	*1.6e-2*:256	15/15
BIPOP-aCMA	10(3)	8.4(2)	7.0(2)	7.0(2)	5.9(1)	15/15
BIPOP-saAC	7.1(2)	5.8(1)	4.6(0.9)	3.7(2)	**2.7**(0.6)	15/15
CMAES hut	8.4(3)	7.3(3)	6.1(3)	6.0(4)	∞ *506*	0/15
DE pal	31(13)	27(9)	24(10)	22(13)	33(8)	15/15
HCMA los	7.0(6)	6.4(6)	5.7(5)	5.6(3)	3.6(3)	15/15
HMLSL pal	**0.66**(0)	**1.1**(0.2)	**0.94**(0)	**0.80**(0.1)	**0.60**(0.0)	15/15
IPOP-10DDr	8.8(4)	7.5(3)	6.1(2)	7.3(5)	8.1(5)	15/15
IPOP-500 l	8.8(4)	7.5(3)	6.1(2)	7.3(5)	8.1(5)	15/15
IPOP-tany	6.9(3)	5.9(2)	5.2(2)	7.3(8)	8.2(7)	15/15
IPOP-texp	3.6(2)	3.3(1)	3.0(2)	4.6(4)	7.0(2)	15/15
IPOP lia	8.8(4)	7.5(3)	6.1(2)	7.3(5)	8.1(5)	15/15
MLSL pal	**0.66**(0)	**1.1**(0.2)	**0.94**(0)	**0.80**(0.1)	**0.60**(0.0)	15/15
OQNLP pal	**0.71**(0)	**0.62**(0)	**0.71**(0.0)	**0.43**(8e-3)	**0.54**(0.0)	15/15
P-DCN tra	776(1712)	597(1314)	446(980)	2.1e4(4e4)	1.7e4(2e4)	9/15
P-zero tra	1194(3320)	918(2547)	685(1900)	482(1068)	1.2e4(7875)	14/15
SMAC hut	14(6)	12(4)	12(8)	120(130)	∞ *500*	0/15
U-DCN tra	64(43)	64(49)	65(59)	9769(8356)	2.5e4(3e4)	8/15
U-zero tra	648(98)	501(74)	378(55)	2.1e4(4e4)	∞ *5e6*	0/15
fmincon pa	**0.66**(0)	**1.1**(0.2)	**0.94**(0)	**0.80**(0.1)	**0.60**(0.0)	15/15
fminunc pa	**0.66**(0)	**0.50**(0)$^{\star 4}$	**0.55**(0)$^{\star 4}$	**0.41**(0)$^{\star 4}$	**0.51**(0.0)$^{\star 2}$	15/15
ga100 hol	72(30)	68(26)	58(23)	159(57)	∞ *2e5*	0/15
grid100 ho	268(214)	380(315)	315(218)	1823(2190)	∞ *2e5*	0/15
grid16 hol	71(36)	62(41)	57(42)	1802(2245)	∞ *2e5*	0/15
hill hol	14(9)	14(12)	13(11)	1159(2050)	∞ *2e5*	0/15
lmmCMA aug	3.7(2)	3.3(1)	**2.7**(0.9)	**2.7**(2)	**2.4**(1)	15/15
memPSODE v	10(4)	7.7(3)	5.9(2)	6.2(2)	4.2(6)	15/15
prcga saw	8.8(3)	11(6)	11(5)	11(4)	∞ *5e5*	0/15
ring100 ho	136(41)	133(38)	138(47)	166(61)	∞ *2e5*	0/15
ring16 hol	32(15)	30(11)	30(11)	327(16)	∞ *2e5*	0/15
simplex pa	**1.7**(0.1)	4.0(3)	5.1(3)	4.1(2)	3.2(0.8)	15/15

Table 11: 05-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	*2.5e+6*:2.9	*6.3e+5*:7.0	*2.5e+5*:17	*6.3e+3*:54	*2.5e+1*:297	15/15
BIPOP-aCMA	**1.6**(2)	**1.7**(2)	**1.5**(1)	3.5(2)	**2.9**(0.8)	15/15
BIPOP-saAC	**2.2**(2)	**2.1**(3)	**1.4**(1)	**2.4**(1)	**0.79**(0.1)	15/15
CMAES hut	**2.7**(3)	**2.4**(3)	**1.5**(1)	3.8(2)	∞ *506*	0/15
DE pal	**1.3**(1)	**1.3**(1)	**0.94**(0.8)	6.2(4)	20(9)	15/15
HCMA los	**1.1**(0.7)	**1.1**(0.9)	**1.00**(0.6)	**2.1**(2)	**1.2**(0.1)	15/15
HMLSL pal	**2.9**(2)	**1.9**(3)	**1.1**(1)	**0.88**(0.3)	**0.31**(0.1)	15/15
IPOP-10DDr	**1.1**(0.9)	**1.5**(2)	**1.2**(0.8)	5.3(3)	3.4(0.9)	15/15
IPOP-500 l	**1.1**(0.9)	**1.5**(2)	**1.2**(0.8)	5.3(3)	3.4(0.9)	15/15
IPOP-tany	**1.1**(0.9)	**1.2**(1)	**0.76**(0.7)	3.7(2)	3.4(1)	15/15
IPOP-texp	**2.6**(4)	**2.6**(3)	**1.9**(2)	3.9(3)	3.5(1)	15/15
IPOP lia	**1.1**(0.9)	**1.5**(2)	**1.2**(0.8)	5.3(3)	3.4(0.9)	15/15
MLSL pal	**2.9**(2)	**1.9**(3)	**1.1**(1)	**0.88**(0.3)	**0.31**(0.1)	15/15
OQNLP pal	4.3(3)	**2.0**(1)	**1.2**(0.9)	**0.93**(0.5)	**0.43**(0.3)	15/15
P-DCN tra	**1.5**(1)	**2.4**(3)	3.4(6)	23(16)	4834(8682)	12/15
P-zero tra	**1.5**(1)	4.3(2)	4.7(6)	27(26)	1.1e4(1e4)	11/15
SMAC hut	**1.3**(0.9)	**0.80**(0.6)	**0.58**(0.6)	**2.5**(2)	∞ *500*	0/15
U-DCN tra	**1.3**(1)	**1.2**(0.9)	**2.2**(1)	20(8)	1.2e4(2e4)	11/15
U-zero tra	**1.3**(1)	**1.7**(2)	**1.2**(0.9)	75(69)	7.3e4(8e4)	3/15
fmincon pa	**2.9**(2)	**1.9**(3)	**1.1**(1)	**0.88**(0.3)	**0.30**(0.1)	15/15
fminunc pa	**2.4**(2)	**1.6**(2)	**1.1**(0.9)	**1.6**(1)	**0.97**(0.5)	15/15
ga100 hol	**1.4**(1)	**1.8**(3)	**1.2**(1)	21(19)	1562(1903)	6/15
grid100 ho	**1.7**(1)	**1.2**(0.8)	**1.6**(2)	49(80)	∞ *2e5*	0/15
grid16 hol	**1.7**(2)	**2.9**(2)	**2.3**(2)	32(33)	1.2e4(1e4)	1/15
hill hol	4.7(5)	4.0(5)	**2.3**(3)	42(65)	1.2e4(1e4)	1/15
lmmCMA aug	**2.3**(3)	**1.5**(1)	**1.1**(0.9)	**1.5**(0.4)	**0.83**(0.4)	15/15
memPSODE v	**1.8**(1)	**2.0**(2)	**1.8**(1)	3.2(1)	4.1(8)	15/15
prcga saw	**1.1**(0.9)	**0.86**(0.9)	**0.92**(0.8)	272(136)	3384(4085)	5/15
ring100 ho	**1**(2)	**0.71**(0.7)	**1.1**(2)	27(18)	2047(2172)	5/15
ring16 hol	**1.6**(1)	**1.8**(2)	**2.4**(2)	10(9)	3927(4278)	3/15
simplex pa	15(13)	8.2(5)	5.0(6)	7.0(6)	5.8(2)	15/15

Table 12: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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+6*:3.0	*6.3e+4*:6.2	*6.3e+2*:16	*6.3e+1*:74	*6.3e-1*:298	15/15
BIPOP-aCMA	**2.0**(4)	3.0(3)	3.8(4)	7.0(5)	3.4(0.5)	15/15
BIPOP-saAC	3.5(3)	**2.8**(2)	5.0(7)	3.4(0.6)	**1.1**(0.1)	15/15
CMAES hut	**2.9**(2)	**2.6**(3)	5.5(5)	5.3(5)	∞ *506*	0/15
DE pal	**1.6**(2)	**2.9**(3)	9.0(8)	5.4(6)	28(8)	15/15
HCMA los	**2.5**(2)	**1.8**(1.0)	**1.4**(0.6)	3.1(2)	**1.4**(0.2)	15/15
HMLSL pal	3.2(2)	**2.5**(2)	**1.4**(0.3)	**0.36**(0.1)	**0.15**(0.0)	15/15
IPOP-10DDr	**2.0**(2)	3.2(4)	6.2(3)	4.8(6)	4.9(0.4)	15/15
IPOP-500 l	**2.0**(2)	3.2(4)	6.2(3)	4.8(6)	4.9(0.4)	15/15
IPOP-tany	**1.9**(2)	**2.4**(2)	5.3(4)	6.0(6)	4.9(0.5)	15/15
IPOP-texp	5.7(6)	4.3(3)	3.7(2)	4.0(6)	4.7(0.8)	15/15
IPOP lia	**2.0**(2)	3.2(4)	6.2(3)	4.8(6)	4.9(0.4)	15/15
MLSL pal	3.2(2)	**2.5**(2)	**1.4**(0.3)	**0.36**(0.1)	**0.15**(0.0)	15/15
OQNLP pal	4.4(3)	**2.8**(2)	**2.1**(1)	**0.56**(0.4)	**0.65**(1.0)	15/15
P-DCN tra	**2.3**(2)	4.4(4)	4.5(5)	171(238)	646(402)	15/15
P-zero tra	**2.1**(2)	3.4(6)	3.8(3)	112(216)	967(578)	15/15
SMAC hut	**0.73**(0.5)	**0.94**(0.9)	**1.9**(2)	**0.94**(0.8)	∞ *500*	0/15
U-DCN tra	**1.8**(2)	**2.6**(2)	4.6(4)	12(8)	5350(4218)	14/15
U-zero tra	**2.5**(1)	**2.5**(3)	5.9(3)	27(34)	4759(4840)	14/15
fmincon pa	3.2(2)	**2.5**(2)	**1.4**(0.3)	**0.36**(0.1)	**0.16**(0.0)	15/15
fminunc pa	3.5(3)	**2.4**(1)	**1.7**(0.8)	**0.46**(0.1)	**1.7**(2)	15/15
ga100 hol	**1.7**(2)	**3.0**(3)	14(14)	9.5(12)	2161(2359)	5/15
grid100 ho	**2.4**(3)	3.4(3)	11(9)	210(299)	∞ *2e5*	0/15
grid16 hol	**2.6**(2)	3.5(4)	7.0(5)	148(354)	5991(6296)	2/15
hill hol	3.1(4)	3.2(4)	4.9(5)	45(83)	1433(1428)	7/15
lmmCMA aug	**1.4**(2)	**2.1**(2)	**2.6**(1.0)	**1.9**(1)	**1.3**(0.3)	15/15
memPSODE v	**1.5**(1)	**3.0**(3)	5.9(2)	**2.0**(0.7)	5.9(7)	15/15
prcga saw	**2.3**(1)	**2.8**(3)	6.7(5)	3.8(3)	∞ *3e5*	0/15
ring100 ho	**1.6**(2)	5.3(4)	8.4(10)	16(14)	2746(2938)	4/15
ring16 hol	**1.9**(2)	**2.4**(3)	8.8(8)	12(8)	2695(2938)	4/15
simplex pa	16(12)	10(6)	5.4(2)	**1.4**(0.6)	8.5(2)	15/15

Table 13: 05-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	*4.0e+7*:3.6	*1.6e+7*:7.6	*4.0e+6*:19	*1.6e+4*:52	*1.0e+0*:268	15/15
BIPOP-aCMA	3.3(5)	5.1(4)	3.7(2)	5.4(0.8)	4.7(3)	15/15
BIPOP-saAC	**3.0**(3)	3.5(3)	**2.9**(2)	**2.5**(0.3)	**1.9**(2)	15/15
CMAES hut	**2.0**(3)	**1.7**(2)	**2.1**(2)	4.2(1)	28(30)	1/15
DE pal	4.0(5)	3.1(3)	3.8(3)	16(4)	50(20)	15/15
HCMA los	**2.7**(2)	**2.0**(1)	**1.2**(0.4)	3.3(2)	4.4(8)	15/15
HMLSL pal	**1.4**(1.0)	**1.6**(2)	**1.5**(0.8)	**1.5**(0.4)	**0.94**(0.6)	15/15
IPOP-10DDr	**2.3**(2)	**2.9**(2)	**2.6**(1)	4.1(1)	5.9(3)	15/15
IPOP-500 l	**2.3**(2)	**2.9**(2)	**2.6**(1)	4.1(1)	5.9(3)	15/15
IPOP-tany	**1.7**(2)	**2.4**(2)	**2.4**(1)	4.8(1.0)	7.1(5)	15/15
IPOP-texp	**2.1**(2)	3.4(2)	**2.6**(1)	4.2(0.6)	8.7(9)	15/15
IPOP lia	**2.3**(2)	**2.9**(2)	**2.6**(1)	4.1(1)	5.9(3)	15/15
MLSL pal	**1.4**(1.0)	**1.6**(2)	**1.5**(0.8)	**1.5**(0.4)	**0.94**(0.6)	15/15
OQNLP pal	3.1(2)	**2.3**(1)	**1.3**(0.4)	**1.5**(0.9)	**0.95**(0.8)	15/15
P-DCN tra	**2.0**(2)	**2.8**(3)	7.2(7)	10(4)	2.8e4(4e4)	6/15
P-zero tra	**1.2**(1)	5.3(9)	9.4(11)	10(4)	1.2e5(1e5)	2/15
SMAC hut	**0.57**(0.4)	**1.3**(2)	3.6(5)	34(34)	∞ *500*	0/15
U-DCN tra	**1.3**(2)	**2.8**(3)	4.4(4)	33(10)	3.7e4(5e4)	5/15
U-zero tra	**1.3**(2)	**2.3**(2)	3.0(1)	21(16)	3.8e4(5e4)	5/15
fmincon pa	**1.4**(1.0)	**1.6**(2)	**1.5**(0.8)	**1.5**(0.4)	**0.95**(0.5)	15/15
fminunc pa	**2.1**(2)	**1.9**(2)	**1.3**(0.9)	**1.0**(0.9)	**1.1**(1.0)	15/15
ga100 hol	**1.6**(1)	**2.9**(3)	7.6(8)	57(27)	2353(2457)	5/15
grid100 ho	**1.4**(1.0)	**2.0**(2)	9.3(14)	159(67)	∞ *2e5*	0/15
grid16 hol	**1.4**(2)	6.3(11)	8.1(9)	31(10)	6623(7909)	2/15
hill hol	6.1(8)	4.2(5)	**2.7**(2)	15(8)	6174(7001)	2/15
lmmCMA aug	**0.80**(0.6)	**1.6**(2)	**1.6**(0.8)	**1.7**(0.6)	**1.4**(1)	15/15
memPSODE v	**2.1**(4)	**2.8**(3)	6.1(5)	3.9(3)	4.8(5)	15/15
prcga saw	**0.98**(1)	**1.7**(2)	3.9(4)	12(4)	296(609)	14/15
ring100 ho	**1.6**(2)	**2.7**(3)	8.2(9)	109(40)	1999(1867)	6/15
ring16 hol	**1.2**(1.0)	4.0(4)	8.1(4)	29(9)	1172(1372)	8/15
simplex pa	16(10)	18(27)	15(14)	12(3)	6.7(3)	15/15

Table 14: 05-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	*1.0e+3*:2.8	*6.3e+2*:8.4	*4.0e+2*:17	*6.3e+1*:52	*6.3e-2*:264	15/15
BIPOP-aCMA	**1.1**(1)	**2.4**(3)	3.4(2)	4.8(2)	4.1(0.8)	15/15
BIPOP-saAC	**2.7**(2)	**2.0**(2)	**2.0**(2)	**2.3**(0.5)	**1.3**(0.3)	15/15
CMAES hut	4.0(4)	**2.8**(2)	3.0(2)	3.3(1.0)	∞ *506*	0/15
DE pal	**1.5**(1)	**1.6**(2)	3.2(3)	10(3)	46(20)	15/15
HCMA los	**2.5**(2)	**1.5**(1)	**1.1**(0.3)	**1.4**(2)	**1.6**(0.6)	15/15
HMLSL pal	**1.7**(1)	**1.0**(0.8)	**1.2**(0.6)	**1.2**(0.2)	**0.79**(0.1)	15/15
IPOP-10DDr	**2.5**(2)	**2.4**(2)	**2.6**(0.7)	3.5(1)	5.7(3)	15/15
IPOP-500 l	**2.5**(2)	**2.4**(2)	**2.6**(0.7)	3.5(1)	5.7(3)	15/15
IPOP-tany	3.0(4)	**2.4**(3)	**2.5**(2)	3.5(2)	6.2(2)	15/15
IPOP-texp	4.4(5)	3.0(3)	**2.5**(2)	3.1(1)	6.4(2)	15/15
IPOP lia	**2.5**(2)	**2.4**(2)	**2.6**(0.7)	3.5(1)	5.7(3)	15/15
MLSL pal	**1.7**(1)	**1.0**(0.8)	**1.2**(0.6)	**1.2**(0.2)	**0.79**(0.1)	15/15
OQNLP pal	3.7(3)	**2.0**(1)	**1.4**(0.4)	**1.5**(0.2)	**0.98**(0.2)	15/15
P-DCN tra	**2.5**(4)	4.8(5)	10(10)	847(1396)	2.6e5(3e5)	1/15
P-zero tra	**2.9**(3)	5.2(7)	7.8(10)	1.2e4(4e4)	2.7e5(3e5)	1/15
SMAC hut	**1**(1)	**1.1**(1)	**0.96**(0.5)	**1.1**(0.5)	∞ *500*	0/15
U-DCN tra	**1.8**(2)	**2.6**(2)	3.5(3)	20(18)	∞ *5e6*	0/15
U-zero tra	**2.0**(2)	**2.5**(3)	**2.6**(2)	6891(21)	2.7e5(3e5)	1/15
fmincon pa	**1.7**(1)	**1.0**(0.8)	**1.2**(0.6)	**1.2**(0.2)	**0.79**(0.1)	15/15
fminunc pa	**2.4**(3)	**1.5**(1)	**1.1**(0.4)	**1.0**(0.2)	**0.98**(0.1)	15/15
ga100 hol	**2.7**(4)	**2.4**(4)	7.1(10)	36(19)	∞ *2e5*	0/15
grid100 ho	**1.6**(2)	**2.9**(5)	9.2(10)	557(388)	∞ *2e5*	0/15
grid16 hol	3.1(2)	5.0(7)	5.9(5)	20(16)	∞ *2e5*	0/15
hill hol	7.3(8)	3.5(5)	**2.4**(3)	1218(2409)	∞ *2e5*	0/15
lmmCMA aug	**1.4**(2)	**1.6**(2)	**1.7**(1.0)	**1.8**(0.5)	**1.6**(0.4)	15/15
memPSODE v	**2.9**(2)	3.4(3)	4.7(3)	3.0(3)	**2.4**(6)	15/15
prcga saw	**1.4**(1)	4.0(6)	5.0(7)	10(4)	2241(2765)	6/15
ring100 ho	**2.2**(2)	**2.8**(3)	12(15)	59(17)	∞ *2e5*	0/15
ring16 hol	**1.7**(2)	**2.9**(5)	4.9(4)	16(8)	∞ *2e5*	0/15
simplex pa	13(13)	14(13)	18(15)	20(12)	16(13)	15/15

Table 15: 05-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*:3.0	*1.0e+1*:10	*6.3e+0*:15	*2.5e-1*:53	*1.0e-5*:251	15/15
BIPOP-aCMA	**1.9**(2)	**2.9**(4)	3.6(4)	4.0(1)	4.3(0.8)	15/15
BIPOP-saAC	3.2(3)	**1.5**(1)	**2.1**(1)	**2.9**(1.0)	**1.8**(0.3)	15/15
CMAES hut	3.6(6)	**1.7**(2)	**1.7**(2)	3.2(1)	∞ *506*	0/15
DE pal	**2.4**(3)	**2.2**(2)	**2.6**(3)	9.0(3)	36(12)	15/15
HCMA los	3.7(3)	**1.6**(0.6)	**1.2**(0.6)	**2.1**(2)	**2.2**(0.3)	15/15
HMLSL pal	**1.2**(1)	**0.68**(0.4)	**0.59**(0.4)	**0.60**(0.1)	**0.72**(0.1)	15/15
IPOP-10DDr	**2.0**(2)	**1.2**(1)	**2.0**(2)	3.1(1)	5.7(0.4)	15/15
IPOP-500 l	**2.0**(2)	**1.2**(1)	**2.0**(2)	3.1(1)	5.7(0.4)	15/15
IPOP-tany	**1.6**(2)	**0.94**(1)	**1.3**(0.9)	3.1(1)	5.5(0.7)	15/15
IPOP-texp	**1.5**(2)	**0.93**(1)	**1.2**(0.9)	**2.2**(0.7)	4.9(0.7)	15/15
IPOP lia	**2.0**(2)	**1.2**(1)	**2.0**(2)	3.1(1)	5.7(0.4)	15/15
MLSL pal	**1.2**(1)	**0.68**(0.4)	**0.59**(0.4)	**0.60**(0.1)	**0.72**(0.1)	15/15
OQNLP pal	**2.2**(3)	**1.4**(0.9)	**1.2**(1.0)	**0.99**(0.3)	7.0(9)	15/15
P-DCN tra	3.2(4)	**2.0**(2)	3.6(4)	10(3)	5.4e4(5e4)	5/15
P-zero tra	4.0(5)	3.1(4)	5.5(6)	11(6)	∞ *5e6*	0/15
SMAC hut	**1.2**(2)	**0.62**(0.6)	**0.76**(1)	4.9(2)	∞ *500*	0/15
U-DCN tra	**2.7**(2)	**1.2**(0.7)	**1.9**(2)	14(8)	∞ *5e6*	0/15
U-zero tra	3.0(3)	**1.5**(2)	**1.7**(2)	6.4(4)	∞ *5e6*	0/15
fmincon pa	**1.2**(1)	**0.68**(0.4)	**0.59**(0.4)	**0.60**(0.1)	**0.72**(0.1)	15/15
fminunc pa	**1**(1)	**0.71**(0.6)	**0.71**(0.6)	**1**(0.5)	**0.84**(0.2)	15/15
ga100 hol	**2.4**(3)	**1.6**(1)	**1.9**(2)	27(8)	∞ *2e5*	0/15
grid100 ho	**2.5**(4)	**1.9**(2)	3.3(2)	84(42)	∞ *2e5*	0/15
grid16 hol	**1.2**(1)	**0.81**(0.7)	**2.3**(2)	18(7)	∞ *2e5*	0/15
hill hol	4.1(4)	**1.9**(2)	**2.0**(2)	4.0(2)	∞ *2e5*	0/15
lmmCMA aug	**1.1**(1)	**0.62**(0.6)	**0.81**(0.7)	**1.6**(0.5)	**1.8**(0.2)	15/15
memPSODE v	5.4(5)	**2.6**(2)	3.3(2)	**2.5**(0.3)	**2.2**(0.1)	15/15
prcga saw	**2.7**(3)	**1.1**(1)	**1.7**(2)	10(3)	6773(7089)	3/15
ring100 ho	**2.6**(2)	**1.7**(1)	4.3(5)	53(14)	∞ *2e5*	0/15
ring16 hol	3.0(4)	**1.8**(3)	3.8(3)	12(4)	∞ *2e5*	0/15
simplex pa	7.4(12)	6.4(4)	7.0(9)	17(7)	5.6(1)	15/15

Table 16: 05-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*:3.0	*1.0e+2*:13	*6.3e+1*:24	*4.0e+1*:55	*1.6e+1*:289	5/5
BIPOP-aCMA	5.8(6)	**2.8**(2)	3.0(2)	**2.5**(1)	**1.7**(1)	15/15
BIPOP-saAC	4.7(4)	**1.9**(2)	**2.1**(2)	**2.1**(1)	**1.5**(0.9)	15/15
CMAES hut	4.1(4)	**1.9**(2)	**2.0**(0.9)	**1.7**(0.9)	**1.7**(1)	11/15
DE pal	**2.6**(2)	**1.9**(1)	**2.9**(3)	3.9(2)	3.8(3)	15/15
HCMA los	5.3(2)	**2.3**(2)	**2.1**(3)	**1.9**(2)	**2.0**(0.8)	15/15
HMLSL pal	16(31)	6.8(7)	10(9)	9.1(4)	3.3(0.6)	15/15
IPOP-10DDr	4.2(4)	**1.9**(2)	**2.0**(1)	**1.5**(0.7)	**1.2**(0.6)	15/15
IPOP-500 l	4.2(4)	**1.9**(2)	**2.0**(1)	**1.5**(0.7)	**1.2**(0.6)	15/15
IPOP-tany	3.6(4)	**1.6**(2)	**2.0**(1)	**1.8**(0.7)	**2.2**(0.8)	15/15
IPOP-texp	6.8(8)	**2.8**(2)	**2.4**(1)	**2.1**(2)	**2.1**(3)	15/15
IPOP lia	4.2(4)	**1.9**(2)	**2.0**(1)	**1.5**(0.7)	**1.2**(0.6)	15/15
MLSL pal	15(30)	6.3(9)	10(8)	10(3)	5.5(4)	15/15
OQNLP pal	30(43)	14(17)	20(14)	16(19)	11(11)	15/15
P-DCN tra	3.1(2)	3.4(3)	242(14)	1.3e4(4e4)	7.0e4(8e4)	3/15
P-zero tra	3.2(2)	1275(2705)	3676(5912)	2.8e4(4e4)	4.1e4(4e4)	5/15
SMAC hut	**1.1**(2)	**0.83**(0.6)	**1.6**(1)	**2.2**(2)	8.1(8)	3/15
U-DCN tra	**3.1**(3)	**2.2**(2)	**2.9**(2)	4.9(4)	10(12)	15/15
U-zero tra	3.8(4)	**2.0**(1)	**2.4**(2)	7.0(5)	713(218)	15/15
fmincon pa	16(30)	7.2(10)	10(8)	7.2(3)	5.5(5)	15/15
fminunc pa	15(26)	8.0(9)	11(8)	7.4(3)	10(10)	15/15
ga100 hol	3.3(4)	**3.0**(2)	7.9(5)	10(5)	7.9(4)	15/15
grid100 ho	4.0(4)	4.9(4)	13(15)	25(26)	71(144)	15/15
grid16 hol	5.7(8)	4.7(6)	8.2(10)	19(10)	49(38)	15/15
hill hol	4.3(6)	**1.9**(2)	3.7(5)	3.1(2)	65(107)	15/15
lmmCMA aug	**1.3**(2)	**1.3**(1)	**1.5**(0.9)	**1.6**(1)	**1.4**(2)	15/15
memPSODE v	15(10)	11(18)	16(10)	12(6)	15(17)	15/15
prcga saw	**2.5**(2)	**1.8**(2)	3.5(3)	4.1(3)	**3.0**(2)	15/15
ring100 ho	4.8(5)	3.3(3)	11(8)	12(10)	18(13)	15/15
ring16 hol	3.7(7)	3.4(3)	6.0(4)	6.2(2)	25(9)	15/15
simplex pa	153(191)	51(40)	41(14)	21(5)	20(20)	15/15

Table 17: 05-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	*4.0e+1*:4.8	*2.5e+1*:16	*1.6e+1*:46	*1.0e+1*:120	*4.0e+0*:334	15/15
BIPOP-aCMA	**1.8**(1)	**1.8**(3)	3.2(4)	4.6(10)	3.8(5)	15/15
BIPOP-saAC	**1.8**(2)	**2.1**(2)	**1.9**(2)	**2.1**(2)	**2.7**(4)	15/15
CMAES hut	**1.9**(2)	**2.3**(4)	**2.8**(2)	**2.5**(3)	**2.6**(2)	7/15
DE pal	**1.8**(2)	**1.1**(1.0)	**2.1**(2)	3.3(3)	6.4(5)	15/15
HCMA los	4.7(5)	**2.2**(2)	**1.6**(1)	**2.9**(2)	3.0(4)	15/15
HMLSL pal	14(37)	10(12)	6.5(5)	4.4(2)	7.2(5)	15/15
IPOP-10DDr	**1.4**(1)	**1.3**(1)	**1.4**(1)	**2.0**(2)	**2.3**(1)	15/15
IPOP-500 l	**1.4**(1)	**1.3**(1)	**1.4**(1)	**2.0**(2)	**2.3**(1)	15/15
IPOP-tany	**1.7**(2)	**1.7**(2)	**1.9**(2)	**1.9**(1)	**1.6**(1)	15/15
IPOP-texp	**2.1**(2)	**2.0**(2)	**1.3**(1)	**1.1**(1)	**0.96**(1.0)	15/15
IPOP lia	**1.4**(1)	**1.3**(1)	**1.4**(1)	**2.0**(2)	**2.3**(1)	15/15
MLSL pal	14(38)	10(11)	5.9(5)	4.7(3)	9.4(8)	15/15
OQNLP pal	48(52)	18(17)	10(4)	12(19)	16(16)	15/15
P-DCN tra	**2.2**(2)	**1.6**(1)	**1.2**(1)	**1.1**(0.7)	73(9)	15/15
P-zero tra	**1.7**(1)	**1.7**(2)	5.1(4)	5.5(16)	5592(7745)	11/15
SMAC hut	**1.7**(2)	**0.77**(0.5)	**0.53**(0.5)	**0.42**(0.3)	**0.45**(0.6)	15/15
U-DCN tra	**1.8**(1)	**1.9**(2)	**2.3**(2)	**1.7**(1.0)	3.6(4)	15/15
U-zero tra	**1.9**(2)	**1.7**(2)	**1.4**(2)	**1.3**(0.9)	16(21)	15/15
fmincon pa	16(43)	11(14)	6.5(5)	4.1(2)	8.2(11)	15/15
fminunc pa	51(42)	20(15)	10(4)	12(12)	39(36)	15/15
ga100 hol	**1.2**(1)	**1.1**(1)	**1.5**(2)	3.2(3)	6.3(7)	15/15
grid100 ho	**1.8**(2)	**1.1**(1)	**1.9**(3)	**2.6**(2)	5.6(6)	15/15
grid16 hol	**1.5**(1)	**2.1**(3)	**1.6**(2)	**2.1**(3)	5.5(8)	15/15
hill hol	3.4(5)	3.1(2)	**2.0**(2)	**2.9**(2)	14(30)	15/15
lmmCMA aug	**1.7**(2)	**1.8**(2)	**2.7**(3)	**2.0**(2)	**1.3**(0.8)	15/15
memPSODE v	**1.4**(1)	**1.7**(1)	3.6(3)	3.0(2)	5.6(12)	15/15
prcga saw	**2.2**(3)	**2.2**(3)	**2.0**(4)	3.0(2)	7.2(3)	15/15
ring100 ho	**1.5**(2)	**1.8**(3)	**0.94**(1)	3.1(4)	8.4(8)	15/15
ring16 hol	**1.3**(1)	**1.5**(1)	**2.0**(2)	**1.5**(1.0)	**2.9**(2)	15/15
simplex pa	114(45)	38(12)	14(4)	6.3(1)	3.3(2)	15/15

Table 18: 05-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	*1.0e+1*:5.2	*6.3e+0*:26	*4.0e+0*:57	*2.5e+0*:110	*6.3e-1*:412	15/15
BIPOP-aCMA	5.5(6)	**2.1**(1)	**1.6**(0.7)	**1.2**(0.5)	**0.63**(0.3)	15/15
BIPOP-saAC	4.9(3)	**2.8**(2)	5.3(3)	3.1(1)	**1.4**(1)	15/15
CMAES hut	4.1(6)	**1.3**(1)	**1.3**(1.0)	**0.93**(0.4)	**0.62**(0.3)	14/15
DE pal	5.4(5)	**2.3**(2)	**2.1**(1.0)	**2.1**(0.9)	**1.8**(0.6)	15/15
HCMA los	**2.2**(2)	**1.6**(1)	**1.7**(1)	**1.5**(1.0)	**0.90**(0.2)	15/15
HMLSL pal	26(34)	7.3(7)	20(34)	12(17)	6.3(5)	15/15
IPOP-10DDr	3.2(3)	**1.5**(1)	**1.0**(0.5)	**0.84**(0.3)	**0.57**(0.2)	15/15
IPOP-500 l	3.2(3)	**1.5**(1)	**1.0**(0.5)	**0.84**(0.3)	**0.57**(0.2)	15/15
IPOP-tany	3.6(6)	**2.1**(2)	**1.6**(1)	**0.98**(0.5)	**0.67**(0.3)	15/15
IPOP-texp	47(7)	11(2)	5.9(2)	3.6(3)	**1.9**(4)	15/15
IPOP lia	3.2(3)	**1.5**(1)	**1.0**(0.5)	**0.84**(0.3)	**0.57**(0.2)	15/15
MLSL pal	24(35)	7.5(9)	22(34)	16(33)	173(163)	12/15
OQNLP pal	15(19)	15(11)	27(54)	34(51)	108(117)	6/15
P-DCN tra	4.3(4)	3.1(4)	6637(1051)	1.7e4(2e4)	4.9e4(5e4)	3/15
P-zero tra	5.6(8)	5339(1863)	1.6e4(4e4)	2.7e4(5e4)	2.7e4(4e4)	5/15
SMAC hut	**2.5**(4)	**1.6**(2)	**1.9**(2)	**2.1**(2)	**2.5**(3)	6/15
U-DCN tra	4.1(4)	**1.9**(2)	**2.0**(1)	**2.0**(1)	32(19)	15/15
U-zero tra	**2.6**(2)	**1.5**(1)	**2.5**(3)	**2.5**(4)	158(66)	15/15
fmincon pa	20(25)	6.4(7)	9.0(10)	25(66)	161(92)	14/15
fminunc pa	11(16)	6.4(6)	5.4(4)	10(9)	47(67)	14/15
ga100 hol	3.5(6)	**2.7**(3)	4.7(4)	5.0(3)	5.2(1)	15/15
grid100 ho	3.7(3)	3.3(4)	7.7(9)	15(6)	54(33)	15/15
grid16 hol	4.2(6)	**2.7**(2)	4.3(5)	18(9)	58(41)	14/15
hill hol	39(19)	11(10)	8.0(12)	8.2(11)	219(312)	12/15
lmmCMA aug	**1.7**(2)	**0.91**(0.8)	**0.70**(0.5)	**0.55**(0.2)	**0.62**(0.3)	15/15
memPSODE v	6.9(4)	12(11)	10(12)	12(6)	10(14)	15/15
prcga saw	**1.9**(2)	**1.5**(1)	**2.0**(2)	**2.5**(2)	6.3(1)	15/15
ring100 ho	3.8(6)	3.9(4)	7.8(5)	10(5)	13(5)	15/15
ring16 hol	5.9(8)	**2.9**(4)	**3.0**(2)	**2.6**(2)	3.6(2)	15/15
simplex pa	63(71)	28(25)	16(10)	20(22)	293(273)	8/15

Table 19: 05-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	*6.3e+1*:3.4	*4.0e+1*:7.2	*2.5e+1*:20	*1.6e+1*:58	*1.6e+0*:318	15/15
BIPOP-aCMA	**2.4**(4)	3.5(2)	**2.9**(3)	**1.8**(1)	**1.0**(0.4)	15/15
BIPOP-saAC	4.4(4)	4.7(4)	3.0(2)	**1.5**(0.9)	3.5(6)	15/15
CMAES hut	**1.6**(2)	**2.7**(3)	**1.9**(1)	**1.2**(0.7)	**0.92**(0.3)	14/15
DE pal	3.5(4)	3.8(5)	**2.6**(3)	**1.6**(1)	4.2(1)	15/15
HCMA los	**3.0**(2)	3.0(2)	**1.9**(2)	**1.5**(1)	**2.2**(0.8)	15/15
HMLSL pal	**2.6**(3)	17(16)	11(10)	11(13)	10(7)	15/15
IPOP-10DDr	**2.2**(2)	**2.2**(2)	**1.9**(2)	**1.1**(0.6)	**1.9**(0.4)	15/15
IPOP-500 l	**2.2**(2)	**2.2**(2)	**1.9**(2)	**1.1**(0.6)	**1.9**(0.4)	15/15
IPOP-tany	**1.7**(2)	**1.8**(2)	**1.4**(0.8)	**0.94**(0.7)	**1.0**(0.5)	15/15
IPOP-texp	4.2(5)	5.4(5)	**3.0**(2)	**1.4**(0.8)	**1.8**(0.7)	15/15
IPOP lia	**2.2**(2)	**2.2**(2)	**1.9**(2)	**1.1**(0.6)	**1.9**(0.4)	15/15
MLSL pal	**2.6**(3)	17(19)	10(8)	10(12)	781(851)	5/15
OQNLP pal	6.5(2)	13(24)	12(10)	12(1)	136(157)	6/15
P-DCN tra	**1.6**(1)	**1.9**(2)	**1.8**(1)	27(52)	2.6e4(3e4)	6/15
P-zero tra	**1.8**(2)	**2.5**(3)	452(1)	533(36)	3.5e4(4e4)	5/15
SMAC hut	**1.1**(1)	**0.85**(0.6)	**0.97**(1.0)	**1.1**(1)	11(12)	2/15
U-DCN tra	**1.2**(1)	**1.7**(2)	3.0(2)	**1.7**(1)	3684(7109)	14/15
U-zero tra	**1.2**(1)	**1.6**(1)	**2.8**(3)	**1.8**(2)	4474(8009)	12/15
fmincon pa	**2.6**(3)	15(15)	11(11)	11(12)	400(342)	9/15
fminunc pa	**2.2**(3)	12(17)	7.7(7)	5.0(4)	242(322)	8/15
ga100 hol	**1.0**(0.7)	**2.6**(3)	3.2(3)	3.3(4)	11(7)	15/15
grid100 ho	**1.3**(1)	3.0(4)	5.3(7)	7.0(7)	504(786)	10/15
grid16 hol	**2.4**(3)	3.9(5)	4.8(5)	3.9(3)	251(395)	13/15
hill hol	10(20)	17(23)	12(26)	4.8(9)	269(403)	12/15
lmmCMA aug	**1.3**(1)	**1.6**(2)	**0.92**(0.8)	**0.73**(0.4)	**0.52**(0.2)$^{\star 2}$	15/15
memPSODE v	3.2(3)	5.1(3)	19(17)	13(10)	17(17)	15/15
prcga saw	**1.3**(2)	**1.6**(2)	**2.8**(4)	**1.9**(3)	**2.8**(1)	15/15
ring100 ho	**1.4**(2)	**1.7**(0.8)	4.7(4)	6.6(5)	27(15)	15/15
ring16 hol	**1.8**(2)	3.1(3)	4.3(3)	3.8(2)	144(394)	13/15
simplex pa	21(13)	38(45)	28(20)	14(3)	374(357)	8/15

Table 20: 05-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*:172	*1.0e-1*:242	*6.3e-2*:675	*4.0e-2*:3078	*2.5e-2*:4946	15/15
BIPOP-aCMA	159(150)	139(107)	55(38)	18(19)	18(20)	15/15
BIPOP-saAC	51(40)	76(97)	61(78)	15(19)	18(20)	15/15
CMAES hut	∞	∞	∞	∞	∞ *506*	0/15
DE pal	571(475)	1087(1107)	1053(1111)	238(241)	148(170)	2/15
HCMA los	95(112)	99(104)	41(60)	14(21)	13(12)	15/15
HMLSL pal	**0.11**(0)$_{\downarrow 4}$	**0.17**(0.0)$_{\downarrow 4}$	**0.07**(0.0)$_{\downarrow}$	**0.02**(3e-3)$_{\downarrow 4}$	**0.01**(4e-3)$_{\downarrow 4}$	15/15
IPOP-10DDr	614(657)	519(658)	263(299)	72(77)	46(48)	15/15
IPOP-500 l	563(657)	483(576)	251(256)	57(60)	37(37)	15/15
IPOP-tany	493(546)	391(388)	192(136)	57(102)	36(66)	15/15
IPOP-texp	895(958)	746(669)	284(240)	68(52)	51(44)	15/15
IPOP lia	563(657)	483(576)	251(256)	57(60)	37(37)	15/15
MLSL pal	**0.11**(0)$_{\downarrow 4}$	**0.17**(0.0)$_{\downarrow 4}$	**0.07**(0.0)$_{\downarrow}$	**0.02**(3e-3)$_{\downarrow 4}$	**0.01**(4e-3)$_{\downarrow 4}$	15/15
OQNLP pal	**0.10**(3e-3)$^{\star 4}_{\downarrow 4}$	**0.09**(0)$^{\star 4}_{\downarrow 4}$	**0.03**(0)$^{\star 4}_{\downarrow}$	**7.5e-3**(0)$^{\star 4}_{\downarrow 4}$	**4.7e-3**(0)$^{\star 4}_{\downarrow 4}$	15/15
P-DCN tra	5.2e4(6e4)	6.5e4(7e4)	1.1e5(1e5)	2.3e4(3e4)	1.4e4(2e4)	1/15
P-zero tra	4.3e5(5e5)	3.1e5(3e5)	∞	∞	∞ *5e6*	0/15
SMAC hut	∞	∞	∞	∞	∞ *500*	0/15
U-DCN tra	2.6e4(3e4)	4.9e4(5e4)	5.1e4(6e4)	2.4e4(3e4)	1.5e4(2e4)	1/15
U-zero tra	1.7e4(2e4)	3.2e4(4e4)	4.8e4(6e4)	∞	∞ *5e6*	0/15
fmincon pa	**0.11**(0)$_{\downarrow 4}$	**0.17**(0.0)$_{\downarrow 4}$	**0.07**(0.0)$_{\downarrow}$	**0.02**(3e-3)$_{\downarrow 4}$	**0.01**(4e-3)$_{\downarrow 4}$	15/15
fminunc pa	**0.16**(0.0)$_{\downarrow 4}$	**0.13**(0.0)$_{\downarrow 4}$	**0.05**(0.0)$_{\downarrow}$	**0.01**(3e-3)$_{\downarrow 4}$	**7.8e-3**(2e-3)$_{\downarrow 4}$	15/15
ga100 hol	807(922)	1121(1120)	724(813)	1156(1381)	∞ *2e5*	0/15
grid100 ho	1.0e4(1e4)	1.5e4(2e4)	5534(5924)	∞	∞ *2e5*	0/15
grid16 hol	2686(3001)	4684(5161)	5264(5739)	∞	∞ *2e5*	0/15
hill hol	3635(3925)	6883(7742)	2472(2777)	1159(1178)	738(809)	1/15
lmmCMA aug	55(57)	56(58)	30(33)	14(14)	∞ *2805*	0/15
memPSODE v	157(105)	154(80)	96(106)	41(33)	33(23)	15/15
prcga saw	56(7)	55(5)	20(2)	4.8(3)	3.2(2)	15/15
ring100 ho	1435(1554)	3410(4030)	2468(2962)	541(609)	341(404)	2/15
ring16 hol	2015(2001)	3361(3613)	1635(1837)	1149(1340)	715(834)	1/15
simplex pa	**0.17**(0.1)$_{\downarrow 4}$	**0.18**(0.0)$_{\downarrow 4}$	**0.08**(0.0)$_{\downarrow}$	**0.02**(4e-3)$_{\downarrow 4}$	**0.01**(3e-3)$_{\downarrow 4}$	15/15

Table 21: 05-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	*6.3e+3*:5.1	*4.0e+3*:8.4	*4.0e+1*:15	*2.5e+0*:69	*1.0e+0*:851	15/15
BIPOP-aCMA	**2.3**(4)	**2.2**(2)	4.0(2)	**2.9**(2)	7.6(9)	15/15
BIPOP-saAC	3.5(4)	**2.5**(2)	3.5(3)	**2.5**(2)	5.5(7)	15/15
CMAES hut	3.4(3)	**2.2**(2)	3.7(2)	3.1(1)	∞ *506*	0/15
DE pal	**1.8**(2)	**1.6**(2)	7.7(4)	5.7(2)	**2.3**(2)	15/15
HCMA los	**1.7**(1)	**1.3**(0.8)	**0.90**(0.2)	**1.2**(2)	5.2(7)	15/15
HMLSL pal	**1.6**(0)	**0.95**(0)	**1.5**(0)	**1.2**(0)	**2.3**(1)	15/15
IPOP-10DDr	**1.9**(2)	**1.4**(2)	3.4(1)	**2.9**(2)	12(11)	15/15
IPOP-500 l	**1.9**(2)	**1.4**(2)	3.4(1)	**2.9**(2)	12(11)	15/15
IPOP-tany	**1.6**(2)	**1.1**(1.0)	**2.4**(1)	**2.9**(2)	12(10)	15/15
IPOP-texp	**1.1**(1)	**0.72**(0.8)	**1.6**(0.6)	**1.7**(1)	17(19)	15/15
IPOP lia	**1.9**(2)	**1.4**(2)	3.4(1)	**2.9**(2)	12(11)	15/15
MLSL pal	**1.6**(0)	**0.95**(0)	**1.5**(0)	**1.2**(0)	7.2(10)	15/15
OQNLP pal	**2.7**(0)	**2.0**(0)	**1.2**(0)	**0.51**(0)	5.8(7)	12/15
P-DCN tra	**2.4**(2)	**2.9**(1)	8.2(8)	3.6(2)	336(965)	15/15
P-zero tra	7.9(14)	6.4(10)	14(9)	4.9(2)	371(909)	15/15
SMAC hut	**0.57**(0.2)	**0.44**(0.2)	**0.73**(0.3)	4.3(3)	∞ *500*	0/15
U-DCN tra	**1.6**(1)	**1.7**(2)	3.6(3)	4.6(5)	5.6(8)	15/15
U-zero tra	**2.4**(2)	**2.3**(2)	3.7(2)	3.4(2)	17(29)	15/15
fmincon pa	**1.6**(0)	**0.95**(0)	**1.5**(0)	**1.2**(0)	6.4(9)	15/15
fminunc pa	**1.4**(0)	**0.83**(0)	**0.46**(0)*	**1.8**(0)	4.6(4)	15/15
ga100 hol	**1.9**(2)	**2.3**(2)	17(13)	13(7)	**4.1**(1)	15/15
grid100 ho	**2.4**(3)	**1.6**(2)	28(37)	30(14)	14(7)	15/15
grid16 hol	**2.9**(2)	**2.6**(6)	11(9)	7.4(4)	8.1(3)	15/15
hill hol	7.1(8)	4.7(5)	5.9(5)	**2.2**(1)	4.4(8)	15/15
lmmCMA aug	**1.2**(0.9)	**0.83**(0.5)	**1.8**(1)	4.0(6)	15(15)	3/15
memPSODE v	3.1(3)	3.5(3)	5.3(2)	**2.5**(0.9)	**3.6**(5)	15/15
prcga saw	**1.2**(2)	**0.91**(1)	4.7(3)	5.5(3)	25(44)	15/15
ring100 ho	**2.1**(2)	**2.3**(2)	31(20)	24(7)	7.4(2)	15/15
ring16 hol	**1.5**(1)	**2.3**(2)	8.0(6)	5.6(2)	**3.3**(0.5)	15/15
simplex pa	7.8(0.3)	6.9(0.2)	8.4(4)	10(9)	5.4(3)	15/15

Table 22: 05-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	*4.0e+1*:3.9	*2.5e+1*:11	*1.6e+1*:31	*6.3e+0*:73	*1.6e+0*:347	5/5
BIPOP-aCMA	**1.3**(2)	**1.5**(2)	**2.0**(2)	**2.2**(1.0)	10(13)	15/15
BIPOP-saAC	**2.4**(3)	**1.5**(2)	**1.2**(1)	3.2(5)	3.1(5)	15/15
CMAES hut	**2.3**(3)	**1.3**(1)	**1.3**(2)	**2.0**(1)	3.4(4)	5/15
DE pal	**1.7**(2)	**1.8**(2)	**2.1**(2)	4.7(4)	4.4(4)	15/15
HCMA los	3.3(2)	**2.0**(0.9)	**0.89**(0.7)	**2.5**(6)	4.6(5)	15/15
HMLSL pal	3.6(5)	3.5(5)	**1.8**(2)	4.5(5)	**2.6**(2)	15/15
IPOP-10DDr	3.0(3)	**2.4**(3)	**1.2**(1)	6.1(11)	15(11)	15/15
IPOP-500 l	3.0(3)	**2.4**(3)	**1.2**(1)	6.1(11)	14(11)	15/15
IPOP-tany	**2.4**(2)	**1.7**(2)	**1.1**(1)	3.8(9)	6.6(9)	15/15
IPOP-texp	**1.4**(1)	**1.6**(2)	**1.0**(0.9)	**2.0**(1)	23(43)	15/15
IPOP lia	3.0(3)	**2.4**(3)	**1.2**(1)	6.1(11)	14(11)	15/15
MLSL pal	3.6(5)	3.8(6)	**2.0**(3)	3.4(3)	**2.1**(2)	15/15
OQNLP pal	4.9(3)	3.6(5)	**1.8**(2)	**1.9**(2)	3.0(6)	13/15
P-DCN tra	**2.1**(2)	**1.8**(2)	1.2e4(3)	2.5e4(3e4)	2.2e4(3e4)	6/15
P-zero tra	**2.3**(2)	**2.4**(5)	**2.9**(3)	1.7e4(3e4)	4.0e4(5e4)	4/15
SMAC hut	**1.8**(2)	**1.8**(2)	**1.0**(0.9)	**1.0**(0.9)	**1.0**(1)	11/15
U-DCN tra	**2.1**(3)	**1.8**(2)	**2.2**(2)	3.0(2)	358(645)	15/15
U-zero tra	**1.8**(2)	**1.2**(0.9)	**0.91**(0.9)	3.7(7)	697(1323)	15/15
fmincon pa	3.6(5)	3.6(5)	**2.2**(2)	3.6(3)	**1.5**(1)	15/15
fminunc pa	4.1(2)	3.6(6)	**1.8**(3)	**2.6**(3)	**2.1**(2)	15/15
ga100 hol	**1.7**(2)	**2.6**(3)	**2.1**(2)	7.0(3)	58(6)	14/15
grid100 ho	**1.9**(2)	**1.9**(2)	**1.8**(2)	12(14)	379(718)	11/15
grid16 hol	**1.4**(1)	**1.2**(1)	**2.0**(2)	6.8(8)	558(729)	9/15
hill hol	**2.7**(3)	**2.9**(4)	**2.7**(4)	13(27)	883(1083)	7/15
lmmCMA aug	**1.9**(2)	**1.4**(2)	**0.93**(0.7)	**1.6**(0.8)	**2.7**(4)	13/15
memPSODE v	**2.3**(2)	**2.2**(2)	4.3(7)	6.0(4)	12(13)	15/15
prcga saw	**1.3**(1)	**2.2**(2)	**2.3**(2)	4.3(4)	44(68)	15/15
ring100 ho	**1.8**(2)	**1.4**(1)	**2.3**(3)	10(8)	7.5(3)	15/15
ring16 hol	**2.1**(4)	**2.4**(3)	**2.2**(2)	4.0(2)	116(361)	13/15
simplex pa	47(63)	35(57)	18(19)	14(8)	5.1(4)	15/15

Table 23: 05-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	*6.3e+1*:3.6	*4.0e+1*:15	*2.5e+1*:32	*1.0e+1*:71	*1.6e+0*:341	5/5
BIPOP-aCMA	**2.6**(2)	**2.4**(2)	**1.9**(1)	8.1(11)	22(40)	15/15
BIPOP-saAC	3.8(5)	4.4(3)	3.8(8)	9.1(13)	7.2(10)	15/15
CMAES hut	**2.5**(3)	**1.8**(2)	**1.3**(2)	**1.9**(1)	4.6(5)	4/15
DE pal	**2.0**(2)	**2.2**(2)	**1.8**(2)	3.5(2)	77(149)	12/15
HCMA los	**2.9**(2)	**2.4**(2)	**1.5**(1)	3.3(6)	6.1(6)	15/15
HMLSL pal	**2.4**(2)	3.2(5)	**1.9**(3)	3.6(3)	**2.3**(2)	15/15
IPOP-10DDr	**2.7**(2)	**2.2**(2)	**1.8**(1)	7.4(11)	47(60)	15/15
IPOP-500 l	**2.7**(2)	**2.2**(2)	**1.8**(1)	7.4(11)	104(31)	15/15
IPOP-tany	**1.9**(2)	**1.6**(1)	**1.4**(1)	12(9)	32(57)	15/15
IPOP-texp	**2.1**(2)	**1.5**(1)	**1.0**(1)	22(9)	14(27)	15/15
IPOP lia	**2.7**(2)	**2.2**(2)	**1.8**(1)	7.4(11)	37(31)	15/15
MLSL pal	**2.4**(2)	3.3(6)	**2.0**(4)	**2.7**(3)	**2.0**(3)	15/15
OQNLP pal	4.5(3)	3.0(3)	**2.7**(3)	**2.8**(2)	**2.8**(4)	14/15
P-DCN tra	4.5(6)	4.0(4)	2.4e4(8e4)	2.6e4(4e4)	2.2e4(3e4)	6/15
P-zero tra	3.3(4)	4.0(5)	2.4e4(8e4)	2.6e4(4e4)	4.0e4(5e4)	4/15
SMAC hut	**1.8**(3)	**1.5**(1)	**1.0**(0.8)	**0.90**(0.8)	**1.0**(1)	11/15
U-DCN tra	**2.9**(2)	**2.3**(2)	**1.6**(0.8)	**1.9**(1)	368(186)	15/15
U-zero tra	**2.8**(2)	**1.7**(1)	**2.5**(2)	4.8(6)	1248(519)	14/15
fmincon pa	**2.4**(2)	3.4(6)	**1.9**(3)	**2.2**(3)	**1.4**(1)	15/15
fminunc pa	**2.8**(2)	**2.5**(4)	**2.4**(3)	3.3(3)	**1.4**(1)	15/15
ga100 hol	3.2(5)	**2.2**(3)	**2.1**(2)	5.9(5)	272(369)	11/15
grid100 ho	3.0(2)	**2.0**(1)	**2.5**(3)	5.5(6)	139(368)	13/15
grid16 hol	**1.9**(2)	**1.3**(2)	**1.00**(1.0)	5.1(7)	771(1103)	8/15
hill hol	4.7(5)	**2.0**(2)	7.5(11)	6.7(10)	516(735)	9/15
lmmCMA aug	**1.6**(2)	**1.4**(1)	**1.3**(1)	**2.5**(3)	4.2(5)	12/15
memPSODE v	4.0(3)	4.4(3)	4.3(6)	4.6(3)	8.7(12)	15/15
prcga saw	**1.3**(2)	**2.4**(4)	**2.1**(3)	3.3(3)	123(275)	15/15
ring100 ho	**2.1**(2)	**1.4**(2)	3.4(4)	5.5(3)	8.7(5)	15/15
ring16 hol	**2.0**(2)	**1.3**(1)	**2.0**(2)	**2.5**(2)	104(347)	14/15
simplex pa	22(25)	25(37)	16(21)	11(10)	5.7(3)	15/15

Table 24: 05-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	*1.0e+1*:3.0	*6.3e+0*:9.0	*4.0e+0*:33	*2.5e+0*:84	*1.0e+0*:518	15/15
BIPOP-aCMA	**1.8**(2)	**2.0**(3)	3.6(7)	6.8(7)	8.6(6)	15/15
BIPOP-saAC	**2.0**(2)	**2.3**(3)	4.2(4)	7.3(12)	12(14)	15/15
CMAES hut	**1.6**(1)	**2.9**(3)	5.4(5)	6.7(7)	∞ *506*	0/15
DE pal	**1.9**(2)	**2.5**(4)	3.2(2)	7.0(8)	31(27)	15/15
HCMA los	8.1(8)	4.6(5)	3.0(2)	6.8(7)	13(10)	15/15
HMLSL pal	9.2(11)	5.1(5)	**2.9**(2)	**2.4**(1)	**2.4**(2)	15/15
IPOP-10DDr	**2.1**(2)	**1.9**(2)	**2.3**(2)	3.4(3)	7.2(5)	15/15
IPOP-500 l	**2.1**(2)	**1.9**(2)	**2.3**(2)	3.4(3)	7.2(5)	15/15
IPOP-tany	**1.7**(1)	**2.3**(2)	3.3(4)	6.7(6)	7.5(6)	15/15
IPOP-texp	**3.0**(3)	**2.7**(4)	3.1(3)	3.7(4)	7.0(7)	15/15
IPOP lia	**2.1**(2)	**1.9**(2)	**2.3**(2)	3.4(3)	7.2(5)	15/15
MLSL pal	9.2(11)	5.1(5)	**2.9**(2)	**2.2**(1)	**1.9**(2)	15/15
OQNLP pal	29(47)	14(18)	6.5(7)	5.8(4)	5.6(4)	15/15
P-DCN tra	3.6(3)	**2.9**(3)	**2.1**(2)	**2.6**(3)	**3.2**(4)	15/15
P-zero tra	3.6(3)	**2.1**(2)	**2.7**(3)	**2.6**(3)	29(62)	15/15
SMAC hut	**1.6**(2)	**2.9**(3)	**2.6**(3)	3.3(3)	∞ *500*	0/15
U-DCN tra	3.4(2)	**2.9**(3)	**2.2**(2)	3.2(4)	10(17)	15/15
U-zero tra	3.2(2)	**2.2**(3)	**2.0**(1)	6.4(8)	43(50)	15/15
fmincon pa	7.2(6)	5.6(4)	3.4(6)	**2.4**(3)	**1.6**(2)	15/15
fminunc pa	9.1(16)	10(12)	6.4(7)	5.5(5)	10(10)	15/15
ga100 hol	**2.3**(2)	**2.7**(4)	**2.3**(3)	5.2(5)	45(46)	15/15
grid100 ho	**3.0**(2)	**2.1**(2)	4.7(3)	8.9(13)	60(74)	15/15
grid16 hol	**2.2**(3)	**1.8**(2)	**3.0**(4)	6.5(5)	40(30)	15/15
hill hol	**2.5**(3)	**1.7**(2)	4.1(4)	11(9)	49(45)	15/15
lmmCMA aug	**1.9**(2)	**2.6**(2)	**2.6**(3)	7.1(6)	10(11)	6/15
memPSODE v	3.4(3)	4.1(2)	5.4(5)	4.0(3)	3.4(3)	15/15
prcga saw	**1.9**(2)	3.0(2)	3.0(4)	6.2(7)	39(50)	15/15
ring100 ho	**1.8**(2)	**2.3**(2)	**2.8**(2)	4.6(4)	23(27)	15/15
ring16 hol	**3.0**(2)	**2.5**(3)	4.1(4)	7.3(10)	26(29)	15/15
simplex pa	63(104)	47(51)	19(16)	11(3)	**3.0**(1)	15/15

Table 25: 05-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	*6.3e+1*:15	*4.0e+1*:37	*4.0e+1*:37	*2.5e+1*:118	*1.6e+1*:692	15/15
BIPOP-aCMA	**2.6**(1)	3.3(2)	3.3(2)	**2.2**(1)	**1.1**(0.7)	15/15
BIPOP-saAC	**1.9**(2)	**2.6**(1)	**2.6**(1)	**2.6**(2)	**0.98**(1.0)	15/15
CMAES hut	**1.6**(2)	**1.9**(2)	**1.9**(2)	**2.2**(2)	**1.4**(2)	6/15
DE pal	3.6(3)	6.2(3)	6.2(3)	5.3(3)	4.4(3)	15/15
HCMA los	**1.0**(0.3)	**1.4**(1)	**1.4**(1)	**2.0**(2)	**1.3**(1)	15/15
HMLSL pal	**2.1**(0.9)	**2.9**(4)	**2.9**(4)	6.0(4)	**1.9**(0.9)	15/15
IPOP-10DDr	**2.1**(2)	**2.1**(0.7)	**2.1**(0.7)	**1.6**(1)	**0.99**(0.6)	15/15
IPOP-500 l	**2.1**(2)	**2.1**(0.7)	**2.1**(0.7)	**1.6**(1)	**0.99**(0.6)	15/15
IPOP-tany	**1.3**(1)	**2.1**(1)	**2.1**(1)	**1.4**(0.6)	**1.2**(0.9)	15/15
IPOP-texp	**0.49**(0.4)	**1.3**(1)	**1.3**(1)	**1.2**(1.0)	**1.2**(1)	15/15
IPOP lia	**2.1**(2)	**2.1**(0.7)	**2.1**(0.7)	**1.6**(1)	**0.99**(0.6)	15/15
MLSL pal	**1.9**(0.9)	**2.7**(5)	**2.7**(5)	3.5(3)	**2.0**(2)	15/15
OQNLP pal	**1.1**(0.7)	**1.6**(0.6)	**1.6**(0.6)	4.4(1)	**1.2**(0.8)	15/15
P-DCN tra	**1.9**(1)	4.7(4)	4.7(4)	422(1096)	534(553)	15/15
P-zero tra	**2.1**(2)	1691(1763)	1691(1763)	6787(2e4)	1.2e4(1e4)	7/15
SMAC hut	**0.51**(0.5)	**2.6**(3)	**2.6**(3)	7.4(7)	∞ *500*	0/15
U-DCN tra	**2.4**(3)	5.1(5)	5.1(5)	5.8(3)	7.2(8)	15/15
U-zero tra	**1.5**(0.8)	3.3(5)	3.3(5)	7.5(9)	10(9)	15/15
fmincon pa	**1.7**(0.9)	**2.3**(2)	**2.3**(2)	3.4(2)	**2.2**(2)	15/15
fminunc pa	**1.9**(1)	**1.9**(0.7)	**1.9**(0.7)	6.0(1)	**2.5**(2)	15/15
ga100 hol	**2.1**(3)	10(6)	10(6)	10(6)	6.2(6)	15/15
grid100 ho	4.2(4)	18(18)	18(18)	23(16)	38(55)	15/15
grid16 hol	3.3(4)	6.4(4)	6.4(4)	6.0(4)	6.1(7)	15/15
hill hol	5.2(6)	6.6(7)	6.6(7)	17(35)	12(8)	15/15
lmmCMA aug	**0.77**(1.0)	**2.0**(2)	**2.0**(2)	**1.7**(1)	**0.91**(0.6)	15/15
memPSODE v	13(16)	18(7)	18(7)	11(9)	8.9(8)	15/15
prcga saw	**1.2**(1)	**2.5**(2)	**2.5**(2)	**2.8**(2)	**2.0**(1)	15/15
ring100 ho	4.6(5)	14(11)	14(11)	20(13)	8.7(7)	15/15
ring16 hol	**2.6**(2)	5.1(6)	5.1(6)	7.7(6)	3.7(2)	15/15
simplex pa	**2.9**(4)	6.9(4)	6.9(4)	20(19)	6.2(6)	15/15

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