Comparison Tables: BBOB 2013 Testbed in 10-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: 10-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	*4.0e+1*:8.0	*2.5e+1*:16	*1.0e-8*:23	*1.0e-8*:23	*1.0e-8*:23	15/15
BIPOP-aCMA	6.4(0.9)	3.7(0.6)	16(0)	16(0)	16(0)	15/15
BIPOP-saAC	6.0(4)	4.3(2)	18(1)	18(1)	18(1)	15/15
CMAES hut	4.2(4)	3.7(3)	∞	∞	∞ *1002*	0/15
DE pal	9.0(7)	8.5(5)	339(12)	339(12)	339(12)	15/15
HCMA los	**2.6**(0)	**1.4**(0)	**0.99**(0.0)	**0.99**(0.0)	**0.99**(0.0)	15/15
HMLSL pal	**1.3**(0.7)	**0.70**(0)	**4.7**(0.5)	**4.7**(0.5)	**4.7**(0.5)	15/15
IPOP-10DDr	4.2(2)	3.6(1)	63(4)	63(4)	63(4)	15/15
IPOP-500 l	4.2(2)	3.6(1)	63(4)	63(4)	63(4)	15/15
IPOP-tany	3.5(2)	3.1(2)	70(5)	70(5)	70(5)	15/15
IPOP-texp	**2.4**(2)	**2.5**(1)	69(4)	69(4)	69(4)	15/15
IPOP lia	4.2(2)	3.6(1)	63(4)	63(4)	63(4)	15/15
MLSL pal	**1.3**(0.7)	**0.70**(0)	**4.7**(0.5)	**4.7**(0.5)	**4.7**(0.5)	15/15
OQNLP pal	3.1(2)	**1.7**(0.1)	**2.0**(0.0)	**2.0**(0.0)	**2.0**(0.0)	15/15
P-DCN tra	7.0(6)	13(10)	1999(957)	1999(957)	1999(957)	15/15
P-zero tra	12(12)	14(13)	4241(1514)	4241(1514)	4241(1514)	15/15
SMAC hut	**0.99**(0.9)	**0.80**(0.4)	∞	∞	∞ *1000*	0/15
U-DCN tra	5.0(5)	4.7(3)	8551(4389)	8551(4389)	8551(4389)	15/15
U-zero tra	4.3(3)	3.4(1)	2.4e5(8e4)	2.4e5(8e4)	2.4e5(8e4)	15/15
fmincon pa	**1.3**(0.7)	**0.70**(0)	**4.7**(0.5)	**4.7**(0.5)	**4.7**(0.5)	15/15
fminunc pa	**1.6**(1)	**1.2**(0.3)	**1**(0)	**1**(0)	**1**(0)	15/15
ga100 hol	10(9)	14(13)	∞	∞	∞ *5e5*	0/15
grid100 ho	11(15)	33(38)	∞	∞	∞ *5e5*	0/15
grid16 hol	17(15)	16(8)	∞	∞	∞ *5e5*	0/15
hill hol	7.5(4)	5.2(3)	∞	∞	∞ *5e5*	0/15
lmmCMA aug	**2.6**(3)	**2.4**(2)	9.1(0.5)	9.1(0.5)	9.1(0.5)	15/15
memPSODE v	8.7(3)	5.0(1)	**4.5**(0.2)	**4.5**(0.2)	**4.5**(0.2)	15/15
prcga saw	5.2(6)	7.6(8)	1959(1719)	1959(1719)	1959(1719)	15/15
ring100 ho	16(30)	25(24)	∞	∞	∞ *5e5*	0/15
ring16 hol	10(8)	11(6)	∞	∞	∞ *5e5*	0/15
simplex pa	19(12)	27(30)	3497(3137)	3497(3137)	3497(3137)	14/15

Table 3: 10-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	*2.5e+6*:5.6	*1.0e+6*:17	*1.0e+5*:33	*2.5e+3*:118	*1.0e-8*:196	15/15
BIPOP-aCMA	**1.8**(2)	**2.2**(3)	**3.2**(0.3)	**1.4**(0.1)	**6.2**(0.2)	15/15
BIPOP-saAC	3.2(2)	**2.0**(1)	5.8(2)	3.2(0.4)	**4.6**(0.3)	15/15
CMAES hut	**1.6**(2)	**1.2**(1)	9.3(5)	14(10)	∞ *1002*	0/15
DE pal	**1.8**(1)	**1.4**(1)	9.3(4)	11(2)	54(2)	15/15
HCMA los	3.7(0)	**1.3**(0)	**0.90**(0.1)$^{\star 2}$	**1.5**(0.5)	**2.9**(0.2)	15/15
HMLSL pal	10(11)	5.1(5)	6.2(4)	3.4(1)	25(38)	15/15
IPOP-10DDr	**2.0**(2)	**2.1**(2)	5.7(3)	8.7(3)	34(2)	15/15
IPOP-500 l	**2.0**(2)	**2.1**(2)	5.7(3)	8.7(3)	34(2)	15/15
IPOP-tany	**2.0**(2)	**2.0**(1)	7.6(4)	12(3)	34(2)	15/15
IPOP-texp	**2.6**(3)	**1.6**(1)	4.5(3)	9.2(3)	32(2)	15/15
IPOP lia	**2.0**(2)	**2.1**(2)	5.7(3)	8.7(3)	34(2)	15/15
MLSL pal	10(11)	5.1(5)	6.2(4)	3.4(1)	15(19)	15/15
OQNLP pal	4.8(0.3)	**2.1**(0.6)	**2.7**(1)	**1.7**(0.4)	∞ *6e4*	0/15
P-DCN tra	**2.8**(4)	**2.8**(4)	13(6)	11(5)	9168(2e4)	14/15
P-zero tra	**1.3**(0.9)	3.0(6)	11(7)	12(6)	3.7e5(4e5)	2/15
SMAC hut	**1.2**(1)	**0.74**(1)	4.4(4)	22(22)	∞ *1000*	0/15
U-DCN tra	**2.3**(2)	**1.9**(2)	4.7(2)	15(11)	6.9e4(8e4)	7/15
U-zero tra	**1.4**(2)	**1.2**(0.9)	4.5(3)	22(20)	∞ *1e7*	0/15
fmincon pa	10(12)	5.5(6)	7.1(6)	3.4(2)	26(41)	15/15
fminunc pa	4.1(3)	**1.9**(1.0)	**3.5**(3)	4.7(2)	15(2)	15/15
ga100 hol	**1.5**(2)	**1.9**(2)	20(11)	28(8)	∞ *5e5*	0/15
grid100 ho	**1.4**(2)	**2.4**(2)	59(51)	92(36)	∞ *5e5*	0/15
grid16 hol	4.2(7)	7.3(7)	17(9)	20(5)	∞ *5e5*	0/15
hill hol	7.1(6)	3.3(3)	6.1(4)	6.7(8)	∞ *5e5*	0/15
lmmCMA aug	**1.0**(1)	**0.80**(0.6)	**3.7**(1)	**2.7**(0.6)	**7.7**(0.9)	15/15
memPSODE v	**1.4**(2)	**3.0**(3)	3.8(1)	**1.9**(0.4)	**2.4**(0.4)$^{\star 2}$	15/15
prcga saw	**1.7**(2)	**1.0**(0.9)	10(5)	11(2)	4696(4913)	10/15
ring100 ho	**0.86**(0.7)	3.7(4)	39(22)	50(10)	∞ *5e5*	0/15
ring16 hol	**0.95**(1.0)	**2.8**(4)	12(3)	16(6)	∞ *5e5*	0/15
simplex pa	27(5)	17(9)	32(23)	35(21)	∞ *2e5*	0/15

Table 4: 10-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	*4.0e+2*:8.2	*1.6e+2*:37	*1.0e+2*:69	*6.3e+1*:147	*2.5e+1*:1129	15/15
BIPOP-aCMA	3.3(3)	**1.9**(0.3)	**1.3**(0.3)	**0.86**(0.2)	**0.22**(0.1)	15/15
BIPOP-saAC	**2.2**(3)	**2.5**(1)	**2.5**(0.7)	3.2(2)	**1.5**(1)	15/15
CMAES hut	**2.2**(2)	**2.5**(1)	**2.7**(0.7)	**2.9**(0.9)	**1.5**(1)	8/15
DE pal	**1.7**(2)	6.3(3)	8.8(3)	8.1(2)	4.8(1)	15/15
HCMA los	**2.2**(2)	**2.4**(1)	**2.0**(0.5)	**1.2**(0.1)	**0.23**(0.1)	15/15
HMLSL pal	**0.82**(0.9)	15(16)	17(11)	13(3)	3.1(1)	15/15
IPOP-10DDr	**0.66**(0.8)	**2.6**(1)	**2.5**(1)	3.1(1)	**1.1**(0.4)	15/15
IPOP-500 l	**0.66**(0.8)	**2.6**(1)	**2.5**(1)	3.1(1)	**1.1**(0.4)	15/15
IPOP-tany	**0.57**(0.9)	**2.2**(0.9)	**2.8**(1.0)	**2.6**(0.8)	**0.89**(0.2)	15/15
IPOP-texp	**0.39**(0.2)	**1.4**(0.7)	**2.5**(1)	**2.9**(1)	**1.3**(0.3)	15/15
IPOP lia	**0.66**(0.8)	**2.6**(1)	**2.5**(1)	3.1(1)	**1.1**(0.4)	15/15
MLSL pal	**0.82**(0.9)	14(15)	20(19)	64(90)	240(200)	8/15
OQNLP pal	**1.4**(2)	20(11)	71(108)	135(218)	82(96)	8/15
P-DCN tra	4.0(2)	10(14)	20(29)	30(40)	57(121)	15/15
P-zero tra	**1.8**(2)	10(15)	16(22)	46(53)	142(331)	15/15
SMAC hut	**0.46**(0.5)	**2.2**(4)	8.3(9)	18(17)	∞ *1000*	0/15
U-DCN tra	**2.1**(2)	3.1(2)	3.5(2)	**2.7**(1)	**0.99**(0.4)	15/15
U-zero tra	**1.6**(1)	**1.9**(2)	**2.2**(1)	**1.6**(0.6)	**0.62**(0.3)	15/15
fmincon pa	**0.82**(0.9)	12(14)	38(60)	78(97)	100(86)	13/15
fminunc pa	**0.75**(0.7)	14(14)	53(83)	140(148)	379(383)	5/15
ga100 hol	**2.0**(2)	13(4)	15(4)	11(2)	**2.6**(0.6)	15/15
grid100 ho	**1.8**(2)	38(31)	40(12)	34(13)	10(4)	15/15
grid16 hol	**2.6**(4)	7.3(5)	8.1(3)	6.0(2)	**1.7**(0.4)	15/15
hill hol	4.7(5)	**2.4**(1)	**1.9**(0.9)	**1.4**(0.7)	**0.45**(0.1)	15/15
lmmCMA aug	**0.54**(0.6)	**1.3**(1)	**2.1**(0.4)	**2.3**(0.8)	**0.85**(1)	15/15
memPSODE v	3.4(3)	**2.6**(0.6)	8.1(7)	6.9(11)	3.2(3)	15/15
prcga saw	**0.41**(0.2)	5.8(3)	8.7(2)	8.5(2)	**2.7**(0.8)	15/15
ring100 ho	**1.7**(2)	17(13)	25(10)	20(4)	5.8(0.8)	15/15
ring16 hol	**2.1**(2)	5.9(2)	5.8(2)	4.3(0.8)	**1.1**(0.3)	15/15
simplex pa	47(87)	47(8)	230(331)	575(657)	∞ *2e5*	0/15

Table 5: 10-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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
f4	*2.5e+2*:21	*1.6e+2*:59	*1.6e+2*:59	*6.3e+1*:139	*4.0e+1*:854	15/15
BIPOP-aCMA	3.0(1)	**2.0**(0.7)	**2.0**(0.7)	**1.5**(0.4)	**0.33**(0.1)	15/15
BIPOP-saAC	3.4(2)	**2.4**(1)	**2.4**(1)	5.3(2)	**1.2**(0.4)	15/15
CMAES hut	3.7(2)	**2.7**(2)	**2.7**(2)	4.7(1)	**1.4**(0.8)	11/15
DE pal	7.8(6)	7.0(2)	7.0(2)	13(4)	4.0(1)	15/15
HCMA los	4.2(2)	**2.6**(1)	**2.6**(1)	**1.6**(0.3)	**0.33**(0.1)	15/15
HMLSL pal	**2.4**(3)	12(10)	12(10)	19(3)	3.6(0.2)	15/15
IPOP-10DDr	3.5(3)	3.3(0.8)	3.3(0.8)	4.7(1)	**1.2**(0.2)	15/15
IPOP-500 l	3.5(3)	3.3(0.8)	3.3(0.8)	4.7(1)	**1.2**(0.2)	15/15
IPOP-tany	**2.6**(2)	**2.8**(1)	**2.8**(1)	4.5(2)	**1.1**(0.2)	15/15
IPOP-texp	**1.0**(1)	**1.2**(0.8)	**1.2**(0.8)	4.2(2)	**1.0**(0.4)	15/15
IPOP lia	3.5(3)	3.3(0.8)	3.3(0.8)	4.7(1)	**1.2**(0.2)	15/15
MLSL pal	**2.4**(3)	15(12)	15(12)	222(193)	347(400)	7/15
OQNLP pal	20(21)	56(67)	56(67)	290(360)	100(111)	8/15
P-DCN tra	3.2(2)	5.3(5)	5.3(5)	25(24)	15(21)	15/15
P-zero tra	12(3)	21(22)	21(22)	70(55)	25(17)	15/15
SMAC hut	7.5(10)	31(30)	31(29)	∞	∞ *1000*	0/15
U-DCN tra	3.6(1)	**2.5**(0.6)	**2.5**(0.6)	**3.4**(1)	**0.94**(0.4)	15/15
U-zero tra	**2.7**(1)	**1.8**(0.6)	**1.8**(0.6)	**2.4**(1)	**0.68**(0.3)	15/15
fmincon pa	**2.4**(3)	19(21)	19(21)	293(248)	227(265)	10/15
fminunc pa	9.2(19)	23(16)	23(16)	605(632)	1568(1847)	2/15
ga100 hol	14(7)	13(5)	13(5)	14(3)	3.3(0.5)	15/15
grid100 ho	42(42)	44(21)	44(21)	52(14)	12(4)	15/15
grid16 hol	8.9(8)	7.5(3)	7.5(3)	8.9(2)	**2.2**(0.6)	15/15
hill hol	4.0(2)	**1.9**(0.9)	**1.9**(0.9)	**1.7**(0.5)	**0.46**(0.1)	15/15
lmmCMA aug	**1.3**(1)	**1.7**(0.9)	**1.7**(0.9)	3.6(1.0)	**0.92**(0.2)	15/15
memPSODE v	4.3(0.5)	**2.4**(2)	**2.4**(2)	9.0(0.9)	3.5(4)	15/15
prcga saw	4.8(5)	7.2(3)	7.2(3)	14(4)	3.1(0.8)	15/15
ring100 ho	26(18)	24(10)	24(10)	27(6)	6.6(0.9)	15/15
ring16 hol	8.5(3)	5.7(2)	5.7(2)	6.2(1)	**1.5**(0.3)	15/15
simplex pa	30(44)	220(501)	220(501)	3148(3084)	3517(3411)	1/15

Table 6: 10-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	*1.0e+2*:16	*6.3e+1*:19	*1.0e-8*:20	*1.0e-8*:20	*1.0e-8*:20	15/15
BIPOP-aCMA	**1.2**(0.4)	**1.2**(0)	**1.1**(0)	**1.1**(0)	**1.1**(0)	15/15
BIPOP-saAC	**1.9**(0.9)	**2.4**(0.8)	6.0(1)	6.0(1)	6.0(1)	15/15
CMAES hut	**1.8**(0.5)	**2.3**(0.5)	5.8(1)	5.8(1)	5.8(1)	15/15
DE pal	4.4(4)	16(10)	2174(71)	2174(71)	2174(71)	15/15
HCMA los	**1.3**(0)	**1.2**(0.0)	**1.6**(0.5)	**1.6**(0.5)	**1.6**(0.5)	15/15
HMLSL pal	**0.73**(0)$_{\downarrow 4}$	**1.8**(0)	2202(1149)	2202(1149)	2202(1149)	15/15
IPOP-10DDr	**1.1**(0.7)	**2.0**(0.8)	196(81)	196(81)	196(81)	15/15
IPOP-500 l	**1.1**(0.7)	**2.0**(0.8)	196(81)	196(81)	196(81)	15/15
IPOP-tany	**1.6**(0.6)	**2.2**(0.8)	168(52)	168(67)	168(67)	15/15
IPOP-texp	3.8(0.8)	4.7(2)	236(142)	236(142)	236(142)	15/15
IPOP lia	**1.1**(0.7)	**2.0**(0.8)	196(81)	196(81)	196(81)	15/15
MLSL pal	**0.73**(0)$_{\downarrow 4}$	**1.8**(0)	4536(6380)	4536(6386)	4536(6407)	11/15
OQNLP pal	**1.9**(0)	**1.6**(0)	**1.7**(0)	**1.7**(0)	**1.7**(0)	15/15
P-DCN tra	3.5(4)	17(19)	393(70)	393(70)	393(70)	15/15
P-zero tra	**2.8**(4)	15(13)	187(66)	187(66)	187(66)	15/15
SMAC hut	**0.39**(0.2)$^{\star}_{\downarrow 4}$	**0.48**(0.2)$^{\star 4}_{\downarrow 4}$	**0.63**(0.2)$^{\star 4}_{\downarrow 4}$	**0.63**(0.2)$^{\star 4}_{\downarrow 4}$	**0.63**(0.2)$^{\star 4}_{\downarrow 4}$	15/15
U-DCN tra	**2.0**(2)	5.0(3)	∞	∞	∞ *1e7*	0/15
U-zero tra	**1.4**(1)	3.3(1)	∞	∞	∞ *1e7*	0/15
fmincon pa	**0.73**(0)$_{\downarrow 4}$	**1.8**(0)	3146(4090)	3146(4191)	3146(3932)	11/15
fminunc pa	**1.4**(0)	**1.2**(0)	**2.8**(0)	**2.8**(0)	**2.8**(0)	15/15
ga100 hol	5.2(6)	26(10)	132(17)	132(17)	132(17)	15/15
grid100 ho	14(14)	51(22)	385(106)	385(106)	385(106)	15/15
grid16 hol	6.7(6)	15(8)	70(13)	70(13)	70(13)	15/15
hill hol	**2.6**(2)	3.6(2)	12(5)	12(5)	12(5)	15/15
lmmCMA aug	**2.1**(1)	**2.6**(0.7)	6.4(2)	6.4(2)	6.4(2)	15/15
memPSODE v	**1.7**(0.9)	3.6(3)	6.5(2)	6.5(2)	6.5(2)	15/15
prcga saw	14(7)	22(8)	∞	∞	∞ *5e5*	0/15
ring100 ho	10(16)	36(21)	246(26)	246(26)	246(26)	15/15
ring16 hol	5.6(5)	11(5)	45(10)	45(10)	45(10)	15/15
simplex pa	14(6)	26(23)	142(112)	142(112)	142(112)	15/15

Table 7: 10-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	*1.6e+5*:7.0	*6.3e+4*:16	*4.0e+2*:36	*1.0e+2*:102	*4.0e+0*:504	15/15
BIPOP-aCMA	**2.0**(2)	**2.9**(3)	3.8(2)	3.7(0.9)	**1.8**(0.4)	15/15
BIPOP-saAC	3.3(2)	**2.2**(2)	3.5(4)	3.9(2)	**2.0**(0.3)	15/15
CMAES hut	**2.2**(3)	**1.7**(2)	**2.3**(1)	**2.6**(1)	**2.0**(1)	12/15
DE pal	**2.4**(4)	3.8(4)	8.0(5)	5.4(3)	12(3)	15/15
HCMA los	**2.3**(1)	**1.2**(0.7)	**1.1**(0.6)	**2.6**(3)	**2.3**(0.9)	15/15
HMLSL pal	**1.7**(2)	**1.7**(1)	3.7(3)	**2.2**(1)	**1.2**(0.5)	15/15
IPOP-10DDr	**1.5**(2)	**1.6**(1)	**2.0**(2)	**1.6**(1)	**1.5**(0.2)	15/15
IPOP-500 l	**1.5**(2)	**1.6**(1)	**2.0**(2)	**1.6**(1)	**1.5**(0.2)	15/15
IPOP-tany	**1.5**(2)	**1.9**(2)	**2.8**(2)	**1.9**(0.7)	**1.6**(0.3)	15/15
IPOP-texp	**2.6**(2)	**2.2**(2)	3.0(2)	**1.7**(0.9)	**1.7**(0.3)	15/15
IPOP lia	**1.5**(2)	**1.6**(1)	**2.0**(2)	**1.6**(1)	**1.5**(0.2)	15/15
MLSL pal	**1.7**(2)	**1.7**(1)	3.7(3)	**2.2**(1)	**1.2**(0.5)	15/15
OQNLP pal	**2.7**(2)	**1.8**(0.1)	**1.7**(0.3)	**0.71**(0.2)	**1.2**(0.6)	15/15
P-DCN tra	4.6(4)	5.9(5)	14(12)	13(6)	9.1(5)	15/15
P-zero tra	6.4(2)	5.6(5)	12(11)	10(6)	86(24)	15/15
SMAC hut	**1.0**(0.9)	**0.96**(0.8)	**2.1**(2)	**2.0**(2)	∞ *1000*	0/15
U-DCN tra	**2.1**(2)	**2.6**(3)	5.9(10)	7.1(8)	61(60)	15/15
U-zero tra	**2.2**(2)	**1.6**(2)	4.2(5)	4.2(4)	4527(9929)	13/15
fmincon pa	**1.7**(2)	**1.7**(1)	3.7(2)	**2.2**(2)	**1.2**(0.5)	15/15
fminunc pa	**1.8**(2)	**1.3**(0.7)	**1.3**(0.6)	**0.70**(0.4)	**2.6**(1)	15/15
ga100 hol	**2.3**(3)	6.8(10)	15(14)	11(6)	23(7)	15/15
grid100 ho	7.0(14)	6.4(10)	48(40)	43(34)	229(219)	15/15
grid16 hol	3.2(5)	5.0(8)	11(11)	10(8)	114(80)	14/15
hill hol	5.0(5)	3.3(2)	3.7(4)	4.1(3)	32(72)	15/15
lmmCMA aug	**1.8**(2)	**1.4**(1)	3.2(1)	5.2(3)	6.3(3)	14/15
memPSODE v	**2.4**(3)	**2.5**(2)	**3.0**(1)	4.0(2)	**2.5**(1)	15/15
prcga saw	**2.7**(4)	5.1(4)	17(15)	9.2(5)	149(21)	15/15
ring100 ho	3.0(4)	6.1(11)	25(32)	17(9)	50(10)	15/15
ring16 hol	4.1(5)	3.9(5)	6.1(6)	5.9(3)	10(3)	15/15
simplex pa	17(13)	18(13)	40(22)	19(8)	1357(1262)	4/15

Table 8: 10-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	*2.5e+2*:9.2	*1.6e+2*:18	*1.0e+2*:33	*1.0e+1*:172	*4.0e+0*:678	15/15
BIPOP-aCMA	5.5(6)	4.7(3)	3.9(2)	**2.2**(0.9)	**0.76**(0.2)	15/15
BIPOP-saAC	**2.9**(3)	**2.9**(2)	**2.6**(1)	**1.4**(0.5)	**0.44**(0.1)	15/15
CMAES hut	**2.1**(2)	3.2(2)	**2.8**(2)	**2.1**(0.5)	**1.1**(0.8)	12/15
DE pal	3.8(4)	4.2(6)	5.1(3)	12(5)	5.5(2)	15/15
HCMA los	**2.5**(1)	**1.6**(0.5)	**1.0**(0.3)	**2.2**(0.7)	**0.82**(0.2)	15/15
HMLSL pal	5.9(6)	8.5(7)	13(9)	17(8)	7.9(2)	15/15
IPOP-10DDr	**2.4**(3)	**2.3**(2)	**2.8**(1)	**2.2**(0.9)	**1.6**(2)	15/15
IPOP-500 l	**2.4**(3)	**2.3**(2)	**2.8**(1)	**2.2**(0.9)	**1.6**(2)	15/15
IPOP-tany	**1.6**(2)	**1.6**(1)	**1.9**(1)	**2.1**(0.7)	**1.0**(0.3)	15/15
IPOP-texp	**2.2**(2)	**1.8**(2)	**1.5**(0.9)	**2.1**(0.5)	**2.1**(2)	15/15
IPOP lia	**2.4**(3)	**2.3**(2)	**2.8**(1)	**2.2**(0.9)	**1.6**(2)	15/15
MLSL pal	5.1(6)	11(10)	44(47)	∞	∞ *1e5*	0/15
OQNLP pal	12(11)	17(13)	17(25)	160(160)	∞ *5509*	0/15
P-DCN tra	4.5(4)	10(13)	18(18)	337(314)	2376(6057)	14/15
P-zero tra	3.2(3)	24(35)	41(57)	916(1230)	1305(2876)	15/15
SMAC hut	**1.0**(1)	**0.82**(0.6)	**0.84**(0.7)	**1.2**(0.7)	**0.53**(0.3)	15/15
U-DCN tra	3.5(3)	4.3(3)	4.0(3)	2097(132)	2370(7386)	13/15
U-zero tra	**2.8**(2)	3.8(2)	3.5(4)	284(185)	1443(1438)	14/15
fmincon pa	4.4(5)	11(11)	41(35)	∞	∞ *1e5*	0/15
fminunc pa	5.1(6)	13(29)	25(26)	∞	∞ *1e5*	0/15
ga100 hol	4.1(4)	6.0(8)	9.0(7)	14(6)	13(17)	15/15
grid100 ho	10(3)	11(13)	23(25)	350(222)	395(410)	12/15
grid16 hol	4.4(8)	5.8(6)	8.9(9)	87(72)	218(373)	13/15
hill hol	3.9(4)	3.0(3)	**2.8**(2)	70(102)	320(495)	11/15
lmmCMA aug	**1.8**(2)	**1.6**(2)	**2.1**(1)	**1.1**(0.4)	**0.65**(1)	15/15
memPSODE v	4.2(4)	13(18)	42(44)	48(22)	18(13)	15/15
prcga saw	3.3(5)	3.7(3)	6.0(4)	12(7)	181(382)	12/15
ring100 ho	3.6(3)	8.7(11)	14(14)	36(13)	25(17)	15/15
ring16 hol	4.6(6)	5.9(5)	6.0(5)	14(12)	57(85)	15/15
simplex pa	4.5(5)	7.6(5)	20(8)	2927(3478)	∞ *1e5*	0/15

Table 9: 10-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	*1.6e+4*:15	*1.0e+4*:22	*1.6e+3*:34	*2.5e+2*:103	*4.0e+0*:727	15/15
BIPOP-aCMA	3.4(2)	**2.8**(2)	5.3(2)	3.1(0.9)	3.2(0.7)	15/15
BIPOP-saAC	4.1(2)	3.4(2)	4.0(0.7)	**1.8**(0.4)	**1.3**(0.3)	15/15
CMAES hut	**2.8**(2)	**2.5**(2)	4.3(3)	**2.4**(1)	∞ *1002*	0/15
DE pal	6.7(4)	6.0(3)	14(3)	11(3)	30(1)	14/15
HCMA los	**1.5**(0.1)	**1.0**(0.0)	**0.82**(0.2)	**1.2**(2)	**1.8**(0.4)	15/15
HMLSL pal	**0.95**(0.8)	**0.89**(0.5)	**1.6**(0.9)	**1.1**(0.5)	**1.6**(2)	15/15
IPOP-10DDr	3.4(2)	**2.8**(2)	4.4(1)	**2.9**(1)	4.5(2)	15/15
IPOP-500 l	3.4(2)	**2.8**(2)	4.4(1)	**2.9**(1)	4.5(2)	15/15
IPOP-tany	**2.9**(1)	**2.4**(1)	4.0(1)	**2.5**(0.6)	4.0(2)	15/15
IPOP-texp	**1.6**(2)	**1.6**(2)	**2.8**(2)	**2.1**(0.9)	3.9(1)	15/15
IPOP lia	3.4(2)	**2.8**(2)	4.4(1)	**2.9**(1)	4.5(2)	15/15
MLSL pal	**0.95**(0.8)	**0.89**(0.5)	**1.6**(0.9)	**1.1**(0.5)	**0.97**(0.9)	15/15
OQNLP pal	**1.4**(1.0)	**1.1**(0.6)	**1.1**(0.2)	**0.61**(0.2)	**0.82**(0.7)	15/15
P-DCN tra	12(13)	12(10)	19(9)	10(4)	7035(1e4)	10/15
P-zero tra	10(11)	11(9)	16(11)	9.0(5)	2208(6900)	13/15
SMAC hut	**0.98**(0.8)	**0.95**(0.4)	**1.6**(0.8)	**1.7**(0.8)	∞ *1000*	0/15
U-DCN tra	5.7(2)	5.1(3)	10(4)	9.3(4)	246(325)	15/15
U-zero tra	4.8(2)	3.9(1)	6.1(3)	4.9(2)	1924(3420)	15/15
fmincon pa	**0.95**(0.8)	**0.89**(0.5)	**1.6**(0.9)	**1.1**(0.5)	**0.97**(1.0)	15/15
fminunc pa	**0.72**(0.8)	**0.65**(0.5)	**1.0**(0.3)	**0.72**(0.3)	**1.3**(0.3)	15/15
ga100 hol	14(18)	14(14)	29(12)	20(7)	4528(5492)	2/15
grid100 ho	20(20)	39(40)	83(46)	66(32)	606(725)	10/15
grid16 hol	8.4(5)	8.0(5)	17(7)	13(5)	675(770)	8/15
hill hol	5.5(2)	4.1(2)	4.9(2)	3.3(2)	60(11)	14/15
lmmCMA aug	**1.4**(1)	**1.4**(1)	**2.8**(1)	**1.7**(0.4)	**1.3**(0.4)	15/15
memPSODE v	5.3(0.9)	3.6(0.6)	**3.0**(0.5)	**1.6**(0.7)	**1.4**(2)	15/15
prcga saw	3.4(4)	5.6(6)	15(9)	11(3)	1411(1731)	8/15
ring100 ho	12(12)	20(15)	51(11)	41(5)	123(54)	14/15
ring16 hol	10(7)	8.8(5)	13(5)	8.3(2)	1633(1994)	5/15
simplex pa	10(11)	13(12)	43(24)	23(5)	96(79)	14/15

Table 10: 10-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	*4.0e+1*:125	*2.5e+1*:148	*1.6e+1*:180	*1.0e+1*:200	*1.6e+0*:563	15/15
BIPOP-aCMA	4.0(2)	3.6(1)	3.3(1)	3.5(1)	6.2(2)	15/15
BIPOP-saAC	**2.5**(0.7)	**2.4**(0.6)	**2.1**(0.5)	**2.1**(0.7)	**2.3**(0.4)	15/15
CMAES hut	**2.8**(0.4)	**2.6**(0.5)	**2.5**(0.3)	**2.7**(0.5)	∞ *1002*	0/15
DE pal	20(6)	20(7)	18(9)	21(9)	201(90)	14/15
HCMA los	**2.8**(2)	**2.5**(2)	**2.3**(1)	**2.4**(0.7)	**2.4**(0.5)	15/15
HMLSL pal	**0.26**(0)$_{\downarrow 4}$	**0.41**(0)$_{\downarrow 4}$	**0.43**(0.0)$_{\downarrow 4}$	**0.49**(0.1)	**0.48**(0.1)	15/15
IPOP-10DDr	3.6(1)	3.3(0.9)	3.0(0.6)	3.4(0.8)	6.9(2)	15/15
IPOP-500 l	3.6(1)	3.3(0.9)	3.0(0.6)	3.4(0.8)	6.9(2)	15/15
IPOP-tany	**2.9**(0.9)	**2.8**(0.7)	**2.7**(0.7)	3.1(0.7)	6.7(1.0)	15/15
IPOP-texp	**1.9**(0.5)	**1.9**(0.3)	**1.9**(0.5)	**2.5**(0.6)	6.8(2)	15/15
IPOP lia	3.6(1)	3.3(0.9)	3.0(0.6)	3.4(0.8)	6.9(2)	15/15
MLSL pal	**0.26**(0)$_{\downarrow 4}$	**0.41**(0)$_{\downarrow 4}$	**0.43**(0.0)$_{\downarrow 4}$	**0.49**(0.1)	**0.48**(0.1)	15/15
OQNLP pal	**0.32**(4e-3)$_{\downarrow 4}$	**0.47**(3e-3)$_{\downarrow 4}$	**0.71**(0.0)	**0.86**(2e-3)	**0.38**(2e-3)	15/15
P-DCN tra	660(114)	556(96)	458(79)	413(72)	3745(9003)	13/15
P-zero tra	1766(14)	1487(12)	1224(10)	1102(9)	9819(2e4)	10/15
SMAC hut	4.9(2)	18(18)	41(44)	∞	∞ *1000*	0/15
U-DCN tra	7658(4496)	6471(3799)	5343(3131)	4836(2817)	9768(1e4)	11/15
U-zero tra	6588(5780)	5553(4875)	4571(4013)	4129(3619)	2.4e4(2e4)	9/15
fmincon pa	**0.26**(0)$_{\downarrow 4}$	**0.41**(0)$_{\downarrow 4}$	**0.43**(0.0)$_{\downarrow 4}$	**0.49**(0.1)	**0.48**(0.1)	15/15
fminunc pa	**0.27**(0)$_{\downarrow 4}$	**0.38**(0)$^{\star}_{\downarrow 4}$	**0.38**(0)$^{\star 2}_{\downarrow 4}$	**0.40**(0.0)$^{\star}_{\downarrow 4}$	**0.38**(0.0)	15/15
ga100 hol	58(35)	59(31)	60(35)	72(28)	∞ *5e5*	0/15
grid100 ho	217(201)	275(292)	316(264)	539(206)	∞ *5e5*	0/15
grid16 hol	1213(2013)	1028(1691)	852(1396)	788(1260)	∞ *5e5*	0/15
hill hol	330(155)	280(131)	232(108)	215(95)	5799(7107)	2/15
lmmCMA aug	**1.8**(0.5)	**1.8**(0.4)	**1.6**(0.4)	**1.6**(0.3)	**2.2**(0.8)	15/15
memPSODE v	**2.5**(0.6)	**2.2**(0.5)	**1.9**(0.5)	**1.8**(0.4)	4.7(6)	15/15
prcga saw	10(4)	14(4)	17(7)	20(8)	2367(2649)	8/15
ring100 ho	78(21)	83(20)	89(18)	133(25)	5969(6219)	2/15
ring16 hol	309(26)	265(24)	222(22)	210(17)	∞ *5e5*	0/15
simplex pa	5.4(4)	20(22)	31(33)	79(102)	463(458)	8/15

Table 11: 10-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*:6.0	*1.0e+6*:21	*4.0e+5*:38	*2.5e+4*:104	*6.3e+2*:512	15/15
BIPOP-aCMA	**2.6**(3)	**2.5**(2)	3.4(4)	5.5(2)	**2.8**(0.5)	15/15
BIPOP-saAC	3.4(3)	**1.8**(2)	**1.9**(1)	**2.9**(0.6)	**0.85**(0.1)	15/15
CMAES hut	3.5(3)	**1.9**(1)	**1.9**(3)	4.5(2)	∞ *1002*	0/15
DE pal	**1.8**(2)	**2.2**(2)	3.8(3)	20(14)	200(123)	15/15
HCMA los	**1.6**(2)	**0.84**(0.6)	**0.81**(0.3)	**2.3**(2)	**1.1**(0.1)	15/15
HMLSL pal	3.6(3)	**1.7**(1)	**1.7**(0.9)	**1.7**(0.6)	**0.60**(0.4)	15/15
IPOP-10DDr	**2.1**(3)	**1.7**(2)	**2.0**(0.8)	4.3(2)	3.3(0.9)	15/15
IPOP-500 l	**2.1**(3)	**1.7**(2)	**2.0**(0.8)	4.3(2)	3.3(0.9)	15/15
IPOP-tany	**1.2**(0.8)	**0.81**(0.6)	**1.2**(1.0)	4.6(2)	3.4(1)	15/15
IPOP-texp	3.4(3)	**1.6**(1)	**1.8**(2)	4.0(1)	3.4(0.9)	15/15
IPOP lia	**2.1**(3)	**1.7**(2)	**2.0**(0.8)	4.3(2)	3.3(0.9)	15/15
MLSL pal	3.6(3)	**1.7**(1)	**1.7**(0.9)	**1.7**(0.6)	**0.60**(0.4)	15/15
OQNLP pal	4.2(2)	**1.7**(0.4)	**1.2**(0.4)	**1.3**(0.7)	**0.65**(0.4)	15/15
P-DCN tra	**2.4**(2)	**1.3**(1)	**2.3**(3)	16(19)	1419(1337)	15/15
P-zero tra	**2.7**(4)	**2.6**(5)	5.3(9)	15(16)	1550(2460)	15/15
SMAC hut	**1.5**(2)	**1.1**(1.0)	**1.3**(1)	4.6(5)	∞ *1000*	0/15
U-DCN tra	**3.0**(3)	**1.5**(1)	**2.0**(2)	79(197)	3048(3590)	15/15
U-zero tra	**2.0**(2)	**1.1**(1)	**1.3**(1)	76(76)	6.0e4(7e4)	4/15
fmincon pa	3.6(3)	**1.7**(1)	**1.7**(0.9)	**1.6**(0.6)	**0.61**(0.3)	15/15
fminunc pa	3.3(3)	**1.4**(0.8)	**1.4**(0.9)	**1.8**(1)	**1.4**(0.5)	15/15
ga100 hol	**2.3**(3)	**2.7**(2)	4.0(4)	26(12)	3025(3420)	4/15
grid100 ho	**2.3**(2)	4.2(6)	7.5(6)	341(341)	1.4e4(2e4)	1/15
grid16 hol	3.9(5)	**2.2**(3)	5.8(9)	152(211)	∞ *5e5*	0/15
hill hol	4.3(5)	**2.0**(2)	3.3(5)	172(344)	1.5e4(2e4)	1/15
lmmCMA aug	**1.9**(2)	**0.79**(0.6)	**1.0**(0.7)	**1.8**(0.5)	**0.84**(0.2)	15/15
memPSODE v	3.4(3)	**2.3**(1)	**2.2**(0.9)	**2.9**(2)	4.5(7)	15/15
prcga saw	3.5(9)	3.7(7)	5.6(7)	14(10)	3188(3538)	7/15
ring100 ho	**2.2**(3)	**2.1**(1)	5.6(10)	38(14)	1931(2147)	6/15
ring16 hol	3.9(5)	**2.3**(3)	3.1(3)	20(18)	6450(7269)	2/15
simplex pa	29(34)	14(7)	12(6)	17(5)	7.9(3)	15/15

Table 12: 10-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	*4.0e+4*:6.4	*2.5e+3*:15	*6.3e+1*:217	*4.0e+1*:244	*2.5e+0*:675	15/15
BIPOP-aCMA	3.4(4)	4.0(2)	7.2(1.0)	6.9(0.6)	3.2(0.3)	15/15
BIPOP-saAC	3.1(3)	**3.0**(3)	**2.6**(0.3)	**2.4**(0.2)	**0.96**(0.1)	15/15
CMAES hut	**2.3**(2)	3.2(3)	66(77)	∞	∞ *1002*	0/15
DE pal	3.2(2)	3.5(4)	12(9)	30(23)	341(193)	11/15
HCMA los	**2.1**(2)	**1.8**(1.0)	3.3(0.4)	**3.0**(0.3)	**1.2**(0.1)	15/15
HMLSL pal	4.2(2)	**2.7**(0.8)	**0.24**(0.1)	**0.23**(0.0)	**0.13**(0.0)	15/15
IPOP-10DDr	**2.6**(3)	5.3(6)	10(5)	12(2)	5.8(0.7)	15/15
IPOP-500 l	**2.6**(3)	5.3(6)	10(5)	12(2)	5.8(0.7)	15/15
IPOP-tany	**2.6**(3)	4.5(4)	10(4)	11(3)	5.9(0.6)	15/15
IPOP-texp	3.4(4)	**2.7**(3)	8.9(6)	10(2)	4.9(0.6)	15/15
IPOP lia	**2.6**(3)	5.3(6)	10(5)	12(2)	5.8(0.7)	15/15
MLSL pal	4.2(2)	**2.7**(0.8)	**0.24**(0.1)	**0.23**(0.0)	**0.13**(0.0)	15/15
OQNLP pal	4.7(0.4)	**2.6**(2)	**0.52**(0.6)	**0.49**(0.5)	**0.53**(0.6)	15/15
P-DCN tra	4.2(4)	3.6(2)	298(265)	468(455)	716(679)	15/15
P-zero tra	3.1(3)	**2.5**(2)	345(404)	542(610)	1016(858)	15/15
SMAC hut	**1.8**(2)	**1.4**(1)	3.1(3)	28(31)	∞ *1000*	0/15
U-DCN tra	3.6(3)	3.4(2)	50(72)	142(201)	1482(1012)	15/15
U-zero tra	3.6(3)	3.6(2)	86(113)	189(214)	1801(1335)	15/15
fmincon pa	4.2(2)	**2.7**(0.8)	**0.24**(0.1)	**0.23**(0.0)	**0.13**(0.0)	15/15
fminunc pa	4.4(3)	**2.7**(1)	**0.35**(0.2)	**0.89**(0.5)	**0.97**(1)	15/15
ga100 hol	3.8(3)	6.8(8)	30(21)	64(68)	662(573)	11/15
grid100 ho	3.8(6)	8.1(8)	239(371)	2783(2827)	∞ *5e5*	0/15
grid16 hol	5.8(8)	6.0(4)	277(251)	488(262)	∞ *5e5*	0/15
hill hol	**3.0**(2)	**2.3**(1)	114(90)	168(126)	721(532)	11/15
lmmCMA aug	3.0(4)	**2.5**(2)	**2.9**(0.8)	**2.7**(0.6)	**1.2**(0.2)	15/15
memPSODE v	4.3(4)	3.2(2)	**0.53**(0.0)	**0.48**(0.0)	**0.21**(0.0)	15/15
prcga saw	**2.7**(2)	5.0(5)	23(4)	907(2050)	∞ *9e5*	0/15
ring100 ho	5.0(5)	7.1(6)	25(34)	124(138)	1383(1137)	7/15
ring16 hol	4.3(4)	5.4(4)	40(51)	106(106)	1500(1530)	6/15
simplex pa	23(4)	11(2)	3.1(5)	14(17)	2027(2141)	2/15

Table 13: 10-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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
f12	*4.0e+7*:15	*2.5e+7*:24	*1.6e+7*:34	*1.0e+6*:103	*1.0e+1*:515	15/15
BIPOP-aCMA	6.9(5)	5.8(3)	4.9(2)	3.4(0.6)	3.5(2)	15/15
BIPOP-saAC	4.1(2)	3.6(2)	3.2(1)	**1.9**(0.7)	**1.0**(0.4)	15/15
CMAES hut	3.4(2)	**2.8**(1)	3.1(1)	**2.7**(0.3)	5.7(5)	5/15
DE pal	4.8(4)	5.9(4)	8.9(4)	12(3)	116(67)	14/15
HCMA los	**2.9**(1)	**2.1**(0.8)	**1.9**(0.7)	**1.8**(2)	**1.3**(0.3)	15/15
HMLSL pal	**1.6**(1)	**1.4**(1)	**1.3**(1)	**1.3**(0.8)	**0.71**(0.3)	15/15
IPOP-10DDr	3.4(2)	3.5(1)	3.3(0.9)	**2.7**(0.6)	4.6(4)	15/15
IPOP-500 l	3.4(2)	3.5(1)	3.3(0.9)	**2.7**(0.6)	4.6(4)	15/15
IPOP-tany	**2.0**(1.0)	**2.2**(1)	**2.6**(1)	**2.7**(0.3)	3.1(2)	15/15
IPOP-texp	**2.8**(2)	**2.6**(2)	**2.5**(1)	**2.7**(0.6)	**2.5**(0.2)	15/15
IPOP lia	3.4(2)	3.5(1)	3.3(0.9)	**2.7**(0.6)	4.6(4)	15/15
MLSL pal	**1.6**(1)	**1.4**(1)	**1.3**(1)	**1.3**(0.8)	**0.71**(0.3)	15/15
OQNLP pal	**2.2**(0.7)	**1.6**(0.4)	**1.2**(0.3)	**0.61**(0.2)	**0.82**(0.6)	15/15
P-DCN tra	6.3(8)	9.4(9)	12(9)	11(4)	7077(9711)	11/15
P-zero tra	10(12)	12(14)	13(12)	10(4)	4862(9708)	12/15
SMAC hut	**2.5**(2)	6.8(11)	12(17)	141(156)	∞ *1000*	0/15
U-DCN tra	3.7(3)	3.6(3)	4.2(3)	10(5)	7172(9744)	11/15
U-zero tra	**3.0**(1)	**3.0**(1.0)	3.3(2)	4.8(2)	1.7e4(3e4)	8/15
fmincon pa	**1.6**(1)	**1.4**(1)	**1.3**(1)	**1.3**(0.8)	**0.72**(0.3)	15/15
fminunc pa	**1.9**(2)	**1.8**(2)	**1.5**(1)	**0.84**(0.6)	**0.40**(0.2)	15/15
ga100 hol	10(10)	14(8)	17(5)	23(4)	463(500)	13/15
grid100 ho	30(33)	56(50)	61(59)	75(18)	∞ *5e5*	0/15
grid16 hol	12(11)	12(8)	13(8)	15(5)	1078(1166)	9/15
hill hol	4.2(3)	3.1(2)	**2.7**(1)	**2.7**(1)	477(525)	12/15
lmmCMA aug	**1.3**(1)	**1.4**(1)	**2.0**(1)	**1.7**(0.4)	**0.86**(0.2)	15/15
memPSODE v	5.0(2)	4.2(2)	3.4(1)	**2.2**(1.0)	**2.6**(2)	15/15
prcga saw	3.2(4)	6.7(5)	9.3(5)	14(4)	249(512)	14/15
ring100 ho	15(16)	20(16)	28(10)	46(9)	507(142)	15/15
ring16 hol	6.2(5)	7.1(3)	7.2(4)	9.1(2)	331(491)	13/15
simplex pa	32(50)	35(37)	33(23)	23(3)	16(11)	15/15

Table 14: 10-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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
f13	*1.0e+3*:12	*6.3e+2*:32	*4.0e+2*:40	*6.3e+1*:154	*2.5e+0*:521	15/15
BIPOP-aCMA	6.9(4)	5.2(1)	5.8(2)	3.4(0.4)	3.4(2)	15/15
BIPOP-saAC	5.2(3)	3.4(1)	3.2(0.3)	**1.2**(0.2)	**0.75**(0.3)	15/15
CMAES hut	3.3(2)	3.7(2)	4.5(1)	**3.0**(0.3)	4.6(4)	6/15
DE pal	8.0(7)	11(4)	15(5)	19(4)	46(25)	15/15
HCMA los	**2.2**(0.6)	**0.99**(0.3)	**0.98**(0.3)	**0.95**(0.8)	**0.91**(0.1)	15/15
HMLSL pal	**1.8**(0.9)	**1.2**(1)	**1.9**(1)	**1.2**(0.1)	**0.73**(0.1)	15/15
IPOP-10DDr	4.3(3)	3.4(1)	4.4(0.8)	**2.9**(0.5)	3.8(4)	15/15
IPOP-500 l	4.3(3)	3.4(1)	4.4(0.8)	**2.9**(0.5)	3.8(4)	15/15
IPOP-tany	**3.0**(2)	**2.9**(2)	4.5(1)	3.1(0.3)	5.6(3)	15/15
IPOP-texp	**2.8**(2)	**2.8**(2)	4.0(1)	3.2(0.6)	5.0(4)	15/15
IPOP lia	4.3(3)	3.4(1)	4.4(0.8)	**2.9**(0.5)	3.8(4)	15/15
MLSL pal	**1.8**(0.9)	**1.2**(1)	**1.9**(1)	**1.2**(0.1)	**0.73**(0.1)	15/15
OQNLP pal	**2.3**(0.2)	**1.1**(0.3)	**1.4**(0.2)	**1.3**(0.1)	**0.70**(0.2)	15/15
P-DCN tra	5.1(3)	10(6)	16(5)	4659(3)	3.8e4(6e4)	5/15
P-zero tra	6.3(9)	10(8)	14(6)	4659(9)	5.3e4(8e4)	4/15
SMAC hut	**0.81**(0.7)	**0.68**(0.3)	**0.87**(0.3)	**0.71**(0.2)	∞ *1000*	0/15
U-DCN tra	4.2(3)	4.1(3)	9.2(5)	4714(45)	2.9e4(4e4)	6/15
U-zero tra	3.1(2)	3.2(2)	6.8(3)	4681(65)	7.7e4(9e4)	3/15
fmincon pa	**1.8**(0.9)	**1.2**(1)	**1.9**(1)	**1.2**(0.1)	**0.74**(0.1)	15/15
fminunc pa	**1.8**(0.9)	**1.0**(0)	**1.2**(0.3)	**0.80**(0.1)	**0.98**(0.1)	15/15
ga100 hol	7.7(9)	21(7)	31(7)	42(10)	1572(1920)	6/15
grid100 ho	24(30)	55(40)	92(48)	755(1597)	∞ *5e5*	0/15
grid16 hol	15(9)	14(8)	21(6)	69(57)	4165(4798)	3/15
hill hol	7.0(5)	4.3(2)	4.8(2)	11(7)	2106(2405)	5/15
lmmCMA aug	**1.6**(2)	**2.0**(1.0)	**2.8**(0.6)	**1.7**(0.2)	**1.2**(0.4)	15/15
memPSODE v	6.1(2)	3.1(0.5)	3.1(0.7)	**2.3**(0.1)	**1.6**(0.1)	15/15
prcga saw	6.9(6)	9.5(6)	19(7)	22(10)	2911(3531)	6/15
ring100 ho	20(21)	32(12)	57(24)	98(21)	601(544)	12/15
ring16 hol	10(7)	10(4)	15(6)	24(12)	1554(1921)	6/15
simplex pa	26(33)	37(25)	42(23)	23(14)	40(43)	15/15

Table 15: 10-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	*4.0e+1*:7.7	*1.6e+1*:27	*1.0e+1*:37	*6.3e-1*:107	*1.0e-4*:505	15/15
BIPOP-aCMA	**1.2**(1)	**2.9**(1)	3.8(2)	3.5(0.8)	3.8(0.5)	15/15
BIPOP-saAC	**1.7**(2)	**1.4**(0.7)	**2.0**(2)	**2.3**(0.4)	**1.7**(0.3)	15/15
CMAES hut	**1.4**(1)	**1.7**(2)	**2.2**(2)	**2.7**(0.7)	∞ *1002*	0/15
DE pal	**1.2**(1)	3.2(2)	4.7(3)	14(3)	295(213)	13/15
HCMA los	**2.4**(2)	**1.1**(0.3)	**1.1**(0.5)	**2.3**(2)	**2.1**(0.5)	15/15
HMLSL pal	**1.1**(1)	**0.57**(0.2)	**0.60**(0.3)	**0.55**(0.1)	**0.63**(0.1)	15/15
IPOP-10DDr	**1.1**(1)	**1.8**(1)	**2.5**(2)	3.1(0.7)	5.1(0.5)	15/15
IPOP-500 l	**1.1**(1)	**1.8**(1)	**2.5**(2)	3.1(0.7)	5.1(0.5)	15/15
IPOP-tany	**0.88**(1.0)	**1.3**(0.7)	**1.7**(0.9)	**2.9**(0.5)	5.1(0.5)	15/15
IPOP-texp	**0.62**(0.8)	**0.82**(1)	**1.3**(1)	**2.8**(0.6)	4.8(0.6)	15/15
IPOP lia	**1.1**(1)	**1.8**(1)	**2.5**(2)	3.1(0.7)	5.1(0.5)	15/15
MLSL pal	**1.1**(1)	**0.57**(0.2)	**0.60**(0.3)	**0.55**(0.1)	**0.63**(0.1)	15/15
OQNLP pal	**1.7**(2)	**1.1**(0.4)	**1.00**(0.3)	**0.83**(0.1)	**0.89**(0.6)	15/15
P-DCN tra	**1.4**(1)	3.6(3)	6.9(7)	14(5)	5241(1972)	15/15
P-zero tra	**1.4**(2)	3.1(3)	7.5(6)	13(6)	∞ *1e7*	0/15
SMAC hut	**0.41**(0.5)	**0.61**(0.8)	**1.4**(2)	140(158)	∞ *1000*	0/15
U-DCN tra	**1.7**(2)	**2.2**(2)	**2.9**(1)	14(4)	2.4e4(2e4)	9/15
U-zero tra	**1.4**(2)	**1.8**(1)	**2.5**(2)	7.2(2)	∞ *1e7*	0/15
fmincon pa	**1.1**(1)	**0.57**(0.2)	**0.60**(0.3)	**0.55**(0.1)	**0.63**(0.1)	15/15
fminunc pa	**0.79**(0.7)	**0.60**(0.2)	**0.68**(0.4)	**1.1**(0.6)	**0.86**(0.2)	15/15
ga100 hol	**1.0**(1)	**2.6**(3)	9.5(6)	25(3)	∞ *5e5*	0/15
grid100 ho	**1.8**(2)	6.3(7)	23(28)	94(38)	∞ *5e5*	0/15
grid16 hol	**1.3**(0.8)	3.9(3)	5.6(4)	16(6)	∞ *5e5*	0/15
hill hol	3.5(4)	**2.4**(1)	**2.7**(1)	3.8(2)	∞ *5e5*	0/15
lmmCMA aug	**0.77**(2)	**0.62**(0.8)	**0.93**(0.9)	**1.9**(0.3)	**1.9**(0.2)	15/15
memPSODE v	**2.2**(2)	**2.5**(1)	**2.6**(0.7)	**1.4**(0.2)	**0.66**(0.1)	15/15
prcga saw	**0.73**(0.9)	**1.7**(1)	4.4(4)	16(5)	∞ *1e6*	0/15
ring100 ho	**1.0**(0.7)	4.6(7)	13(15)	62(15)	∞ *5e5*	0/15
ring16 hol	**1.6**(2)	3.4(4)	5.3(4)	12(2)	∞ *5e5*	0/15
simplex pa	8.1(10)	11(13)	20(24)	36(27)	∞ *2e5*	0/15

Table 16: 10-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	*2.5e+2*:9.0	*1.6e+2*:72	*1.0e+2*:186	*6.3e+1*:450	*4.0e+1*:872	15/15
BIPOP-aCMA	6.3(5)	**2.0**(1)	**1.3**(0.3)	**0.97**(0.3)	**1.3**(0.5)	15/15
BIPOP-saAC	4.6(3)	**1.3**(0.5)	**0.99**(0.4)	**0.88**(0.6)	**1.0**(0.3)	15/15
CMAES hut	5.1(6)	**1.4**(0.5)	**1.2**(0.6)	**1.0**(0.4)	3.2(3)	5/15
DE pal	9.1(9)	3.6(2)	4.1(2)	5.0(2)	17(14)	15/15
HCMA los	**2.7**(0.6)	**0.70**(0.4)	**0.68**(0.8)	**1.1**(1)	**1.3**(0.8)	15/15
HMLSL pal	18(30)	9.2(8)	7.7(2)	5.8(1)	3.7(0.1)	15/15
IPOP-10DDr	4.3(4)	**1.3**(0.6)	**1.0**(0.2)	**0.95**(0.5)	**1.4**(0.6)	15/15
IPOP-500 l	4.3(4)	**1.3**(0.6)	**1.0**(0.2)	**0.95**(0.5)	**1.4**(0.6)	15/15
IPOP-tany	**2.9**(2)	**0.83**(0.6)	**0.96**(0.2)	**0.85**(0.4)	**1.3**(0.6)	15/15
IPOP-texp	**3.2**(3)	**1.00**(0.7)	**0.89**(0.3)	**1.1**(0.4)	**1.2**(0.3)	15/15
IPOP lia	4.3(4)	**1.3**(0.6)	**1.0**(0.2)	**0.95**(0.5)	**1.4**(0.6)	15/15
MLSL pal	17(25)	8.5(7)	9.0(8)	23(27)	52(35)	14/15
OQNLP pal	35(39)	18(31)	43(61)	49(53)	49(55)	12/15
P-DCN tra	6.8(4)	3.5e4(7e4)	1.5e5(2e5)	3.1e5(3e5)	1.6e5(2e5)	1/15
P-zero tra	1.5e5(5e5)	1.6e5(2e5)	1.5e5(2e5)	1.4e5(2e5)	∞ *1e7*	0/15
SMAC hut	**1.2**(1)	**0.57**(0.4)	**1.5**(1)	5.7(6)	∞ *1000*	0/15
U-DCN tra	5.0(3)	**1.9**(0.8)	**2.9**(3)	390(665)	2411(5736)	13/15
U-zero tra	4.7(3)	**1.3**(0.8)	3.8(2)	644(1097)	7624(9873)	10/15
fmincon pa	19(33)	7.8(7)	6.2(3)	18(24)	56(32)	15/15
fminunc pa	30(37)	11(7)	16(29)	29(33)	65(46)	15/15
ga100 hol	11(9)	6.6(5)	6.3(1)	6.7(2)	11(6)	15/15
grid100 ho	14(20)	16(17)	20(11)	103(73)	365(581)	10/15
grid16 hol	14(13)	6.7(5)	7.9(7)	109(129)	553(599)	8/15
hill hol	9.1(5)	**2.8**(2)	30(8)	298(561)	1304(1471)	5/15
lmmCMA aug	**2.0**(2)	**0.76**(0.5)	**0.68**(0.2)	**0.66**(0.4)	**0.65**(0.2)⋆	15/15
memPSODE v	29(17)	33(50)	28(26)	22(14)	15(8)	15/15
prcga saw	5.9(8)	4.1(2)	4.1(1)	4.0(2)	5.2(1)	15/15
ring100 ho	12(18)	10(6)	11(4)	13(5)	19(9)	15/15
ring16 hol	11(11)	3.7(2)	4.1(3)	5.8(4)	151(290)	12/15
simplex pa	104(85)	23(10)	112(182)	223(121)	327(276)	9/15

Table 17: 10-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*:12	*2.5e+1*:47	*1.6e+1*:88	*1.0e+1*:425	*4.0e+0*:989	15/15
BIPOP-aCMA	**2.0**(2)	5.0(6)	10(3)	**2.8**(1)	**2.5**(3)	15/15
BIPOP-saAC	**2.9**(3)	4.4(6)	9.5(7)	**2.6**(2)	**2.2**(2)	15/15
CMAES hut	**1.3**(0.9)	7.2(6)	11(9)	3.7(3)	**2.3**(2)	6/15
DE pal	**2.0**(2)	**2.5**(3)	23(24)	33(32)	337(311)	7/15
HCMA los	3.1(4)	**2.1**(3)	6.4(7)	**2.6**(1)	**2.2**(2)	15/15
HMLSL pal	7.1(9)	9.2(12)	29(20)	16(9)	317(363)	7/15
IPOP-10DDr	**1.3**(1)	3.1(4)	7.0(4)	**1.8**(0.7)	**1.0**(0.3)	15/15
IPOP-500 l	**1.3**(1)	3.1(4)	7.0(4)	**1.8**(0.7)	**1.0**(0.3)	15/15
IPOP-tany	**1.4**(1)	**1.5**(1)	6.8(4)	**2.1**(0.7)	**1.2**(0.4)	15/15
IPOP-texp	**1.8**(2)	**1.3**(1)	**3.3**(4)	**1.4**(1)	**0.91**(0.5)	15/15
IPOP lia	**1.3**(1)	3.1(4)	7.0(4)	**1.8**(0.7)	**1.0**(0.3)	15/15
MLSL pal	7.1(9)	10(12)	21(20)	32(33)	368(362)	7/15
OQNLP pal	37(29)	19(5)	47(54)	58(43)	247(266)	4/15
P-DCN tra	**1.8**(2)	**1.3**(0.9)	**2.4**(2)	**1.0**(0.8)	5769(1e4)	10/15
P-zero tra	**1.6**(2)	**1.3**(1)	**2.6**(2)	5896(1e4)	2.9e4(4e4)	4/15
SMAC hut	**1.7**(1)	**1.2**(1)	**1.7**(2)	**1.2**(1)	15(15)	1/15
U-DCN tra	**1.4**(1)	**2.8**(3)	6.4(3)	4.7(3)	1629(3933)	14/15
U-zero tra	**1.4**(2)	**2.3**(1)	5.6(6)	4.9(7)	2487(5065)	13/15
fmincon pa	15(24)	13(11)	15(12)	17(15)	399(432)	6/15
fminunc pa	70(58)	28(8)	144(282)	294(198)	∞ *2e5*	0/15
ga100 hol	**1**(0.9)	3.5(3)	15(13)	14(9)	12(6)	15/15
grid100 ho	**1.2**(1)	**2.9**(4)	12(12)	13(10)	219(291)	12/15
grid16 hol	**2.0**(2)	3.0(2)	8.6(5)	13(11)	262(453)	11/15
hill hol	**2.9**(3)	**2.2**(2)	**3.6**(3)	52(168)	530(760)	8/15
lmmCMA aug	**1.5**(1)	3.9(4)	5.2(4)	**1.3**(0.8)	**2.0**(2)	14/15
memPSODE v	**1.2**(1)	**1.1**(0.9)	11(22)	7.6(12)	18(17)	15/15
prcga saw	**1.2**(2)	3.9(4)	18(15)	10(7)	169(506)	13/15
ring100 ho	**1.7**(2)	3.7(4)	13(12)	8.5(4)	18(10)	15/15
ring16 hol	**1.3**(2)	3.3(2)	7.1(6)	4.0(3)	63(67)	14/15
simplex pa	106(62)	33(4)	22(3)	9.0(5)	80(71)	15/15

Table 18: 10-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ 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 $\mathrm{ERT}_{\text{best 2009}}$ (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*:26	*6.3e+0*:85	*4.0e+0*:155	*2.5e+0*:238	*6.3e-1*:585	15/15
BIPOP-aCMA	**2.4**(3)	**1.7**(0.5)	**1.4**(0.4)	**1.3**(0.2)	**1.1**(0.4)	15/15
BIPOP-saAC	**2.8**(2)	**1.5**(0.8)	**1.4**(0.5)	**1.4**(0.6)	**1.1**(0.3)	15/15
CMAES hut	**2.2**(2)	**1.3**(0.7)	**1.2**(0.6)	**1.1**(0.5)	**1.0**(0.4)	14/15
DE pal	**2.9**(3)	**2.8**(2)	4.1(3)	5.0(1)	7.2(2)	15/15
HCMA los	**2.2**(2)	**1.7**(2)	**2.0**(1)	**1.9**(0.6)	**1.3**(0.6)	15/15
HMLSL pal	18(17)	12(12)	10(9)	12(6)	11(5)	15/15
IPOP-10DDr	**1.5**(1.0)	**1.3**(0.5)	**1.1**(0.3)	**1.0**(0.4)	**0.99**(0.3)	15/15
IPOP-500 l	**1.5**(1.0)	**1.3**(0.5)	**1.1**(0.3)	**1.0**(0.4)	**0.99**(0.3)	15/15
IPOP-tany	**1.6**(1)	**1.1**(0.7)	**1.2**(0.3)	**1.2**(0.4)	**1.0**(0.3)	15/15
IPOP-texp	**1.8**(1)	**1.3**(0.6)	**1.1**(0.7)	**1.1**(0.3)	**1.1**(0.4)	15/15
IPOP lia	**1.5**(1.0)	**1.3**(0.5)	**1.1**(0.3)	**1.0**(0.4)	**0.99**(0.3)	15/15
MLSL pal	17(19)	12(11)	28(52)	267(241)	∞ *2e5*	0/15
OQNLP pal	10(14)	32(42)	82(131)	351(370)	∞ *1e5*	0/15
P-DCN tra	**1.6**(1)	**1.6**(1)	2.4e4(3e4)	2.9e5(3e5)	∞ *1e7*	0/15
P-zero tra	**1.7**(0.9)	8657(1162)	1.3e5(2e5)	2.7e5(3e5)	∞ *1e7*	0/15
SMAC hut	**0.79**(1)	**2.6**(2)	4.6(4)	5.2(5)	∞ *1000*	0/15
U-DCN tra	**1.9**(1)	**1.9**(1)	18(5)	3044(208)	2.0e4(3e4)	7/15
U-zero tra	**1.5**(0.8)	**2.2**(1)	76(41)	2158(2563)	7.1e4(8e4)	3/15
fmincon pa	19(21)	15(14)	87(125)	294(266)	∞ *2e5*	0/15
fminunc pa	14(21)	13(10)	39(72)	239(295)	∞ *2e5*	0/15
ga100 hol	4.4(4)	6.3(5)	7.4(3)	7.0(2)	11(6)	15/15
grid100 ho	4.0(5)	11(7)	192(527)	556(773)	1.3e4(1e4)	1/15
grid16 hol	3.2(3)	9.4(7)	136(200)	448(1050)	1543(1846)	6/15
hill hol	31(21)	171(473)	210(553)	689(1056)	∞ *5e5*	0/15
lmmCMA aug	**0.63**(0.7)	**0.61**(0.6)	**0.76**(0.5)	**0.78**(0.3)	**1.0**(0.3)	15/15
memPSODE v	24(50)	60(52)	69(31)	79(52)	116(101)	15/15
prcga saw	**2.2**(2)	3.0(2)	4.2(3)	4.6(2)	11(4)	15/15
ring100 ho	6.2(7)	8.9(6)	12(6)	17(8)	57(23)	15/15
ring16 hol	3.1(3)	3.4(2)	5.5(4)	6.9(4)	771(894)	8/15
simplex pa	33(29)	20(8)	204(447)	1283(1137)	∞ *2e5*	0/15

Table 19: 10-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+1*:11	*2.5e+1*:56	*1.6e+1*:172	*1.6e+1*:172	*2.5e+0*:561	15/15
BIPOP-aCMA	5.9(5)	**2.6**(0.8)	**1.3**(0.4)	**1.3**(0.4)	**1.1**(0.2)	15/15
BIPOP-saAC	4.1(4)	**1.6**(1.0)	**0.99**(0.4)	**0.99**(0.4)	**2.6**(6)	15/15
CMAES hut	4.2(3)	**1.8**(2)	**1.1**(1.0)	**1.1**(1.0)	**1.2**(0.4)	14/15
DE pal	10(8)	4.4(2)	3.4(2)	3.4(2)	9.2(4)	15/15
HCMA los	3.8(3)	**2.5**(2)	**1.6**(1)	**1.6**(1)	**2.6**(0.5)	15/15
HMLSL pal	20(41)	16(16)	10(7)	10(7)	18(9)	15/15
IPOP-10DDr	3.7(2)	**1.6**(0.7)	**1.0**(0.2)	**1.0**(0.2)	**0.89**(0.2)	15/15
IPOP-500 l	3.7(2)	**1.6**(0.7)	**1.0**(0.2)	**1.0**(0.2)	**0.89**(0.2)	15/15
IPOP-tany	**2.7**(1)	**1.5**(0.5)	**0.99**(0.4)	**0.99**(0.4)	**1.7**(0.3)	15/15
IPOP-texp	3.9(3)	**1.8**(1.0)	**0.96**(0.6)	**0.96**(0.6)	**2.5**(1)	15/15
IPOP lia	3.7(2)	**1.6**(0.7)	**1.0**(0.2)	**1.0**(0.2)	**0.89**(0.2)	15/15
MLSL pal	16(35)	35(31)	37(46)	37(46)	∞ *2e5*	0/15
OQNLP pal	27(31)	31(44)	80(77)	80(77)	1430(1463)	2/15
P-DCN tra	**2.3**(2)	**2.4**(2)	3.0e4(3e4)	3.0e4(6e4)	2.5e5(3e5)	1/15
P-zero tra	3.9(3)	3.9e4(9e4)	7.2e4(9e4)	7.2e4(1e5)	∞ *1e7*	0/15
SMAC hut	**1.5**(2)	**1.2**(1)	**2.5**(3)	**2.5**(3)	∞ *1000*	0/15
U-DCN tra	**2.3**(2)	**2.2**(2)	3.9(5)	3.9(5)	5.1e4(6e4)	4/15
U-zero tra	3.4(3)	**2.1**(1)	57(170)	57(170)	2.2e4(3e4)	7/15
fmincon pa	18(38)	14(14)	18(6)	18(6)	∞ *2e5*	0/15
fminunc pa	36(59)	18(20)	46(87)	46(87)	∞ *2e5*	0/15
ga100 hol	7.5(7)	5.5(4)	4.9(2)	4.9(2)	19(8)	15/15
grid100 ho	12(18)	17(10)	21(14)	21(14)	2953(3124)	4/15
grid16 hol	8.8(8)	7.4(7)	100(29)	100(29)	2678(3117)	4/15
hill hol	121(54)	348(756)	196(269)	196(269)	2656(3117)	4/15
lmmCMA aug	**1.5**(2)	**0.75**(0.7)	**0.63**(0.3)	**0.63**(0.3)	**0.65**(0.2)⋆	15/15
memPSODE v	92(212)	88(84)	64(33)	64(33)	260(80)	15/15
prcga saw	3.1(3)	3.2(3)	3.2(2)	3.2(2)	26(5)	15/15
ring100 ho	9.1(11)	12(9)	10(4)	10(4)	58(49)	15/15
ring16 hol	5.8(7)	4.7(3)	**2.9**(2)	**2.9**(2)	389(575)	11/15
simplex pa	84(86)	32(31)	196(274)	196(274)	∞ *2e5*	0/15

Table 20: 10-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*:618	*1.0e-1*:10609	*6.3e-2*:10623	*4.0e-2*:10625	*2.5e-2*:10644	15/15
BIPOP-aCMA	64(71)	7.5(7)	19(13)	31(43)	54(62)	15/15
BIPOP-saAC	87(80)	8.2(7)	13(8)	21(18)	43(41)	15/15
CMAES hut	∞	∞	∞	∞	∞ *1002*	0/15
DE pal	∞	∞	∞	∞	∞ *2e5*	0/15
HCMA los	51(27)	7.9(6)	12(9)	25(22)	47(32)	15/15
HMLSL pal	**0.09**(0.0)$_{\downarrow}$	**7.7e-3**(5e-5)$_{\downarrow 4}$	**7.6e-3**(5e-5)$_{\downarrow 4}$	**9.8e-3**(8e-4)$_{\downarrow 4}$	**0.01**(2e-3)$_{\downarrow 4}$	15/15
IPOP-10DDr	974(1315)	67(86)	71(82)	84(79)	152(122)	15/15
IPOP-500 l	974(1315)	67(86)	71(82)	83(79)	135(71)	15/15
IPOP-tany	549(681)	34(39)	51(52)	78(60)	97(59)	15/15
IPOP-texp	196(303)	19(19)	26(20)	70(90)	91(114)	15/15
IPOP lia	974(1315)	67(86)	71(82)	82(79)	110(71)	15/15
MLSL pal	**0.09**(0.0)$_{\downarrow}$	**7.7e-3**(5e-5)$_{\downarrow 4}$	**7.6e-3**(5e-5)$_{\downarrow 4}$	**9.8e-3**(8e-4)$_{\downarrow 4}$	**0.01**(2e-3)$_{\downarrow 4}$	15/15
OQNLP pal	**0.06**(8e-4)$^{\star 4}_{\downarrow}$	**4.8e-3**(5e-5)$^{\star 4}_{\downarrow 4}$	**6.0e-3**(5e-5)$^{\star 4}_{\downarrow 4}$	**7.5e-3**(5e-5)$^{\star 4}_{\downarrow 4}$	**7.4e-3**(5e-5)$^{\star 4}_{\downarrow 4}$	15/15
P-DCN tra	∞	∞	∞	∞	∞ *1e7*	0/15
P-zero tra	∞	∞	∞	∞	∞ *1e7*	0/15
SMAC hut	∞	∞	∞	∞	∞ *1000*	0/15
U-DCN tra	∞	∞	∞	∞	∞ *1e7*	0/15
U-zero tra	∞	∞	∞	∞	∞ *1e7*	0/15
fmincon pa	**0.09**(0.0)$_{\downarrow}$	**7.7e-3**(5e-5)$_{\downarrow 4}$	**7.6e-3**(5e-5)$_{\downarrow 4}$	**9.8e-3**(8e-4)$_{\downarrow 4}$	**0.01**(2e-3)$_{\downarrow 4}$	15/15
fminunc pa	**0.12**(0.0)$_{\downarrow}$	**8.0e-3**(1e-3)$_{\downarrow 4}$	**9.1e-3**(1e-3)$_{\downarrow 4}$	**9.1e-3**(1e-3)$_{\downarrow 4}$	**0.01**(1e-3)$_{\downarrow 4}$	15/15
ga100 hol	∞	∞	∞	∞	∞ *5e5*	0/15
grid100 ho	∞	∞	∞	∞	∞ *5e5*	0/15
grid16 hol	∞	∞	∞	∞	∞ *5e5*	0/15
hill hol	∞	∞	∞	∞	∞ *5e5*	0/15
lmmCMA aug	∞	∞	∞	∞	∞ *4805*	0/15
memPSODE v	386(295)	36(24)	79(56)	220(237)	482(490)	9/15
prcga saw	7.9(2)	**0.61**(0.2)	**0.99**(0.5)	**1.9**(2)	5.0(5)	15/15
ring100 ho	∞	∞	∞	∞	∞ *5e5*	0/15
ring16 hol	∞	∞	∞	∞	∞ *5e5*	0/15
simplex pa	**0.18**(0.1)$_{\downarrow}$	**0.02**(6e-3)$_{\downarrow 4}$	**0.02**(0.0)$_{\downarrow 4}$	**0.03**(0.0)$_{\downarrow 4}$	**0.04**(0.0)$_{\downarrow 4}$	15/15

Table 21: 10-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	*1.0e+4*:17	*6.3e+3*:21	*6.3e+1*:30	*2.5e+0*:122	*1.0e+0*:15426	13/15
BIPOP-aCMA	4.4(2)	3.8(1)	7.7(2)	6.3(2)	**3.0**(2)	15/15
BIPOP-saAC	**2.3**(2)	**2.3**(1)	4.1(0.8)	4.8(2)	**1.0**(0.9)	15/15
CMAES hut	**2.0**(2)	**2.5**(2)	4.9(2)	6.1(4)	**0.97**(1)	1/15
DE pal	3.2(4)	5.3(3)	16(7)	15(3)	**0.75**(0.4)	15/15
HCMA los	**1.3**(0)	**1.1**(0)	**0.90**(0.2)	**2.5**(3)	**0.87**(0.4)	15/15
HMLSL pal	**0.77**(0)$\downarrow$	**0.63**(0)$\downarrow$	**1.7**(0)	**1.1**(0)	**0.57**(0.4)	15/15
IPOP-10DDr	**2.7**(0.6)	3.4(1)	5.9(1)	5.7(2)	3.0(2)	15/15
IPOP-500 l	**2.7**(0.6)	3.4(1)	5.9(1)	5.7(2)	3.0(2)	15/15
IPOP-tany	**1.7**(0.9)	**2.1**(0.5)	5.3(2)	8.6(3)	3.6(2)	15/15
IPOP-texp	**0.36**(0.2)$\downarrow$	**0.45**(0.3)$\downarrow$	**1.8**(2)	12(18)	4.9(4)	15/15
IPOP lia	**2.7**(0.6)	3.4(1)	5.9(1)	5.7(2)	3.0(2)	15/15
MLSL pal	**0.77**(0)$\downarrow$	**0.63**(0)$\downarrow$	**1.7**(0)	**1.1**(0)	**1.3**(1)	15/15
OQNLP pal	**1.4**(0)	**1.3**(0)	**0.95**(0)	**1.4**(0)	8.7(9)	4/15
P-DCN tra	5.6(7)	7.0(8)	18(11)	6.4(3)	15(21)	15/15
P-zero tra	7.1(11)	9.0(11)	21(9)	6.7(3)	25(43)	15/15
SMAC hut	**0.27**(0.1)$\downarrow$	**0.33**(0.1)$\downarrow_2$	**1.1**(0.5)	∞	∞ *1000*	0/15
U-DCN tra	3.1(3)	3.4(2)	12(11)	8.0(5)	**1.4**(2)	15/15
U-zero tra	**2.9**(2)	3.4(2)	9.2(6)	5.0(2)	**1.1**(2)	15/15
fmincon pa	**0.77**(0)$\downarrow$	**0.63**(0)$\downarrow$	**1.7**(0)	**1.1**(0)	**1.1**(1)	15/15
fminunc pa	**0.71**(0)$\downarrow$	**0.58**(0)$\downarrow_2$	**0.75**(0)	6.2(0.1)	**0.87**(0.9)	15/15
ga100 hol	4.5(6)	8.5(10)	34(9)	19(4)	**0.55**(0.2)	15/15
grid100 ho	10(9)	24(24)	106(58)	62(22)	3.9(4)	15/15
grid16 hol	5.1(5)	6.7(7)	23(12)	13(5)	**0.50**(0.5)	15/15
hill hol	4.3(5)	4.3(5)	5.1(3)	**2.7**(1)	**0.22**(0.1)	15/15
lmmCMA aug	**0.80**(0.6)	**1.0**(0.9)	3.1(0.6)	6.5(2)	∞ *4817*	0/15
memPSODE v	4.8(2)	4.7(0.6)	3.8(0.4)	3.9(0.8)	**1.1**(0.8)	15/15
prcga saw	**1.1**(1)	**2.5**(3)	11(4)	17(7)	14(27)	14/15
ring100 ho	4.8(7)	15(11)	58(15)	40(9)	**0.92**(0.3)	15/15
ring16 hol	5.1(4)	5.9(4)	16(5)	7.5(2)	**0.25**(0.1)	15/15
simplex pa	5.3(0.3)	6.7(0.2)	15(5)	20(6)	4.1(5)	14/15

Table 22: 10-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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
f21	*4.0e+1*:30	*2.5e+1*:46	*1.6e+1*:56	*1.0e+1*:130	*6.3e+0*:639	15/15
BIPOP-aCMA	3.6(2)	3.8(2)	11(25)	11(12)	**2.7**(5)	15/15
BIPOP-saAC	**2.5**(1)	**2.2**(1)	4.2(3)	**2.6**(4)	**0.89**(1)	15/15
CMAES hut	3.8(2)	6.9(11)	6.2(9)	3.7(4)	**1.2**(1)	10/15
DE pal	6.8(5)	11(8)	27(16)	16(10)	7.2(7)	15/15
HCMA los	**1.1**(0.2)	**1.3**(0.8)	**3.1**(2)	**1.8**(1)	**0.55**(1)	15/15
HMLSL pal	**2.9**(1)	3.6(10)	7.6(17)	6.8(11)	**2.0**(2)	15/15
IPOP-10DDr	5.2(1)	4.6(0.8)	4.3(1)	3.5(0.9)	**1.4**(2)	15/15
IPOP-500 l	5.2(1)	4.6(0.8)	4.3(1)	3.5(0.9)	**1.4**(2)	15/15
IPOP-tany	3.1(2)	**2.8**(2)	**3.4**(1)	7.5(11)	**1.6**(2)	15/15
IPOP-texp	**2.4**(2)	5.4(2)	5.3(3)	4.0(11)	**2.7**(2)	15/15
IPOP lia	5.2(1)	4.6(0.8)	4.3(1)	3.5(0.9)	**1.4**(2)	15/15
MLSL pal	3.0(1)	3.3(8)	3.8(7)	**2.7**(4)	**0.72**(0.8)	15/15
OQNLP pal	**3.0**(7)	**2.9**(5)	**3.5**(4)	3.3(6)	**0.78**(1)	15/15
P-DCN tra	6.9(7)	3.4e4(1e5)	4.4e4(9e4)	2.8e4(4e4)	2.3e4(3e4)	6/15
P-zero tra	2.4e4(12)	5.5e4(1e5)	6.5e4(9e4)	5.1e4(8e4)	2.3e4(3e4)	6/15
SMAC hut	**1.7**(0.8)	**2.0**(2)	**3.2**(2)	**2.8**(4)	**0.99**(2)	10/15
U-DCN tra	5.8(4)	6.7(4)	10(4)	10(3)	323(346)	15/15
U-zero tra	3.1(1.0)	323(2)	265(3)	5612(843)	5900(7991)	11/15
fmincon pa	**1.7**(1)	**3.0**(8)	3.6(7)	**2.4**(3)	**0.87**(1)	15/15
fminunc pa	4.2(8)	4.8(9)	6.4(8)	3.7(4)	**0.97**(1.0)	15/15
ga100 hol	7.7(8)	17(8)	24(9)	17(5)	59(3)	14/15
grid100 ho	12(11)	28(22)	713(195)	333(108)	212(393)	12/15
grid16 hol	6.4(5)	10(7)	652(18)	301(72)	291(400)	11/15
hill hol	871(4)	573(13)	2989(4445)	1762(1933)	1206(1564)	6/15
lmmCMA aug	**2.1**(1)	**2.1**(1)	**2.5**(0.9)	3.2(3)	**1.5**(2)	15/15
memPSODE v	3.1(0.6)	**2.6**(0.6)	16(21)	27(26)	13(28)	15/15
prcga saw	6.0(6)	10(7)	18(13)	635(545)	260(782)	13/15
ring100 ho	15(18)	22(15)	33(12)	20(5)	5.9(1)	15/15
ring16 hol	6.4(4)	7.7(4)	10(3)	5.4(2)	**1.9**(0.8)	15/15
simplex pa	32(29)	26(20)	28(15)	14(7)	3.8(2)	15/15

Table 23: 10-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*:18	*4.0e+1*:30	*4.0e+1*:30	*6.3e+0*:155	*4.0e+0*:631	14/15
BIPOP-aCMA	6.2(4)	12(4)	12(4)	36(49)	14(16)	15/15
BIPOP-saAC	7.3(2)	6.7(2)	6.7(2)	15(17)	4.7(6)	15/15
CMAES hut	3.5(3)	**3.4**(3)	**3.4**(3)	7.3(10)	**2.2**(3)	7/15
DE pal	8.2(6)	12(8)	12(8)	223(648)	123(163)	11/15
HCMA los	**1.9**(0.3)	**4.1**(1.0)	**4.1**(1.0)	18(14)	5.5(4)	15/15
HMLSL pal	**1.1**(0.7)	5.5(17)	5.5(17)	13(12)	3.7(3)	15/15
IPOP-10DDr	4.6(5)	10(3)	10(3)	313(347)	78(85)	15/15
IPOP-500 l	4.6(5)	10(3)	10(3)	350(917)	101(225)	15/15
IPOP-tany	3.5(2)	4.8(4)	4.8(4)	213(536)	89(166)	15/15
IPOP-texp	3.2(3)	9.0(3)	9.0(3)	75(234)	19(58)	15/15
IPOP lia	4.6(5)	10(3)	10(3)	2723(2177)	1231(562)	14/15
MLSL pal	**1.1**(0.7)	**3.8**(8)	**3.8**(8)	**4.3**(5)	**1.2**(1)	15/15
OQNLP pal	**1.8**(0.4)	**3.3**(5)	**3.3**(5)	**3.0**(4)	**1.5**(2)	15/15
P-DCN tra	10(12)	2.4e4(13)	2.4e4(13)	9.7e4(1e5)	3.2e4(4e4)	5/15
P-zero tra	9.4(9)	13(18)	13(18)	4.3e4(6e4)	1.8e4(2e4)	7/15
SMAC hut	**2.6**(2)	4.6(2)	4.6(2)	8.1(10)	4.5(6)	4/15
U-DCN tra	4.6(4)	6.9(6)	6.9(6)	2.4e4(3e4)	8145(2e4)	10/15
U-zero tra	4.1(3)	6.8(6)	6.8(6)	2.4e4(3e4)	9704(1e4)	11/15
fmincon pa	**1.1**(0.7)	4.5(13)	4.5(13)	**4.0**(4)	**1.1**(1.0)	15/15
fminunc pa	**1.5**(0.6)	4.2(10)	4.2(10)	**4.1**(3)	**1.3**(1)	15/15
ga100 hol	11(9)	18(9)	18(9)	250(10)	401(397)	10/15
grid100 ho	15(15)	27(37)	27(37)	1949(3234)	744(1188)	8/15
grid16 hol	10(9)	272(17)	272(17)	2892(3342)	928(1216)	7/15
hill hol	8.8(8)	10(21)	10(21)	1622(3234)	695(794)	8/15
lmmCMA aug	**1.8**(2)	**2.3**(1)	**2.3**(1)	6.7(16)	**2.4**(4)	12/15
memPSODE v	4.7(1)	17(41)	17(41)	92(108)	66(98)	15/15
prcga saw	5.0(4)	11(8)	11(8)	938(2804)	402(792)	12/15
ring100 ho	14(13)	27(12)	27(12)	23(11)	7.1(4)	15/15
ring16 hol	6.6(6)	7.1(4)	7.1(4)	**6.5**(3)	58(3)	14/15
simplex pa	34(41)	47(25)	47(25)	23(15)	7.1(7)	15/15

Table 24: 10-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	*6.3e+0*:10	*4.0e+0*:62	*2.5e+0*:162	*2.5e+0*:162	*1.0e+0*:915	15/15
BIPOP-aCMA	**2.2**(2)	**2.8**(4)	11(9)	11(9)	20(12)	15/15
BIPOP-saAC	5.2(5)	5.3(5)	7.5(7)	7.5(7)	16(14)	15/15
CMAES hut	**2.8**(4)	**2.7**(3)	9.4(12)	9.4(10)	∞ *1002*	0/15
DE pal	**1.9**(2)	**1.9**(2)	12(11)	12(11)	256(267)	9/15
HCMA los	5.1(3)	**2.7**(3)	6.6(8)	6.6(8)	14(12)	15/15
HMLSL pal	4.5(3)	**2.3**(2)	5.8(9)	5.8(9)	**4.0**(4)	15/15
IPOP-10DDr	**2.2**(3)	**2.5**(4)	7.9(7)	7.9(7)	16(24)	15/15
IPOP-500 l	**2.2**(3)	**2.5**(4)	7.9(7)	7.9(7)	16(24)	15/15
IPOP-tany	**2.0**(3)	**1.9**(2)	5.6(5)	5.6(5)	24(29)	15/15
IPOP-texp	**1.9**(2)	**1.9**(2)	9.1(10)	9.1(10)	18(29)	15/15
IPOP lia	**2.2**(3)	**2.5**(4)	7.9(7)	7.9(7)	16(24)	15/15
MLSL pal	4.5(3)	**2.4**(2)	**3.3**(4)	**3.3**(4)	**2.0**(2)	15/15
OQNLP pal	12(18)	5.0(6)	**3.8**(4)	**3.8**(4)	**3.4**(4)	15/15
P-DCN tra	**1.6**(2)	3.3(3)	**2.9**(2)	**2.9**(2)	11(15)	15/15
P-zero tra	**2.1**(2)	**1.6**(1)	**1.6**(1)	**1.6**(1)	427(12)	15/15
SMAC hut	**1.7**(2)	**1.9**(2)	8.1(9)	8.1(9)	∞ *1000*	0/15
U-DCN tra	**2.8**(3)	**2.2**(2)	5.0(5)	5.0(5)	116(18)	15/15
U-zero tra	**1.5**(1)	**2.8**(4)	8.0(6)	8.0(6)	28(19)	15/15
fmincon pa	4.3(3)	**2.3**(2)	**1.9**(1)	**1.9**(1)	**2.6**(3)	15/15
fminunc pa	13(18)	6.0(6)	11(6)	11(6)	31(36)	15/15
ga100 hol	**2.4**(2)	**1.9**(2)	5.6(8)	5.6(8)	161(193)	14/15
grid100 ho	**1.6**(2)	**1.8**(2)	10(7)	10(7)	207(283)	13/15
grid16 hol	**2.4**(2)	**2.1**(2)	12(12)	12(12)	113(162)	14/15
hill hol	**2.5**(2)	3.3(4)	7.3(5)	7.3(5)	86(109)	15/15
lmmCMA aug	**2.5**(5)	**1.9**(2)	13(16)	13(16)	38(39)	2/15
memPSODE v	**2.9**(4)	7.2(4)	6.4(12)	6.4(12)	11(8)	15/15
prcga saw	**2.2**(3)	**1.8**(1)	10(11)	10(11)	438(425)	12/15
ring100 ho	**1.8**(2)	**2.7**(4)	12(15)	12(15)	56(23)	15/15
ring16 hol	**2.5**(3)	3.3(4)	10(12)	10(12)	73(102)	15/15
simplex pa	102(76)	22(14)	12(2)	12(2)	**2.9**(0.9)	15/15

Table 25: 10-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ 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 $\text{ERT}_{\text{best 2009}}$ (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
f24	*1.0e+2*:66	*6.3e+1*:596	*4.0e+1*:3181	*2.5e+1*:7668	*1.6e+1*:14353	15/15
BIPOP-aCMA	3.1(0.8)	**2.1**(2)	**1.3**(0.9)	**1.1**(0.9)	**1.2**(1)	15/15
BIPOP-saAC	**2.2**(1)	**0.89**(0.4)	**1.4**(1)	**0.72**(0.6)	**0.78**(0.4)	15/15
CMAES hut	**2.6**(0.9)	**1.4**(1)	4.5(5)	∞	∞ *1002*	0/15
DE pal	12(6)	6.3(3)	17(13)	183(205)	104(98)	2/15
HCMA los	**1.2**(0.2)	**1.3**(1.0)	**1.6**(1)	**1.1**(1)	**1.1**(0.9)	15/15
HMLSL pal	**2.7**(0.9)	**2.3**(2)	**1.2**(0.5)	**1.6**(0.9)	11(12)	11/15
IPOP-10DDr	**2.9**(1)	**1.5**(1)	**1.2**(0.6)	**1.1**(1)	**2.0**(1)	15/15
IPOP-500 l	**2.9**(1)	**1.5**(1)	**1.2**(0.6)	**1.1**(1)	**2.0**(1)	15/15
IPOP-tany	**2.4**(1)	**1.1**(0.5)	**1.6**(1)	**0.97**(0.5)	**1.2**(1)	15/15
IPOP-texp	**1.1**(1)	**0.73**(0.4)	**0.75**(0.7)	**0.67**(0.5)	**0.78**(0.4)	15/15
IPOP lia	**2.9**(1)	**1.5**(1)	**1.2**(0.6)	**1.1**(1)	**2.0**(1)	15/15
MLSL pal	**2.6**(0.9)	4.8(10)	10(10)	37(37)	∞ *2e5*	0/15
OQNLP pal	**1.4**(1)	**0.36**(0.1)	3.1(5)	3.6(3)	3.7(4)	11/15
P-DCN tra	3.8e4(8e4)	3.4e4(4e4)	∞	∞	∞ *1e7*	0/15
P-zero tra	1.1e4(68)	2.5e4(3e4)	∞	∞	∞ *1e7*	0/15
SMAC hut	**1.6**(1)	7.1(8)	∞	∞	∞ *1000*	0/15
U-DCN tra	7.1(7)	8.8(10)	1369(2755)	8487(9125)	∞ *1e7*	0/15
U-zero tra	11(4)	13(16)	1031(1594)	9172(1e4)	∞ *1e7*	0/15
fmincon pa	**2.0**(0.9)	5.3(8)	13(12)	34(30)	∞ *2e5*	0/15
fminunc pa	**1.6**(0.7)	**2.1**(0.8)	19(11)	57(63)	87(102)	2/15
ga100 hol	13(7)	4.5(2)	8.0(6)	18(23)	242(261)	2/15
grid100 ho	42(19)	73(56)	143(146)	955(1043)	∞ *5e5*	0/15
grid16 hol	10(5)	29(35)	177(239)	294(293)	∞ *5e5*	0/15
hill hol	13(17)	73(24)	98(157)	921(1011)	∞ *5e5*	0/15
lmmCMA aug	**1.9**(1)	**0.99**(1.0)	**1.2**(1)	**1.0**(1)	**1.6**(2)	3/15
memPSODE v	64(67)	16(14)	6.1(4)	5.2(3)	7.1(6)	15/15
prcga saw	5.6(2)	5.3(4)	3.4(3)	4.7(4)	25(37)	12/15
ring100 ho	34(7)	17(8)	16(10)	39(39)	498(540)	1/15
ring16 hol	8.1(6)	5.7(5)	25(37)	52(71)	489(540)	1/15
simplex pa	6.0(3)	88(86)	135(131)	∞	∞ *2e5*	0/15

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