

Comparison Tables: BBOB 2013 Testbed in 5-D

The BBOBies

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Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2013, 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 (ERT_{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 name	short	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]
HMSL 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]
ImmCMA 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 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f1	11	12	12	12	12	12	12	15/15
BIPOP-aCMA	3.1(0.9)	4.5(0)	5.9(0.6)	7.2(0.6)	8.3(0.8)	11(0.2)	14(0.6)	15/15
BIPOP-saAC	3.7(2)	7.7(2)	9.5(0.9)	11(0.8)	13(1)	16(1)	19(2)	15/15
CMAES hut	1.9 (1)	8.3(3)	15(3)	22(5)	27(5)	65(44)	∞ 506	0/15
DE pal	4.9(3)	20(7)	39(5)	61(6)	79(7)	120(9)	157(8)	15/15
HCMA los	1.1 (0)	0.98 (0) ^{*3}	0.98 (0) ^{*4}	0.98 (0) ^{*4}	0.98 (0) ^{*4}	0.98 (0) ^{*4}	0.98 (0) ^{*4}	15/15
HMLSL pal	0.71 (0.3)	1.4 (0.5)	2.0 (0)	2.1 (0.2)	2.6 (0.2)	3.4 (0.2)	3.9 (0.5)	15/15
IPOP-10DDr	3.0(1)	7.5(1)	13(3)	21(4)	27(3)	40(4)	53(6)	15/15
IPOP-500 l	3.0(1)	7.5(1)	13(3)	21(4)	27(3)	40(4)	53(6)	15/15
IPOP-tany	2.7 (2)	7.4(2)	16(4)	24(4)	30(3)	44(3)	56(3)	15/15
IPOP-texp	2.7 (2)	6.7(3)	13(6)	21(6)	29(4)	44(4)	55(4)	15/15
IPOP lia	3.0(1)	7.5(1)	13(3)	21(4)	27(3)	40(4)	53(6)	15/15
MLSL pal	0.71 (0.3)	1.4 (0.5)	2.0 (0)	2.1 (0.2)	2.6 (0.2)	3.4 (0.2)	3.9 (0.5)	15/15
OQNLP pal	1.7 (0.1)	1.7 (0.1)	2.2 (0.3)	2.4 (0.1)	2.5 (0.1)	2.5 (0.0)	2.6 (0.0)	15/15
P-DCN tra	7.5(12)	28(20)	41(20)	49(20)	64(25)	199(48)	494(147)	15/15
P-zero tra	11(14)	29(26)	41(30)	46(28)	55(27)	133(35)	664(236)	15/15
SMAC hut	0.91 (0.3)	1.5 (0.3)	2.3 (0.4)	3.6(0.9)	119(144)	∞	∞ 500	0/15
U-DCN tra	3.1(3)	21(11)	84(45)	187(92)	367(148)	848(548)	2283(1702)	15/15
U-zero tra	3.2(3)	14(8)	54(43)	177(118)	381(303)	4039(2899)	3.9e4(2e4)	15/15
fmincon pa	0.71 (0.3)	1.4 (0.5)	2.0 (0)	2.1 (0.2)	2.6 (0.2)	3.4 (0.2)	3.9 (0.5)	15/15
fminunc pa	1.0 (0.3)	1.1 (0)	1.1 (0)	1.1 (0)	1.1 (0)	1.1 (0)	1.1 (0)	15/15
ga100 hol	6.1(4)	70(32)	173(67)	382(99)	868(246)	5195(1902)	1.5e5(2e5)	2/15
grid100 ho	16(27)	152(35)	451(163)	1116(714)	3279(2154)	7.3e4(7e4)	∞ 2e5	0/15
grid16 hol	11(12)	37(26)	98(45)	259(140)	631(295)	5962(2179)	3.0e5(3e5)	1/15
hill hol	4.3(3)	8.3(6)	22(8)	61(21)	210(108)	2623(1297)	3.8e4(4e4)	7/15
lmmCMA aug	1.6 (0.9)	2.9 (0.3)	3.5(0.4)	4.3(0.6)	5.1(0.5)	6.7(0.6)	8.4(0.7)	15/15
memPSODE v	5.7(4)	7.3(0)	7.3(0)	7.3(0)	7.3(0)	7.3(0)	7.5(0.2)	15/15
prcga saw	4.1(7)	25(12)	48(18)	83(24)	166(65)	352(453)	1757(3289)	15/15
ring100 ho	12(13)	108(46)	315(77)	651(249)	1235(513)	4221(940)	4.7e4(4e4)	6/15
ring16 hol	6.7(7)	27(11)	66(16)	151(49)	266(118)	2051(1062)	4.6e4(4e4)	6/15
simplex pa	21(37)	63(27)	76(22)	83(13)	85(11)	90(11)	94(12)	15/15

Table 3: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_2 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_2	83	87	88	89	90	92	94	15/15
BIPOP-aCMA	1.4 (0.2)	1.5 (0.2)	1.8 (0.2)	2.0 (0.2)	2.2 (0.3)	2.5 (0.2)	2.8 (0.3)	15/15
BIPOP-saAC	3.6(0.8)	3.9(0.7)	4.1(0.7)	4.4(0.7)	4.6(0.7)	5.0(0.7)	5.4(0.7)	15/15
CMAES hut	∞	∞	∞	∞	∞	∞	∞ 506	0/15
DE pal	11(1)	13(1)	15(1)	18(2)	20(1)	25(1)	30(1)	15/15
HCMA los	1.5 (0.2)	1.6 (0.1)	1.8 (0.1)	2.0 (0.1)	2.2 (0.3)	2.5 (0.2)	2.8 (0.2)	15/15
HMLSL pal	1.9 (1)	2.1 (1)	2.3 (1)	2.4 (1)	2.6 (1)	3.9(1)	5.5(7)	15/15
IPOP-10DDr	13(4)	17(5)	19(4)	20(3)	21(3)	23(3)	24(2)	15/15
IPOP-500 l	13(4)	17(5)	19(2)	20(3)	21(3)	23(3)	24(2)	15/15
IPOP-tany	15(3)	17(3)	18(2)	19(1)	20(1)	22(1.0)	23(1)	15/15
IPOP-texp	15(4)	18(4)	20(2)	21(2)	22(2)	23(2)	24(2)	15/15
IPOP lia	13(4)	17(5)	19(4)	20(3)	21(3)	23(3)	24(2)	15/15
MLSL pal	1.9 (1)	2.1 (1)	2.3 (1)	2.4 (1)	2.6 (1)	3.7 (1)	5.1 (5)	15/15
OQNLP pal	2.0 (0.8)	2.5 (1)	2.6 (1)	2.7 (1)	2.8 (1)	3.0 (1)	131(146)	8/15
P-DCN tra	20(9)	27(9)	47(22)	75(56)	139(99)	212(111)	610(818)	15/15
P-zero tra	16(10)	21(11)	44(32)	120(77)	225(135)	2835(3668)	1.8e4(2e4)	15/15
SMAC hut	∞	∞	∞	∞	∞	∞	∞ 500	0/15
U-DCN tra	107(160)	193(191)	264(225)	396(239)	1229(858)	1345(776)	7404(6761)	14/15
U-zero tra	175(246)	780(964)	1961(1617)	7795(6402)	2.0e4(2e4)	∞	∞ 5e6	0/15
fmincon pa	1.7 (1)	1.8 (0.9)	1.9 (1.0)	2.1 (1)	2.4 (1)	3.1 (2)	4.0 (2)	15/15
fminunc pa	4.5(2)	5.8(2)	6.6(2)	6.9(2)	7.1(2)	7.4(2)	7.5(2)	15/15
ga100 hol	88(71)	293(213)	2069(2162)	9265(1e4)	4.1e4(5e4)	∞	∞ 2e5	0/15
grid100 ho	320(259)	1245(1243)	4897(4623)	∞	∞	∞	∞ 2e5	0/15
grid16 hol	127(144)	347(338)	943(867)	4249(4435)	2.0e4(2e4)	∞	∞ 2e5	0/15
hill hol	94(73)	301(211)	1204(1485)	5819(6363)	1.3e4(1e4)	∞	∞ 2e5	0/15
lmmCMA aug	3.2(0.7)	3.9(0.8)	4.3(0.9)	4.6(1)	4.8(1)	5.0(1)	5.3(1)	15/15
memPSODE v	3.6(3)	4.1(3)	4.5(3)	4.7(3)	4.8(3)	5.0(3)	5.2 (3)	15/15
prcga saw	13(4)	37(61)	52(88)	80(97)	353(339)	747(1082)	1101(1453)	15/15
ring100 ho	137(70)	240(109)	1453(1517)	2882(2926)	1.3e4(1e4)	∞	∞ 2e5	0/15
ring16 hol	68(39)	250(171)	713(703)	3626(3461)	6309(6227)	∞	∞ 2e5	0/15
simplex pa	19(12)	25(9)	27(4)	27(4)	29(3)	28(3)	28(3)	15/15

Table 4: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_3 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_3	716	1622	1637	1642	1646	1650	1654	15/15
BIPOP-aCMA	0.27 (0.1)	0.29 (0.1)	0.32 (0.1)	0.34 (0.1)	0.35 (0.1)	0.39 (0.1)	0.42 (0.1)	15/15
BIPOP-saAC	1.1 (0.9)	12(15)	94(38)	94(38)	94(38)	94(38)	95(38)	15/15
CMAES hut	1.2 (1)	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	1.2 (0.4)	1.7 (0.3)	1.9 (0.3)	2.1 (0.3)	2.3 (0.3)	2.5 (0.3)	2.8 (0.4)	15/15
HCMA los	0.29 (0.1)	3.0(5)	55(87)	54(87)	55(87)	55(86)	55(86)	15/15
HMLSL pal	1.3 (0.2)	2.2 (1)	3.2 (1.0)	3.2 (1)	3.2 (1)	3.3 (1)	3.3 (1)	15/15
IPOP-10DDr	0.99 (1)	15(21)	60(67)	60(67)	60(67)	61(67)	61(67)	15/15
IPOP-500 l	0.99 (1)	18(11)	257(433)	258(434)	258(433)	259(432)	259(432)	15/15
IPOP-tany	0.94 (1)	7.2(8)	51(41)	51(41)	51(41)	51(40)	52(40)	15/15
IPOP-texp	1.1 (1)	10(12)	42(35)	43(35)	43(35)	43(34)	44(34)	15/15
IPOP lia	0.99 (1)	48(11)	2690(4581)	2683(4567)	2677(3057)	2670(4546)	2665(3043)	8/15
MLSL pal	5.6(5)	279(331)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
OQNLP pal	8.6(12)	41(44)	∞	∞	∞	∞	∞ <i>1e4</i>	0/15
P-DCN tra	7.5(11)	26(29)	152(178)	152(178)	152(177)	155(176)	166(173)	15/15
P-zero tra	9.4(9)	44(27)	111(41)	111(41)	111(41)	116(41)	223(75)	15/15
SMAC hut	5.1(6)	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	0.85 (0.5)	3.6(2)	5.4 (3)	8.1 (3)	10 (4)	65(62)	374(678)	14/15
U-zero tra	0.62 (0.5)	2.4 (1)	8.4(5)	35(29)	88(61)	1027(650)	∞ <i>5e6</i>	0/15
fmincon pa	5.2(6)	122(144)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
fminunc pa	5.3(5)	253(297)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
ga100 hol	2.3 (0.6)	4.1(2)	11(5)	33(13)	77(25)	2257(2499)	∞ <i>2e5</i>	0/15
grid100 ho	5.3(4)	19(7)	56(21)	401(457)	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	1.1 (0.5)	4.2(2)	11(5)	35(18)	129(113)	∞	∞ <i>2e5</i>	0/15
hill hol	0.36 (0.2)	1.4 (1.0)	4.6 (3)	18(13)	46(19)	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	0.45 (0.1)	5.3(7)	∞	∞	∞	∞	∞ <i>2806</i>	0/15
memPSODE v	3.6(3)	9.2(6)	15(6)	15 (6)	15 (6)	15 (6)	15 (6)	15/15
prcga saw	1.3 (0.6)	7.1(5)	17(18)	19(19)	19(19)	23 (24)	26 (24)	15/15
ring100 ho	4.4(1)	7.4(2)	16(4)	28(12)	56(21)	∞	∞ <i>2e5</i>	0/15
ring16 hol	0.98 (0.3)	1.9 (0.7)	5.7(4)	17(8)	36(22)	∞	∞ <i>2e5</i>	0/15
simplex pa	12(7)	698(784)	692(811)	690(710)	688(749)	686(718)	685(741)	1/15

Table 5: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_4 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_4	809	1633	1688	1758	1817	1886	1903	15/15
BIPOP-aCMA	0.26 (0.1) _{↓4}	0.60 (0.3)	0.85 (0.2)	1.1 (0.3)	1.3 (0.3)	1.6 (0.3)	1.9 (0.2)	15/15
BIPOP-saAC	1.7 (1)	9027(1e4)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
CMAES hut	1.1 (0.9)	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	1.3 (0.4)	12(31)	165(207)	159(199)	154(193)	149(186)	147 (184)	4/15
HCMA los	0.29 (0.1) _{↓3}	74(28)	457(1482)	439(1423)	425(1376)	410(1326)	406(1314)	13/15
HMLSL pal	1.5 (0.7)	13(31)	93(119)	90(114)	87(111)	84 (107)	83 (106)	6/15
IPOP-10DDr	2.6 (3)	2721(2484)	4.3e4(5e4)	4.1e4(5e4)	4.0e4(4e4)	3.8e4(4e4)	3.8e4(4e4)	1/15
IPOP-500 l	2.6 (3)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
IPOP-tany	2.0 (2)	3009(3498)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
IPOP-texp	1.6 (2)	5050(4882)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
IPOP lia	2.6 (3)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
MLSL pal	22(24)	∞	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
OQNLP pal	25(29)	∞	∞	∞	∞	∞	∞ <i>2e4</i>	0/15
P-DCN tra	42(46)	74(116)	210(286)	201(275)	195(266)	189(258)	189(255)	15/15
P-zero tra	24(9)	81(40)	139(52)	134(50)	131(49)	132(58)	256(95)	15/15
SMAC hut	∞	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	1.1 (0.7)	6.1(4)	8.2 (6)	10 (6)	12 (6)	89 (192)	876(1383)	12/15
U-zero tra	0.76 (0.4)	4.7 (2)	12 (10)	31(31)	112(97)	1134(559)	∞ <i>5e6</i>	0/15
fmincon pa	12(10)	∞	∞	∞	∞	∞	∞ <i>7e4</i>	0/15
fminunc pa	27(43)	∞	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
ga100 hol	2.5 (0.7)	5.9(3)	15(5)	34(16)	181(173)	∞	∞ <i>2e5</i>	0/15
grid100 ho	7.2(3)	24(11)	58(37)	708(711)	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	1.6 (0.6)	5.4 (3)	17(7)	44(28)	302(290)	∞	∞ <i>2e5</i>	0/15
hill hol	0.48 (0.2)	2.1 (2)	7.8 (4)	27 (15)	88(79)	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	1.1 (1)	∞	∞	∞	∞	∞	∞ <i>2810</i>	0/15
memPSODE v	3.2(3)	12(4)	23(16)	25 (22)	24 (21)	23 (21)	24 (23)	15/15
prcga saw	2.0 (1)	11(8)	32(34)	33(32)	34 (31)	46 (41)	55 (55)	15/15
ring100 ho	5.0(1)	10(2)	19(5)	34(11)	86(42)	∞	∞ <i>2e5</i>	0/15
ring16 hol	1.1 (0.4)	2.7 (1)	7.0 (5)	19 (11)	66 (47)	∞	∞ <i>2e5</i>	0/15
simplex pa	39(34)	∞	∞	∞	∞	∞	∞ <i>8e4</i>	0/15

Table 6: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_5 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f5	10	10	10	10	10	10	10	15/15
BIPOP-aCMA	1.2 (0)	1.2 (0)	1.2 (0)	1.2 (0)	1.2 (0)	1.2 (0)	1.2 (0)	15/15
BIPOP-saAC	4.9(2)	6.3(2)	6.4(2)	6.4(2)	6.4(2)	6.4(2)	6.4(2)	15/15
CMAES hut	4.0(2)	5.5(2)	5.6(1)	5.6(1)	5.6(1)	5.6(1)	5.6(1)	15/15
DE pal	29(14)	108(17)	193(31)	295(22)	389(26)	572(37)	771(41)	15/15
HCMA los	1.3 (0.1)	1.4 (0.2)	1.5 (0.3)	1.5 (0.3)	1.5 (0.3)	1.5 (0.3)	1.5 (0.3)	15/15
HMLSL pal	2.5 (0)	4.3(0)	5.5(0)	5.5(0)	6.1(0)	6.7(0)	87(159)	15/15
IPOP-10DDr	6.2(3)	23(18)	30(25)	34(31)	41(33)	45(43)	46(43)	15/15
IPOP-500 l	6.2(3)	23(18)	30(25)	34(31)	41(33)	45(43)	46(43)	15/15
IPOP-tany	8.6(7)	32(24)	40(27)	47(27)	54(31)	62(42)	65(53)	15/15
IPOP-texp	12(11)	36(18)	49(24)	58(31)	67(36)	76(50)	88(71)	15/15
IPOP lia	6.2(3)	23(18)	30(25)	34(31)	41(33)	45(43)	46(43)	15/15
MLSL pal	2.5 (0)	4.3(0)	5.5(0)	5.5(0)	6.1(0)	6.7(0)	18(16)	15/15
OQNLP pal	2.3 (0)	2.4 (0)	2.4 (0)	2.4 (0)	2.4 (0)	2.4 (0)	2.4 (0)	15/15
P-DCN tra	37(29)	118(77)	132(74)	145(74)	168(69)	219(50)	290(56)	15/15
P-zero tra	50(58)	101(85)	113(84)	120(84)	129(84)	146(81)	162(81)	15/15
SMAC hut	0.88 (0.1) ^{*4}	0.91 (0.1) ^{*4}	0.95 (0.1) ^{*3}	0.95 (0.1) ^{*3}	0.95 (0.1) ^{*3}	0.95 (0.1) ^{*3}	0.95 (0.1) ^{*3}	15/15
U-DCN tra	25(18)	240(136)	988(587)	1733(970)	3.7e4(8e4)	2.6e5(4e5)	1.5e6(2e6)	4/15
U-zero tra	19(15)	217(97)	2697(1161)	3.6e4(1e4)	2.5e5(1e5)	∞	∞ 5e6	0/15
fmincon pa	2.5 (0)	4.3(0)	5.5(0)	5.5(0)	6.1(0)	6.7(0)	25(16)	15/15
fminunc pa	1.9 (0)	2.5 (0)	3.1 (0)	3.1 (0)	3.1 (0)	3.1 (0)	3.1 (0)	15/15
ga100 hol	55(19)	100(12)	121(27)	124(27)	124(27)	124(27)	124(27)	15/15
grid100 ho	116(69)	247(102)	264(76)	264(76)	264(76)	264(76)	264(76)	15/15
grid16 hol	28(11)	46(14)	49(12)	50(15)	51(14)	51(14)	51(14)	15/15
hill hol	7.6(4)	11(5)	11(4)	11(4)	11(4)	11(4)	11(4)	15/15
lmmCMA aug	3.4(0.9)	4.8(1)	5.0(1)	5.0(1)	5.0(1)	5.0(1)	5.0(1)	15/15
memPSODE v	10(6)	14(5)	14(6)	14(6)	14(6)	14(6)	14(6)	15/15
prcga saw	318(422)	1999(2627)	4233(3688)	1.1e4(9942)	7.0e4(8e4)	∞	∞ 3e5	0/15
ring100 ho	94(31)	171(26)	190(42)	201(42)	201(42)	201(42)	201(42)	15/15
ring16 hol	20(10)	41(14)	47(12)	47(12)	48(12)	48(12)	48(12)	15/15
simplex pa	74(77)	89(97)	90(97)	90(97)	90(97)	90(97)	90(97)	15/15

Table 7: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_6 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_6	114	214	281	404	580	1038	1332	15/15
BIPOP-aCMA	2.4 (0.9)	2.1 (0.5)	2.2 (0.5)	1.9 (0.4)	1.6 (0.3)	1.2 (0.2)	1.2 (0.2)	15/15
BIPOP-saAC	2.4 (2)	2.2 (1)	2.5 (1.0)	2.3 (0.9)	1.9 (0.6)	1.4 (0.3)	1.5 (0.5)	15/15
CMAES hut	1.9 (0.5)	1.9 (0.4)	4.3(4)	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	2.5 (1)	5.1(2)	7.6(1)	8.6(2)	8.9(2)	8.1(2)	8.9(3)	15/15
HCMA los	2.5 (2)	2.4 (1)	2.9 (1)	2.5 (0.8)	2.0 (0.6)	1.5 (0.4)	1.4 (0.4)	15/15
HMLSL pal	1.2 (0.6)	1.1 (0.4)	1.2 (0.5)	1.0 (0.5)	0.85 (0.3)	0.73 (0.2)	0.71 (0.2)	15/15
IPOP-10DDr	1.6 (0.5)	1.8 (0.4)	2.1 (0.3)	1.9 (0.2)	1.6 (0.2)	1.2 (0.1)	1.2 (0.1)	15/15
IPOP-500 l	1.6 (0.5)	1.8 (0.4)	2.1 (0.3)	1.9 (0.2)	1.6 (0.2)	1.2 (0.1)	1.2 (0.1)	15/15
IPOP-tany	1.5 (0.7)	1.9 (0.5)	2.1 (0.4)	1.9 (0.3)	1.6 (0.2)	1.3 (0.1)	1.3 (0.1)	15/15
IPOP-texp	1.7 (1.0)	2.0 (0.6)	2.2 (0.4)	2.0 (0.4)	1.7 (0.3)	1.3 (0.2)	1.3 (0.2)	15/15
IPOP lia	1.6 (0.5)	1.8 (0.4)	2.1 (0.3)	1.9 (0.2)	1.6 (0.2)	1.2 (0.1)	1.2 (0.1)	15/15
MLSL pal	1.2 (0.6)	1.1 (0.4)	1.2 (0.5)	1.0 (0.5)	0.85 (0.3)	0.73 (0.2)	0.71 (0.2)	15/15
OQNLP pal	0.98 (0.7)	1.00 (0.5)	1.00 (0.4)	1.3 (0.6)	2.3 (2)	7.3(14)	20(25)	11/15
P-DCN tra	7.6(7)	7.6(4)	8.3(5)	13(7)	23(16)	75(88)	410(303)	15/15
P-zero tra	7.3(7)	6.4(5)	8.8(10)	12(11)	109(104)	1887(2491)	6888(7651)	6/15
SMAC hut	5.2(6)	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	7.7(9)	96(189)	293(492)	1255(449)	2097(4380)	3875(5055)	5.3e4(6e4)	1/15
U-zero tra	6.5(7)	77(174)	1678(1399)	4709(6386)	8123(1e4)	9430(1e4)	∞ <i>5e6</i>	0/15
fmincon pa	1.2 (0.5)	1.1 (0.6)	1.2 (0.6)	1.0 (0.5)	0.85 (0.4)	0.67 (0.3)	0.68 (0.2)	15/15
fminunc pa	1.8 (2)	2.2 (1)	2.6 (0.9)	2.5 (0.8)	2.1 (0.5)	1.8 (0.8)	6.4(9)	15/15
ga100 hol	11(7)	31(17)	104(86)	951(1010)	3094(3231)	∞	∞ <i>2e5</i>	0/15
grid100 ho	29(22)	253(190)	964(860)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	8.3(7)	47(44)	400(454)	780(800)	2955(3434)	∞	∞ <i>2e5</i>	0/15
hill hol	2.8 (1)	13(11)	192(348)	483(633)	831(884)	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	4.0(4)	4.3(3)	4.5(3)	3.9(2)	4.8(3)	5.4(4)	∞ <i>2804</i>	0/15
memPSODE v	3.3(3)	2.9 (2)	2.8 (2)	2.3 (1)	1.8 (1)	2.2 (2)	3.7(1)	15/15
prcga saw	7.1(3)	202(355)	243(357)	328(386)	410(442)	362(312)	337(239)	11/15
ring100 ho	17(10)	53(24)	136(76)	284(97)	1526(1530)	∞	∞ <i>2e5</i>	0/15
ring16 hol	4.7(4)	11(8)	46(45)	386(478)	682(783)	∞	∞ <i>2e5</i>	0/15
simplex pa	15(7)	13(6)	13(7)	12(10)	16(16)	20(21)	43(49)	12/15

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Table 8: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_7 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_7	24	324	1171	1451	1572	1572	1597	15/15
BIPOP-aCMA	6.3(3)	1.5 (1)	1.0 (0.8)	0.91 (0.7)	0.95 (0.7)	0.95 (0.7)	0.97 (0.7)	15/15
BIPOP-saAC	3.7(1)	1.2 (1)	0.80 (0.6)	0.75 (0.5)	0.72 (0.5)	0.72 (0.5)	0.90 (0.6)	15/15
CMAES hut	4.2(3)	1.6 (1)	0.92 (0.9)	0.99 (0.9)	0.92 (0.8)	0.92 (0.8)	1.5 (2)	3/15
DE pal	9.0(9)	2.8 (1)	1.7 (1)	2.7 (0.9)	2.8 (0.8)	2.8 (0.8)	3.0 (1)	15/15
HCMA los	3.5 (4)	1.0 (0.3)	0.68 (0.4)	0.79 (0.7)	0.82 (0.7)	0.82 (0.7)	0.85 (0.6)	15/15
HMLSL pal	16(3)	3.8(2)	8.7(1)	8.8(2)	8.5(2)	8.5(2)	8.8(2)	14/15
IPOP-10DDr	5.3(2)	1.1 (0.4)	1.2 (0.9)	1.1 (0.8)	1.2 (0.7)	1.2 (0.7)	1.3 (0.8)	15/15
IPOP-500 l	5.3(2)	1.1 (0.4)	1.2 (0.9)	1.1 (0.8)	1.2 (0.7)	1.2 (0.7)	1.3 (0.8)	15/15
IPOP-tany	3.5 (2)	1.7 (2)	1.3 (1)	1.2 (1.0)	1.1 (0.9)	1.1 (0.9)	1.1 (0.9)	15/15
IPOP-texp	2.7 (2)	2.1 (2)	1.4 (0.7)	1.3 (0.7)	1.2 (0.6)	1.2 (0.6)	1.3 (0.6)	15/15
IPOP lia	5.3(2)	1.1 (0.4)	1.2 (0.9)	1.1 (0.8)	1.2 (0.7)	1.2 (0.7)	1.3 (0.8)	15/15
MLSL pal	64(61)	1097(1167)	∞	∞	∞	∞	∞ <i>5e4</i>	0/15
OQNLP pal	26(28)	48(49)	28(31)	∞	∞	∞	∞ <i>2289</i>	0/15
P-DCN tra	113(233)	1695(2334)	1569(2408)	1271(1796)	1175(1774)	1175(1813)	1158(1747)	12/15
P-zero tra	217(261)	2798(7738)	1284(2207)	1054(1736)	983(1620)	983(1620)	968(1595)	13/15
SMAC hut	2.4 (2)	0.88 (0.9)	3.1(4)	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	20(22)	1132(41)	1421(2315)	4706(5481)	9508(1e4)	9508(1e4)	9362(1e4)	4/15
U-zero tra	12(13)	1488(2964)	2969(3523)	4579(4679)	6279(6881)	6279(6881)	6188(6773)	6/15
fmincon pa	61(73)	1086(1236)	∞	∞	∞	∞	∞ <i>5e4</i>	0/15
fminunc pa	55(65)	∞	∞	∞	∞	∞	∞ <i>5e4</i>	0/15
ga100 hol	21(20)	11(10)	58(108)	131(172)	271(319)	271(329)	269(323)	6/15
grid100 ho	40(39)	74(83)	266(294)	1185(1293)	2287(2544)	2287(2465)	2252(2270)	1/15
grid16 hol	13(10)	97(110)	401(470)	2515(2758)	2321(2703)	2321(2345)	2299(2583)	1/15
hill hol	20(26)	117(200)	300(371)	1227(1289)	2330(2504)	2330(2584)	2294(2583)	1/15
lmmCMA aug	3.3 (2)	0.92 (1.0)	0.94 (0.8)	0.91 (0.7)	0.90 (0.6)	0.90 (0.6)	1.2 (0.9)	13/15
memPSODE v	19(14)	7.5(6)	6.5(2)	8.5(2)	9.0(2)	9.0(2)	17(12)	15/15
prcga saw	9.4(5)	17(17)	22(22)	40(65)	45(68)	45(68)	46(67)	14/15
ring100 ho	28(27)	19(11)	42(40)	173(169)	319(322)	319(345)	322(315)	6/15
ring16 hol	13(8)	104(276)	436(639)	718(846)	1075(1272)	1075(1269)	1059(1170)	2/15
simplex pa	45(39)	155(137)	648(693)	∞	∞	∞	∞ <i>5e4</i>	0/15

Table 9: 05-D, running time excess $ERT/ERT_{\text{best}} 2009$ on f_8 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_8	73	273	336	372	391	410	422	15/15
BIPOP-aCMA	4.3(2)	4.3(4)	4.6(3)	4.7(3)	4.8(3)	5.0(3)	5.2(3)	15/15
BIPOP-saAC	2.2 (0.8)	2.2 (2)	2.3 (2)	2.3 (2)	2.3 (1)	2.3 (1)	2.4 (1)	15/15
CMAES hut	3.1(1)	6.6(7)	∞	∞	∞	∞	∞	0/15
DE pal	8.0(2)	7.6(2)	17(3)	22(4)	26(4)	36(6)	46(6)	15/15
HCMA los	2.3 (2)	2.8 (3)	2.8 (3)	2.7 (2)	2.7 (2)	2.7 (2)	2.7 (2)	15/15
HMLSL pal	1.0 (0.3)	1.3 (2)	1.2 (2)	1.1 (1)	1.1 (1)	1.1 (1)	1.1 (1)	15/15
IPOP-10DDr	3.2(1.0)	4.3(2)	5.1(1)	5.3(1)	5.5(1)	5.8(1)	6.1(1)	15/15
IPOP-500 l	3.2(1.0)	4.3(2)	5.1(1)	5.3(1)	5.5(1)	5.8(1)	6.1(1)	15/15
IPOP-tany	2.7 (0.7)	3.7(1)	4.6(1)	4.9(1)	5.0(1)	5.3(1)	5.6(1)	15/15
IPOP-texp	2.6 (0.7)	4.7(2)	5.6(2)	5.7(2)	5.9(2)	6.1(2)	6.4(2)	15/15
IPOP lia	3.2(1.0)	4.3(2)	5.1(1)	5.3(1)	5.5(1)	5.8(1)	6.1(1)	15/15
MLSL pal	1.0 (0.3)	1.0 (1.0)	0.99 (0.8)	0.96 (0.7)	0.95 (0.7)	0.97 (0.6)	0.96 (0.6)	15/15
OQNLP pal	0.89 (0.4)	0.71 (0.3)	0.75 (0.2)	0.76 (0.2)	0.78 (0.2)	0.78 (0.2)	27(35)	10/15
P-DCN tra	23(24)	6797(9224)	6645(7507)	7680(6911)	9250(7238)	1.4e4(6745)	∞	0/15
P-zero tra	18(19)	2863(9155)	3230(7726)	7962(6973)	1.8e5(2e5)	1.7e5(2e5)	∞	0/15
SMAC hut	4.6(2)	∞	∞	∞	∞	∞	∞	0/15
U-DCN tra	17(16)	713(1962)	4007(4023)	1.1e4(8411)	1.9e5(2e5)	∞	∞	0/15
U-zero tra	16(9)	7820(1e4)	∞	∞	∞	∞	∞	0/15
fmincon pa	1.0 (0.3)	1.1 (1)	1.0 (0.9)	0.98 (0.8)	0.97 (0.7)	0.99 (0.7)	0.98 (0.7)	15/15
fminunc pa	1.2 (0.6)	0.90 (0.3)	0.87 (0.3)	0.87 (0.2)	0.87 (0.2)	0.88 (0.2)	0.88 (0.2)	15/15
gal00 hol	34(20)	487(915)	4864(5941)	4446(5700)	9180(9270)	∞	∞	0/15
grid100 ho	113(86)	1140(1405)	∞	∞	∞	∞	∞	0/15
grid16 hol	33(20)	631(920)	2092(2632)	4610(4859)	∞	∞	∞	0/15
hill hol	8.6(6)	721(917)	1515(1869)	9485(1e4)	∞	∞	∞	0/15
lmmCMA aug	1.6 (0.3)	1.7 (2)	1.8 (1)	1.8 (1)	1.8 (1)	1.8 (1)	1.8 (1)	15/15
memPSODE v	3.0(1)	4.1(5)	3.6(4)	3.4(4)	3.8(5)	3.7(5)	3.8(5)	15/15
prcg saw	11(4)	518(811)	9455(1e4)	8747(9719)	1.7e4(2e4)	∞	∞	0/15
ring100 ho	58(11)	141(66)	559(743)	2199(2143)	4631(5036)	∞	∞	0/15
ring16 hol	17(8)	623(917)	3002(3709)	4425(5036)	∞	∞	∞	0/15
simplex pa	8.8(5)	4.9(3)	4.7(2)	4.8(2)	4.7(2)	4.6(2)	4.8(2)	15/15

Table 10: 05-D, running time excess $ERT/ERT_{\text{best 2009}}$ on f_9 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_9	35	127	214	263	300	335	369	15/15
BIPOP-aCMA	7.0(2)	7.6(2)	6.4(2)	5.9(1)	5.6(1)	5.5(0.8)	5.4(0.8)	15/15
BIPOP-saAC	4.6(0.9)	3.8(1)	3.0 (0.8)	2.7 (0.6)	2.5 (0.6)	2.4 (0.5)	2.3 (0.4)	15/15
CMAES hut	6.1(3)	9.2(8)	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	24(10)	24(9)	30(6)	34(9)	38(10)	49(14)	57(16)	15/15
HCMA los	5.7(5)	5.4(6)	4.0(4)	3.5(3)	3.2(3)	3.0(2)	2.8 (2)	15/15
HMLSL pal	0.94 (0)	0.64 (0.1)	0.61 (0.1)	0.59 (0.0)	0.57 (0.0)	0.56 (0.0)	0.54 (0.0)	15/15
IPOP-10DDr	6.1(2)	10(10)	8.6(6)	8.0(5)	7.6(5)	7.4(4)	7.2(4)	15/15
IPOP-500 l	6.1(2)	10(10)	8.6(6)	8.0(5)	7.6(5)	7.4(4)	7.2(4)	15/15
IPOP-tany	5.2(2)	11(13)	8.7(8)	8.1(7)	7.6(6)	7.5(6)	7.4(5)	15/15
IPOP-texp	3.0(2)	8.1(4)	7.4(2)	6.9(2)	6.6(2)	6.5(1)	6.4(1)	15/15
IPOP lia	6.1(2)	10(10)	8.6(6)	8.0(5)	7.6(5)	7.4(4)	7.2(4)	15/15
MLSL pal	0.94 (0)	0.64 (0.1)	0.61 (0.1)	0.59 (0.0)	0.57 (0.0)	0.56 (0.0)	0.54 (0.0)	15/15
OQNLP pal	0.71 (0.0)	0.51 (8e-3)	0.52 (7e-3)	0.55 (0.0)	0.54 (1e-2)	0.53 (0.0)	1.3 (0.0)	15/15
P-DCN tra	446(980)	2.7e4(4e4)	1.7e4(2e4)	1.7e4(2e4)	1.9e4(2e4)	5.1e4(5e4)	2.0e5(2e5)	1/15
P-zero tra	685(1900)	3145(607)	3476(1371)	3.0e4(3e4)	2.4e5(3e5)	∞	∞ <i>5e6</i>	0/15
SMAC hut	12(8)	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	65(59)	3.1e4(4e4)	2.3e4(3e4)	2.9e4(3e4)	7.2e4(8e4)	∞	∞ <i>5e6</i>	0/15
U-zero tra	378(55)	1.4e4(2e4)	3.4e5(4e5)	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	0.94 (0)	0.64 (0.1)	0.61 (0.1)	0.59 (0.0)	0.57 (0.0)	0.56 (0.0)	0.54 (0.0)	15/15
fminunc pa	0.55 (0) ^{*4}	0.25 (0) ^{*4}	0.50 (0.0)	0.51 (0.0) ^{*3}	0.50 (0.0) ^{*2}	0.49 (0.0) ^{*3}	0.47 (0.0) ^{*1}	15/15
ga100 hol	58(23)	2015(2076)	1.6e4(2e4)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	315(218)	1.3e4(1e4)	1.7e4(2e4)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	57(42)	1.3e4(2e4)	1.6e4(2e4)	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	13(11)	4153(4150)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	2.7 (0.9)	3.4(2)	2.6 (2)	2.4 (1)	2.2 (1)	2.1 (1)	1.9 (0.9)	15/15
memPSODE v	5.9(2)	7.5(11)	4.8(7)	4.1(6)	3.8(6)	3.6(6)	3.4(5)	15/15
prcga saw	11(5)	957(744)	∞	∞	∞	∞	∞ <i>5e5</i>	0/15
ring100 ho	138(47)	1261(1940)	4949(5287)	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	30(11)	2428(2577)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	5.1(3)	3.8(2)	3.6(0.9)	3.2(0.8)	2.9 (0.7)	2.8 (0.6)	2.6 (0.5)	15/15

Table 11: 05-D, running time excess $ERT/ERT_{\text{best 2009}}$ on f_{10} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f10	349	500	574	607	626	829	880	15/15
BIPOP-aCMA	2.8 (0.6)	2.2 (0.2)	2.1 (0.2)	2.1 (0.1)	2.1 (0.2)	1.8 (0.1)	1.9 (0.1)	15/15
BIPOP-saAC	0.77 (0.1)	0.61 (0.1)	0.58 (0.1)	0.59 (0.1)	0.62 (0.1)	0.53 (0.1)	0.55 (0.1)	15/15
CMAES hut	∞	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	23(9)	26(6)	29(6)	37(4)	42(5)	44(4)	52(6)	15/15
HCMA los	1.1 (0.2)	0.81 (0.1)	0.76 (0.1)	0.75 (0.1)	0.78 (0.1)	0.64 (0.1)	0.65 (0.1)	15/15
HMSL pal	0.28 (0.1) \downarrow_4	0.23 (0.1) \downarrow_4	0.22 (0.1) \downarrow_4	0.23 (0.1) \downarrow_4	0.60 (0.2)	18(37)	104(115)	10/15
IPOP-10DDr	3.4(0.9)	3.1(0.6)	3.1(0.3)	3.1(0.3)	3.2(0.3)	2.6 (0.2)	2.7 (0.2)	15/15
IPOP-500 l	3.4(0.9)	3.1(0.6)	3.1(0.3)	3.1(0.3)	3.2(0.3)	2.6 (0.2)	2.7 (0.2)	15/15
IPOP-tany	3.4(0.9)	3.1(0.6)	2.9 (0.4)	3.0 (0.3)	3.0(0.3)	2.5 (0.3)	2.6 (0.2)	15/15
IPOP-texp	3.4(1)	3.1(0.7)	3.1(0.4)	3.1(0.3)	3.1(0.3)	2.6 (0.2)	2.6 (0.2)	15/15
IPOP lia	3.4(0.9)	3.1(0.6)	3.1(0.3)	3.1(0.3)	3.2(0.3)	2.6 (0.2)	2.7 (0.2)	15/15
MSL pal	0.28 (0.1) \downarrow_4	0.23 (0.1) \downarrow_4	0.22 (0.1) \downarrow_4	0.23 (0.1) \downarrow_4	0.60 (0.2)	16(15)	129(159)	8/15
OQNLP pal	0.38 (0.3) \downarrow_3	0.41 (0.3)	0.89 (2)	1.5 (2)	6.5(6)	120(133)	∞ <i>2e4</i>	0/15
P-DCN tra	7421(1e4)	6.6e4(8e4)	1.3e5(1e5)	1.2e5(1e5)	1.2e5(1e5)	∞	∞ <i>5e6</i>	0/15
P-zero tra	2.3e4(2e4)	1.4e5(2e5)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	∞	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	9.9e4(1e5)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	2.1e5(2e5)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	0.27 (0.1) \downarrow_4	0.22 (0.0) \downarrow_4	0.21 (0.0) \downarrow_4	0.21 (0.0) \downarrow_4	1.8 (0.3)	19(20)	150(180)	7/15
fminunc pa	0.99 (0.5)	1.0 (0.3)	1.0 (0.3)	1.1 (0.4)	1.1 (0.4)	2.4 (2)	92(121)	9/15
ga100 hol	3067(3578)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	∞	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	∞	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	1.0e4(1e4)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	0.77 (0.3)	0.67 (0.2)	0.65 (0.1)	0.65 (0.1)	0.66 (0.1)	0.54 (0.1)	0.55 (0.1)	15/15
memPSODE v	3.7(7)	3.5(6)	3.2(5)	3.5(5)	4.6(8)	7.5(9)	11(8)	15/15
prcga saw	5553(6081)	∞	∞	∞	∞	∞	∞ <i>5e5</i>	0/15
ring100 ho	1.0e4(1e4)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	∞	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	5.5(2)	4.5(2)	4.3(0.8)	4.3(0.6)	4.3(0.6)	3.3(0.4)	3.2(0.4)	15/15

Table 12: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{11} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f11	143	202	763	977	1177	1467	1673	15/15
BIPOP-aCMA	5.8(1)	5.0(0.6)	1.4 (0.2)	1.2 (0.1)	1.1 (0.1)	0.97 (0.1)	0.94 (0.1)	15/15
BIPOP-saAC	2.0 (0.3)	1.6 (0.2)	0.46 (0.1)	0.38 (0.0)	0.34 (0.0)	0.30 (0.0)	0.29 (0.0)	15/15
CMAES hut	24(28)	∞	∞	∞	∞	∞	∞ 506	0/15
DE pal	23(13)	36(13)	16(5)	17(5)	18(5)	20(6)	23(6)	15/15
HCMA los	2.6 (0.4)	2.0 (0.3)	0.56 (0.1)	0.46 (0.1)	0.40 (0.1)	0.35 (0.0)	0.34 (0.0)	15/15
HMLSL pal	0.24 (0.1) \downarrow_4	0.21 (0.1) \downarrow_4	0.07 (0.0) \downarrow_4	0.07 (0.0) \downarrow_4	1.0 (2)	76(105)	441(491)	2/15
IPOP-10DDr	7.4(4)	7.1(0.7)	2.1 (0.2)	1.8 (0.1)	1.6 (0.1)	1.4 (0.1)	1.3 (0.1)	15/15
IPOP-500 l	7.4(4)	7.1(0.7)	2.1 (0.2)	1.8 (0.1)	1.6 (0.1)	1.4 (0.1)	1.3 (0.1)	15/15
IPOP-tany	8.1(1)	7.1(0.7)	2.1 (0.2)	1.8 (0.1)	1.5 (0.1)	1.4 (0.1)	1.3 (0.1)	15/15
IPOP-texp	6.9(3)	6.7(1)	2.0 (0.3)	1.7 (0.2)	1.5 (0.1)	1.3 (0.1)	1.3 (0.1)	15/15
IPOP lia	7.4(4)	7.1(0.7)	2.1 (0.2)	1.8 (0.1)	1.6 (0.1)	1.4 (0.1)	1.3 (0.1)	15/15
MLSL pal	0.24 (0.1) \downarrow_4	0.21 (0.1) \downarrow_4	0.07 (0.0) \downarrow_4	0.07 (0.0) \downarrow_4	1.4 (2)	56(69)	868(987)	1/15
OQNLP pal	0.41 (0.1) \downarrow_4	0.95 (1)	0.53 (0.9)	2.1 (3)	4.7(2)	142(162)	∞ 3e4	0/15
P-DCN tra	606(502)	896(629)	312(165)	319(206)	619(310)	1.2e4(1e4)	∞ 5e6	0/15
P-zero tra	781(856)	1264(814)	479(270)	474(174)	797(227)	5.1e4(6e4)	∞ 5e6	0/15
SMAC hut	15(17)	∞	∞	∞	∞	∞	∞ 500	0/15
U-DCN tra	239(214)	2586(3033)	8587(8291)	∞	∞	∞	∞ 5e6	0/15
U-zero tra	447(538)	2846(3800)	9233(9832)	∞	∞	∞	∞ 5e6	0/15
fmincon pa	0.24 (0.1) \downarrow_4	0.22 (0.1) \downarrow_4	0.07 (0.0) \downarrow_4	0.07 (0.0) \downarrow_4	1.1 (3)	59(73)	∞ 1e5	0/15
fminunc pa	0.90 (0.4)	1.7 (2)	1.5 (1)	2.8 (4)	19(24)	288(359)	∞ 1e5	0/15
ga100 hol	202(93)	1652(1639)	∞	∞	∞	∞	∞ 2e5	0/15
grid100 ho	2799(3094)	∞	∞	∞	∞	∞	∞ 2e5	0/15
grid16 hol	752(561)	4204(4469)	∞	∞	∞	∞	∞ 2e5	0/15
hill hol	197(192)	845(865)	4823(5080)	∞	∞	∞	∞ 2e5	0/15
lmmCMA aug	1.9 (0.6)	1.8 (0.5)	0.54 (0.1)	0.45 (0.1)	0.38 (0.1)	0.34 (0.0)	0.32 (0.0)	15/15
memPSODE v	1.4 (0.2)	7.0(11)	3.5(3)	3.7(2)	3.4(2)	4.1(0.6)	5.4(2)	15/15
prcga saw	1331(1851)	∞	∞	∞	∞	∞	∞ 3e5	0/15
ring100 ho	188(220)	3942(4394)	4713(5244)	∞	∞	∞	∞ 2e5	0/15
ring16 hol	295(408)	1715(1858)	∞	∞	∞	∞	∞ 2e5	0/15
simplex pa	8.5(6)	11(5)	4.0(1)	3.1(1)	2.8 (2)	2.3 (1)	2.1 (1)	15/15

Table 13: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{12} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f12	108	268	371	413	461	1303	1494	15/15
BIPOP-aCMA	7.0(4)	4.7(3)	5.0(3)	5.1(3)	5.1(3)	2.3 (1)	2.3 (1)	15/15
BIPOP-saAC	3.0(0.9)	1.9 (2)	2.2 (3)	2.3 (3)	2.4 (3)	1.2 (1)	1.3 (1)	15/15
CMAES hut	17(16)	28(30)	∞	∞	∞	∞	∞ 506	0/15
DE pal	61(18)	50(20)	70(47)	84(60)	94(58)	58(40)	64(44)	11/15
HCMA los	4.7(6)	4.4(0.6)	5.9(11)	5.7(10)	5.9(12)	6.1(7)	5.7(6)	15/15
HMLSL pal	1.3 (0.4)	0.94 (0.6)	0.89 (0.7)	0.91 (0.7)	0.93 (0.8)	3.3(2)	30(34)	13/15
IPOP-10DDr	7.9(5)	5.9(3)	6.0(3)	6.2(4)	6.3(4)	2.8 (2)	2.8 (2)	15/15
IPOP-500 l	7.9(5)	5.9(3)	6.0(3)	6.2(4)	6.3(4)	2.8 (2)	2.8 (2)	15/15
IPOP-tany	6.2(4)	7.1(5)	7.5(7)	8.2(5)	8.2(5)	3.7(2)	3.7(2)	15/15
IPOP-texp	11(10)	8.7(9)	8.4(8)	8.6(8)	8.5(8)	3.7(3)	3.7(3)	15/15
IPOP lia	7.9(5)	5.9(3)	6.0(3)	6.2(4)	6.3(4)	2.8 (2)	2.8 (2)	15/15
MLSL pal	1.3 (0.4)	0.94 (0.6)	0.89 (0.7)	0.91 (0.7)	0.93 (0.8)	1.5 (2)	38(58)	9/15
OQNLP pal	1.2 (1)	0.95 (0.8)	1.2 (1)	2.3 (3)	20(27)	21(32)	328(373)	1/15
P-DCN tra	1.2e4(2e4)	2.8e4(4e4)	1.9e5(2e5)	∞	∞	∞	∞ 5e6	0/15
P-zero tra	9.2e4(1e5)	1.2e5(1e5)	8.8e4(1e5)	∞	∞	∞	∞ 5e6	0/15
SMAC hut	∞	∞	∞	∞	∞	∞	∞ 500	0/15
U-DCN tra	1.7e4(2e4)	3.7e4(5e4)	8.8e4(1e5)	∞	∞	∞	∞ 5e6	0/15
U-zero tra	2.4e4(5e4)	3.8e4(5e4)	8.9e4(1e5)	∞	∞	∞	∞ 5e6	0/15
fmincon pa	1.3 (0.4)	0.95 (0.5)	0.90 (0.7)	0.91 (0.7)	0.93 (0.7)	1.0 (0.9)	29(47)	10/15
fminunc pa	1.0 (1.0)	1.1 (1.0)	1.2 (0.9)	1.2 (0.8)	1.5 (1)	2.4 (4)	80(108)	6/15
ga100 hol	1059(1267)	2353(2457)	9857(1e4)	∞	∞	∞	∞ 2e5	0/15
grid100 ho	3812(3466)	∞	∞	∞	∞	∞	∞ 2e5	0/15
grid16 hol	834(1196)	6623(7417)	∞	∞	∞	∞	∞ 2e5	0/15
hill hol	4969(5942)	6174(7468)	9654(1e4)	∞	∞	∞	∞ 2e5	0/15
lmmCMA aug	1.5 (0.8)	1.4 (1)	1.4 (2)	1.6 (2)	1.7 (2)	0.92 (0.8)	0.95 (0.8)	14/15
memPSODE v	7.4(12)	4.8(5)	5.2(7)	5.3(6)	5.0(6)	7.7(6)	11(11)	15/15
prcga saw	214(615)	296(485)	1403(1608)	2982(3613)	4280(4998)	∞	∞ 3e5	0/15
ring100 ho	1018(676)	1999(1896)	∞	∞	∞	∞	∞ 2e5	0/15
ring16 hol	603(1155)	1172(1372)	4723(5059)	∞	∞	∞	∞ 2e5	0/15
simplex pa	11(7)	6.7(3)	8.3(4)	7.9(3)	8.7(11)	4.6(7)	4.2(6)	15/15

Table 14: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{13} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f13	132	195	250	319	1310	1752	2255	15/15
BIPOP-aCMA	3.4(1)	3.9(2)	4.2(0.8)	3.9(0.6)	1.1 (0.2)	1.1 (0.1)	1.1 (0.2)	15/15
BIPOP-saAC	1.4 (0.5)	1.3 (0.4)	1.3 (0.4)	1.2 (0.3)	0.36 (0.1)	0.37 (0.1)	0.34 (0.1)	15/15
CMAES hut	3.4(2)	13(13)	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	11(4)	23(10)	43(15)	57(18)	20(7)	26(7)	28(5)	15/15
HCMA los	1.6 (1)	1.6 (0.4)	1.7 (0.6)	1.6 (0.5)	0.45 (0.1)	0.42 (0.1)	0.38 (0.1)	15/15
HMLSL pal	0.74 (0.1) \downarrow_2	0.76 (0.1)	0.80 (0.1)	0.78 (0.1)	2.0 (3)	21(22)	164(155)	4/15
IPOP-10DDr	4.7(4)	5.8(4)	5.7(3)	5.3(2)	1.5 (0.7)	1.9 (0.8)	1.9 (0.8)	15/15
IPOP-500 l	4.7(4)	5.8(4)	5.7(3)	5.3(2)	1.5 (0.7)	1.9 (0.8)	1.9 (0.8)	15/15
IPOP-tany	3.9(3)	5.5(3)	5.9(2)	5.9(2)	1.6 (0.4)	1.7 (0.2)	1.7 (0.3)	15/15
IPOP-texp	3.7(3)	5.4(3)	6.5(2)	5.9(1)	1.6 (0.3)	1.7 (0.3)	1.7 (0.4)	15/15
IPOP lia	4.7(4)	5.8(4)	5.7(3)	5.3(2)	1.5 (0.7)	1.9 (0.8)	1.9 (0.8)	15/15
MLSL pal	0.74 (0.1) \downarrow_2	0.76 (0.1)	0.80 (0.1)	0.78 (0.1)	4.2(0.5)	50(60)	∞ <i>7e4</i>	0/15
OQNLP pal	0.95 (0.4)	0.89 (0.2)	0.83 (0.2)	3.1(2)	8.4(12)	∞	∞ <i>3e4</i>	0/15
P-DCN tra	3.4e4(4e4)	3.6e5(4e5)	2.8e5(3e5)	∞	∞	∞	∞ <i>5e6</i>	0/15
P-zero tra	7.6e4(9e4)	1.7e5(2e5)	2.8e5(3e5)	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	4.2(4)	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	1.4e4(2e4)	5.1e4(6e4)	2.8e5(4e5)	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	2.5e4(4e4)	1.7e5(2e5)	2.8e5(3e5)	2.3e5(3e5)	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	0.74 (0.1) \downarrow_2	0.76 (0.1)	0.80 (0.1)	0.77 (0.1)	4.1(1)	61(77)	∞ <i>7e4</i>	0/15
fminunc pa	0.92 (0.2)	1(0.2)	0.98 (0.1)	0.96 (0.1)	4.9(4)	167(198)	∞ <i>7e4</i>	0/15
ga100 hol	1720(2828)	8953(1e4)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	8027(9230)	9305(1e4)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	1004(1884)	1.8e4(2e4)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	2189(2842)	5715(6335)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	1.3 (0.4)	1.8 (0.7)	1.7 (0.4)	1.8 (0.6)	0.50 (0.1)	0.49 (0.1)	0.57 (0.1)	14/15
memPSODE v	3.8(9)	3.0(9)	2.5 (7)	2.1 (5)	2.9 (0.5)	2.6 (0.5)	2.1 (0.4)	15/15
prcga saw	118(3)	697(1004)	2369(2698)	2342(2486)	1742(1819)	∞	∞ <i>3e5</i>	0/15
ring100 ho	152(52)	756(367)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	729(963)	5313(6422)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	15(15)	17(15)	17(14)	19(15)	5.0(4)	5.1(4)	10(10)	14/15

Table 15: 05-D, running time excess $ERT/ERT_{\text{best 2009}}$ on f_{14} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
<i>f14</i>	10	41	58	90	139	251	476	15/15
BIPOP-aCMA	2.9 (4)	3.4(1)	4.4(1)	4.4(1)	4.3(0.8)	4.3(0.8)	3.3 (0.4)	15/15
BIPOP-saAC	1.5 (1)	2.5 (0.8)	3.0 (0.8)	2.6 (0.6)	2.1 (0.5)	1.8 (0.3)	1.3 (0.1)	15/15
CMAES hut	1.7 (2)	2.3 (1)	3.9(1)	3.8(0.7)	11(9)	∞	∞ <i>506</i>	0/15
DE pal	2.2 (2)	6.2(3)	11(3)	12(2)	16(7)	36(12)	46(9)	15/15
HCMA los	1.6 (0.6)	1.5 (2)	2.6 (2)	3.4(0.6)	2.7 (0.3)	2.2 (0.3)	1.5 (0.2)	15/15
HMLSL pal	0.68 (0.4)	0.53 (0.2)	0.64 (0.2)	0.66 (0.2)	0.67 (0.2)	0.72 (0.1)	72(24)	15/15
IPOP-10DDr	1.2 (1)	2.4 (1)	3.7(1.0)	4.1(0.7)	4.7(0.9)	5.7(0.4)	4.6(0.4)	15/15
IPOP-500 l	1.2 (1)	2.4 (1)	3.7(1.0)	4.1(0.7)	4.7(0.9)	5.7(0.4)	4.6(0.4)	15/15
IPOP-tany	0.94 (1)	2.6 (1)	3.9(2)	4.3(0.6)	4.5(1)	5.5(0.7)	4.2(0.4)	15/15
IPOP-texp	0.93 (1)	1.9 (1)	3.0 (1)	3.7(1)	3.8(0.6)	4.9(0.7)	4.0(0.3)	15/15
IPOP lia	1.2 (1)	2.4 (1)	3.7(1.0)	4.1(0.7)	4.7(0.9)	5.7(0.4)	4.6(0.4)	15/15
MLSL pal	0.68 (0.4)	0.53 (0.2)	0.64 (0.2)	0.66 (0.2)	0.67 (0.2)	0.72 (0.1)	793(1019)	2/15
OQNLP pal	1.4 (0.9)	0.94 (0.3)	1.0 (0.2)	0.95 (0.3)	0.80 (0.2)	7.0(9)	∞ <i>2e4</i>	0/15
P-DCN tra	2.0 (2)	9.3(4)	10(3)	10(4)	113(191)	5.4e4(5e4)	∞ <i>5e6</i>	0/15
P-zero tra	3.1(4)	11(7)	11(5)	11(5)	80(54)	∞	∞ <i>5e6</i>	0/15
SMAC hut	0.62 (0.6)	2.6 (2)	11(8)	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	1.2 (0.7)	6.8(5)	23(12)	92(100)	1269(1067)	∞	∞ <i>5e6</i>	0/15
U-zero tra	1.5 (2)	3.6(2)	11(6)	767(834)	2.6e5(3e5)	∞	∞ <i>5e6</i>	0/15
fmincon pa	0.68 (0.4)	0.53 (0.2)	0.64 (0.2)	0.66 (0.2)	0.67 (0.2)	0.72 (0.1)	797(976)	2/15
fminunc pa	0.71 (0.6)	0.85 (0.6)	1.1 (0.4)	1.0 (0.3)	0.89 (0.3)	0.84 (0.2)	1711(1920)	1/15
gal00 hol	1.6 (1)	14(9)	37(11)	72(33)	3523(3609)	∞	∞ <i>2e5</i>	0/15
grid100 ho	1.9 (2)	54(39)	117(54)	686(560)	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	0.81 (0.7)	12(7)	24(13)	456(709)	∞	∞	∞ <i>2e5</i>	0/15
hill hol	1.9 (2)	2.2 (1)	7.3(6)	219(304)	2.5e4(3e4)	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	0.62 (0.6)	1.5 (0.7)	1.6 (0.5)	1.8 (0.5)	1.9 (0.3)	1.8 (0.2)	1.4 (0.1)	15/15
memPSODE v	2.6 (2)	2.9 (0.4)	2.4 (0.2)	1.8 (0.2)	1.4 (0.1)	2.2 (0.1)	23(2)	15/15
prcga saw	1.1 (1)	6.8(3)	15(3)	52(4)	580(784)	6773(7341)	∞ <i>3e5</i>	0/15
ring100 ho	1.7 (1)	27(12)	72(24)	156(41)	2277(2707)	∞	∞ <i>2e5</i>	0/15
ring16 hol	1.8 (3)	8.3(3)	16(7)	117(45)	2.7e4(3e4)	∞	∞ <i>2e5</i>	0/15
simplex pa	6.4(4)	15(11)	17(6)	12(3)	8.9(2)	5.6(1)	3.8 (1)	15/15

Table 16: 05-D, running time excess $ERT/ERT_{\text{best 2009}}$ on f_{15} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f15	511	9310	19369	19743	20073	20769	21359	14/15
BIPOP-aCMA	1.6 (2)	0.88 (0.9)	1.1 (0.7)	1.1 (0.7)	1.1 (0.7)	1.1 (0.7)	1.1 (0.7)	15/15
BIPOP-saAC	1.6 (2)	0.97 (0.4)	0.98 (0.9)	0.97 (0.8)	0.96 (0.8)	0.94 (0.8)	0.93 (0.8)	15/15
CMAES hut	1.9 (2)	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	4.5(3)	6.5(4)	5.9(4)	7.9(8)	7.9(6)	7.7(7)	7.5(7)	8/15
HCMA los	1.7 (2)	0.96 (1)	0.96 (0.7)	0.95 (0.7)	0.94 (0.7)	0.92 (0.6)	0.90 (0.6)	15/15
HMLSL pal	2.3 (1)	5.5(6)	10(11)	10(11)	10(11)	10(10)	10(11)	6/15
IPOP-10DDr	1.5 (0.6)	1.1 (0.9)	0.85 (0.4)	0.85 (0.4)	0.85 (0.4)	0.85 (0.4)	0.86 (0.4)	15/15
IPOP-500 l	1.5 (0.6)	1.1 (0.9)	0.86 (0.4)	0.86 (0.4)	0.86 (0.4)	0.87 (0.4)	0.87 (0.4)	15/15
IPOP-tany	1.8 (2)	0.76 (0.6)	0.80 (0.5)	0.80 (0.6)	0.80 (0.6)	0.80 (0.6)	0.81 (0.5)	15/15
IPOP-texp	2.1 (2)	0.94 (0.9)	0.76 (0.8)	0.77 (0.8)	0.78 (0.7)	0.79 (0.7)	0.80 (0.7)	15/15
IPOP lia	1.5 (0.6)	1.1 (0.9)	0.86 (0.4)	0.86 (0.4)	0.86 (0.4)	0.87 (0.4)	0.87 (0.4)	15/15
MLSL pal	10(7)	∞	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
OQNLP pal	12(13)	∞	∞	∞	∞	∞	∞ <i>1e4</i>	0/15
P-DCN tra	6.4e4(8e4)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
P-zero tra	4.5e4(5e4)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	∞	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	516(62)	2163(2684)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	1553(2758)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	8.2(9)	45(49)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
fminunc pa	8.8(12)	∞	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
ga100 hol	9.2(5)	122(120)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	335(358)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	131(245)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	142(246)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	1.2 (1.0)	1.1 (1)	1.1 (1)	2.1 (2)	2.1 (2)	2.0 (2)	2.0 (2)	1/15
memPSODE v	14(15)	4.4(4)	5.6(4)	5.5(4)	5.4(4)	5.2(4)	5.1(4)	15/15
prcga saw	23(24)	157(167)	∞	∞	∞	∞	∞ <i>3e5</i>	0/15
ring100 ho	19(5)	198(211)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	44(74)	383(450)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	20(21)	122(136)	∞	∞	∞	∞	∞ <i>8e4</i>	0/15

Table 17: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{16} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f16	120	612	2662	10163	10449	11644	12095	15/15
BIPOP-aCMA	4.6(10)	3.3(4)	1.8 (2)	0.67 (0.7)	0.69 (0.8)	0.66 (0.7)	0.65 (0.7)	15/15
BIPOP-saAC	2.1 (2)	3.9(4)	2.0 (2)	0.93 (0.8)	0.95 (0.8)	0.93 (0.7)	0.96 (0.7)	15/15
CMAES hut	2.5 (3)	6.1(6)	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	3.3(3)	32(28)	183(182)	∞	∞	∞	∞ <i>1e5</i>	0/15
HCMA los	2.9 (2)	3.6(4)	2.3 (2)	0.67 (0.5)	0.70 (0.6)	0.66 (0.5)	0.82 (0.8)	15/15
HMLSL pal	4.4(2)	45(30)	530(601)	∞	∞	∞	∞ <i>1e5</i>	0/15
IPOP-10DDr	2.0 (2)	2.2 (3)	1.1 (1)	0.48 (0.5)	0.58 (0.5)	0.67 (0.3)	0.67 (0.3)	15/15
IPOP-500 l	2.0 (2)	2.2 (3)	1.1 (1)	0.48 (0.5)	0.58 (0.5)	0.67 (0.3)	0.67 (0.3)	15/15
IPOP-tany	1.9 (1)	2.1 (3)	0.90 (0.6)	0.54 (0.7)	0.62 (0.7)	0.59 (0.6)	0.59 (0.6)	15/15
IPOP-texp	1.1 (1)	1.5 (2)	1.2 (1)	0.56 (0.4)	0.70 (0.3)	0.68 (0.3)	0.70 (0.3)	15/15
IPOP lia	2.0 (2)	2.2 (3)	1.1 (1)	0.48 (0.5)	0.58 (0.5)	0.67 (0.3)	0.67 (0.3)	15/15
MLSL pal	4.7(3)	70(54)	∞	∞	∞	∞	∞ <i>9e4</i>	0/15
OQNLP pal	12(19)	243(285)	118(128)	∞	∞	∞	∞ <i>2e4</i>	0/15
P-DCN tra	1.1 (0.7)	1846(4085)	7522(8926)	3329(3690)	3290(3174)	∞	∞ <i>5e6</i>	0/15
P-zero tra	5.5(16)	7997(1e4)	1.2e4(2e4)	6896(7872)	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	0.42 (0.3) _{↓2}	3.8(4)	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	1.7 (1.0)	90(82)	1913(2389)	3199(3936)	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	1.3 (0.9)	600(1235)	2030(2326)	1490(1752)	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	4.1(2)	61(53)	495(554)	∞	∞	∞	∞ <i>9e4</i>	0/15
fminunc pa	12(12)	154(167)	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
ga100 hol	3.2(3)	75(206)	119(154)	167(181)	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	2.6 (2)	185(243)	641(750)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	2.1 (3)	98(206)	387(469)	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	2.9 (2)	373(612)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	2.0 (2)	2.1 (2)	1.8 (2)	0.70 (0.6)	0.92 (1.0)	1.1 (1)	1.1 (1)	3/15
memPSODE v	3.0(2)	32(31)	28(12)	13(13)	31(17)	29(15)	95(121)	12/15
prcga saw	3.0(2)	40(27)	46(66)	34(43)	139(159)	∞	∞ <i>3e5</i>	0/15
ring100 ho	3.1(4)	23(19)	65(59)	169(196)	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	1.5 (1.0)	6.4(3)	117(151)	346(418)	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	6.3(1)	20(18)	44(38)	145(164)	∞	∞	∞ <i>1e5</i>	0/15

Table 18: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{17} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f17	5.2	215	899	2861	3669	6351	7934	15/15
BIPOP-aCMA	5.5(6)	1.1 (0.5)	1.4 (2)	0.80 (0.6)	0.88 (0.5)	0.94 (0.4)	1.0 (0.4)	15/15
BIPOP-saAC	4.9(3)	2.1 (0.9)	1.7 (2)	0.97 (0.6)	1.00 (0.4)	1.3 (0.7)	1.7 (1)	15/15
CMAES hut	4.1(6)	0.92 (0.4)	0.73 (0.6)	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	5.4(5)	2.6 (1)	2.3 (0.9)	1.4 (0.6)	1.7 (0.6)	3.1(0.9)	3.2(0.9)	14/15
HCMA los	2.2 (2)	1.4 (0.4)	1.4 (2)	0.88 (0.6)	0.91 (0.5)	1.5 (0.6)	1.7 (1)	15/15
HMLSL pal	26(34)	11(8)	8.2(8)	4.9(3)	5.3(2)	4.6(2)	6.9(6)	13/15
IPOP-10DDr	3.2(3)	0.79 (0.2)	0.77 (0.2)	0.48 (0.6)	0.75 (0.5)	1.1 (0.4)	1.3 (0.4)	15/15
IPOP-500 l	3.2(3)	0.79 (0.2)	0.77 (0.2)	0.48 (0.6)	0.75 (0.5)	1.1 (0.4)	1.3 (0.4)	15/15
IPOP-tany	3.6(6)	1.1 (0.6)	1.1 (2)	0.74 (0.6)	0.71 (0.5)	0.83 (0.7)	0.93 (0.6)	15/15
IPOP-texp	47(7)	3.0 (7)	2.8 (6)	1.2 (2)	1.2 (2)	1.1 (0.7)	1.1 (0.6)	15/15
IPOP lia	3.2(3)	0.79 (0.2)	0.77 (0.2)	0.48 (0.6)	0.75 (0.5)	1.1 (0.4)	1.3 (0.4)	15/15
MLSL pal	24(35)	125(137)	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
OQNLP pal	15(19)	134(163)	∞	∞	∞	∞	∞ <i>2e4</i>	0/15
P-DCN tra	4.3(4)	4.7e4(6e4)	7.8e4(9e4)	∞	∞	∞	∞ <i>5e6</i>	0/15
P-zero tra	5.6(8)	3.3e4(5e4)	2.3e4(3e4)	1.2e4(1e4)	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	2.5 (4)	3.3(3)	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	4.1(4)	6.0(9)	5087(8341)	2.5e4(3e4)	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	2.6 (2)	33(56)	4877(6051)	2.5e4(3e4)	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	20(25)	172(167)	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
fminunc pa	11(16)	25(21)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
ga100 hol	3.5(6)	6.9(2)	32(9)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	3.7(3)	29(18)	836(980)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	4.2(6)	101(69)	167(214)	595(655)	∞	∞	∞ <i>2e5</i>	0/15
hill hol	39(19)	411(584)	1148(1390)	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	1.7 (2)	0.51 (0.3)	0.48 (0.6)	0.47 (0.3)	0.65 (0.6)	1.2 (1)	2.6 (3)	2/15
memPSODE v	6.9(4)	17(20)	36(13)	22(35)	27(33)	23(19)	104(111)	15/15
prcga saw	1.9 (2)	2.9 (2)	7.2(10)	23(30)	64(77)	78(87)	77(76)	6/15
ring100 ho	3.8(6)	16(3)	37(22)	145(157)	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	5.9(8)	3.7(2)	117(141)	1277(1398)	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	63(71)	129(110)	∞	∞	∞	∞	∞ <i>8e4</i>	0/15

Table 19: 05-D, running time excess $\text{ERT}/\text{ERT}_{\text{best } 2009}$ on f_{18} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f18	103	378	3968	8451	9280	10905	12469	15/15
BIPOP-aCMA	1.3 (0.6)	1.0 (0.3)	0.55 (0.5)	0.45 (0.4)	0.70 (0.3)	0.96 (1.0)	0.94 (0.9)	15/15
BIPOP-saAC	1.4 (0.8)	3.2(5)	0.77 (0.5)	0.66 (0.3)	0.70 (0.3)	0.98 (0.7)	1.0 (0.7)	15/15
CMAES hut	1.3 (0.6)	0.94 (0.3)	0.94 (1.0)	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	1.9 (1.0)	4.9(3)	1.5 (0.8)	1.6 (0.5)	2.3 (0.6)	4.1(1)	5.3(4)	13/15
HCMA los	1.3 (1)	2.1 (0.9)	0.74 (0.5)	0.61 (0.4)	0.69 (0.3)	0.94 (0.3)	0.96 (0.6)	15/15
HMLSL pal	10(8)	10(7)	5.1(3)	4.2(1)	5.2(1)	6.9(2)	14(12)	8/15
IPOP-10DDr	1.1 (0.4)	1.8 (0.3)	0.56 (0.5)	0.84 (0.5)	1.0 (0.3)	0.97 (0.3)	1.0 (0.1)	15/15
IPOP-500 l	1.1 (0.4)	1.8 (0.3)	0.56 (0.5)	0.84 (0.5)	1.0 (0.3)	0.97 (0.3)	1.0 (0.1)	15/15
IPOP-tany	0.95 (0.4)	1.8 (0.7)	1.2 (1)	0.76 (0.6)	1.0 (0.7)	1.1 (0.7)	1.0 (0.6)	15/15
IPOP-texp	1.3 (0.8)	2.8 (5)	0.81 (0.6)	0.76 (0.6)	0.88 (0.4)	0.90 (0.4)	0.98 (0.4)	15/15
IPOP lia	1.1 (0.4)	1.8 (0.3)	0.56 (0.5)	0.84 (0.5)	1.0 (0.3)	0.97 (0.3)	1.0 (0.1)	15/15
MLSL pal	20(36)	1206(1498)	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
OQNLP pal	14(27)	190(209)	∞	∞	∞	∞	∞ <i>2e4</i>	0/15
P-DCN tra	193(272)	2.9e4(3e4)	8439(9400)	∞	∞	∞	∞ <i>5e6</i>	0/15
P-zero tra	933(2547)	4.0e4(5e4)	1.8e4(2e4)	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	1.7 (2)	19(21)	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	2.5 (3)	6288(6810)	8405(9243)	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	2.1 (2)	7032(1e4)	8805(9826)	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	16(17)	960(836)	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
fminunc pa	11(14)	412(454)	∞	∞	∞	∞	∞ <i>7e4</i>	0/15
ga100 hol	5.4(4)	14(9)	116(127)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	16(14)	979(1023)	921(1008)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	8.5(12)	462(661)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	36(19)	454(661)	415(504)	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	0.52 (0.3)	0.53 (0.1)* ²	0.38 (0.2)	0.43 (0.4)	1.4 (1)	3.8(4)	∞ <i>2805</i>	0/15
memPSODE v	8.9(6)	30(31)	40(87)	41(53)	41(49)	44(46)	308(341)	7/15
prcga saw	2.5 (3)	3.4(2)	23(30)	48(64)	205(247)	∞	∞ <i>3e5</i>	0/15
ring100 ho	7.9(4)	32(15)	78(67)	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	3.6(3)	453(668)	273(311)	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	25(24)	754(775)	∞	∞	∞	∞	∞ <i>8e4</i>	0/15

Table 20: 05-D, running time excess $\text{ERT}/\text{ERT}_{\text{best } 2009}$ on f_{19} , in *italics* is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f19	1	1	242	1.0e5	1.2e5	1.2e5	1.2e5	15/15
BIPOP-aCMA	21(12)	850(1002)	139(107)	1.3 (1)	1.4 (1)	1.4 (1)	1.4 (1)	15/15
BIPOP-saAC	20(23)	1590(994)	76(97)	1.2 (1)	1.2 (1)	1.2 (1)	1.2 (1)	15/15
CMAES hut	14(18)	2283(2530)	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	34(28)	3306(1883)	1087(1102)	∞	∞	∞	∞ <i>1e5</i>	0/15
HCMA los	15(6)	1195(1448)	99(104)	0.90 (1)	0.80 (0.9)	0.86 (0.9)	0.86 (0.9)	15/15
HMLSL pal	1 (0)	1 (0)	0.17 (0.0)	14(16)	13(15)	12(13)	12(13)	1/15
IPOP-10DDr	13(14)	1466(1310)	519(658)	4.0(4)	4.0(3)	4.0(3)	4.0(3)	15/15
IPOP-500 l	13(14)	1466(1310)	483(576)	2.4 (2)	2.4 (2)	2.4 (2)	2.4 (2)	15/15
IPOP-tany	13(16)	2343(3986)	391(388)	2.8 (3)	3.9(5)	3.9(5)	3.9(5)	15/15
IPOP-texp	3.5(2)	1812(2224)	746(669)	2.9 (2)	3.7(4)	3.7(4)	3.7(4)	15/15
IPOP lia	13(14)	1466(1310)	483(576)	2.3 (2)	2.4 (2)	2.4 (2)	2.4 (2)	15/15
MLSL pal	1 (0)	1 (0)	0.17 (0.0)	∞	∞	∞	∞ <i>1e5</i>	0/15
OQNLP pal	1 (0)	1 (0)	0.09 (0) ^{*4}	0.30 (0.4)	3.5(4)	3.6(4)	∞ <i>3e4</i>	0/15
P-DCN tra	44(40)	5.0e5(9e5)	6.5e4(7e4)	679(763)	619(664)	618(650)	∞ <i>5e6</i>	0/15
P-zero tra	27(16)	2.2e6(3e6)	3.1e5(3e5)	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	1 (0)	1 (0)	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	32(30)	1.3e4(1e4)	4.9e4(6e4)	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	27(20)	7251(6858)	3.2e4(4e4)	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	1 (0)	1 (0)	0.17 (0.0)	∞	∞	∞	∞ <i>1e5</i>	0/15
fminunc pa	1 (0)	1 (0)	0.13 (0.0)	∞	∞	∞	∞ <i>8e4</i>	0/15
ga100 hol	41(37)	3511(2624)	1121(1103)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	39(34)	4.8e4(1e5)	1.5e4(2e4)	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	50(50)	1.6e4(2e4)	4684(4938)	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	42(32)	1.1e4(1e4)	6883(7642)	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	1 (0)	1 (0)	56(58)	∞	∞	∞	∞ <i>2805</i>	0/15
memPSODE v	60(24)	7494(7112)	154(80)	3.1(2)	13(13)	13(13)	16(17)	10/15
prcga saw	14(12)	502(302)	55(5)	∞	∞	∞	∞ <i>3e5</i>	0/15
ring100 ho	49(55)	6741(5378)	3410(4030)	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	31(24)	5321(5646)	3361(3431)	34(41)	29(33)	29(36)	∞ <i>2e5</i>	0/15
simplex pa	1 (0)	1 (0)	0.18 (0.0)	∞	∞	∞	∞ <i>1e5</i>	0/15

Table 21: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{20} , in *italics* is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_{20}	16	851	38111	51362	54470	54861	55313	14/15
BIPOP-aCMA	4.1(3)	7.6(9)	2.7 (1)	2.0 (1.0)	2.0 (0.9)	2.0 (0.9)	2.0 (0.9)	15/15
BIPOP-saAC	3.8(3)	5.5(7)	1.6 (1)	1.2 (0.9)	1.2 (0.8)	1.2 (0.8)	1.3 (0.9)	15/15
CMAES hut	4.2(3)	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	7.7(4)	2.3 (2)	2.4 (4)	1.8 (3)	1.7 (3)	1.7 (3)	1.7 (3)	8/15
HCMA los	0.88 (0.2)	5.2(7)	1.6 (1)	1.2 (0.8)	1.1 (0.8)	1.1 (0.8)	1.2 (0.7)	15/15
HMLSL pal	1.4 (0)	2.3 (1)	4.1(5)	3.0(4)	2.9 (4)	2.8 (4)	2.8 (4)	6/15
IPOP-10DDr	3.4(1)	12(11)	6.2(5)	4.7(4)	4.4(4)	4.4(4)	4.4(4)	15/15
IPOP-500 l	3.4(1)	12(11)	2.1 (3)	1.6 (2)	1.5 (2)	1.5 (2)	1.5 (2)	15/15
IPOP-tany	3.0 (2)	12(10)	5.0(5)	5.8(8)	5.5(7)	5.5(7)	5.4(7)	15/15
IPOP-texp	1.6 (0.6)	17(19)	7.1(6)	5.3(5)	5.0(4)	5.0(4)	5.0(4)	15/15
IPOP lia	3.4(1)	12(11)	1.7 (2)	1.3 (1)	1.3 (1)	1.3 (1)	1.3 (1)	15/15
MLSL pal	1.4 (0)	7.2(10)	21(24)	16(17)	15(17)	15(16)	15(16)	1/15
OQNLP pal	1.2 (0)	5.8(7)	3.5(4)	2.6 (3)	2.4 (3)	2.4 (3)	2.4 (3)	1/15
P-DCN tra	8.6(8)	336(965)	1837(2099)	1363(1533)	1285(1606)	1276(1413)	1266(1446)	1/15
P-zero tra	15(10)	371(909)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	0.77 (0.3)	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	4.5(3)	5.6(8)	367(398)	272(344)	257(324)	255(318)	261(316)	4/15
U-zero tra	4.0(2)	17(29)	527(655)	391(535)	369(459)	371(455)	390(460)	3/15
fmincon pa	1.4 (0)	6.4(9)	10(12)	7.7(9)	7.3(8)	7.2(8)	7.2(8)	2/15
fminunc pa	0.81 (0)	4.6(4)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
ga100 hol	18(12)	4.1 (1)	10(13)	7.6(10)	7.6(10)	66(73)	∞ <i>2e5</i>	0/15
grid100 ho	41(44)	14(7)	14(17)	15(15)	68(69)	∞	∞ <i>2e5</i>	0/15
grid16 hol	13(8)	8.1(3)	8.7(12)	7.1(8)	7.2(7)	∞	∞ <i>2e5</i>	0/15
hill hol	5.7(4)	4.4(8)	18(23)	14(17)	13(18)	16(16)	∞ <i>2e5</i>	0/15
lmmCMA aug	1.8 (1)	15(16)	∞	∞	∞	∞	∞ <i>2814</i>	0/15
memPSODE v	5.7(2)	3.6 (5)	5.5(8)	4.1(6)	3.9(5)	3.9(5)	4.2(5)	15/15
prcga saw	4.9(4)	25(44)	44(48)	33(35)	31(35)	31(35)	31(34)	3/15
ring100 ho	32(17)	7.4(2)	1.4 (2)	1.4 (1)	2.1 (1)	22(23)	∞ <i>2e5</i>	0/15
ring16 hol	8.5(6)	3.3 (0.5)	10(13)	7.7(10)	7.7(9)	21(23)	∞ <i>2e5</i>	0/15
simplex pa	8.3(4)	5.4(3)	27(29)	20(24)	19(21)	19(20)	19(20)	1/15

Table 22: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{21} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_{21}	41	1157	1674	1692	1705	1729	1757	14/15
BIPOP-aCMA	2.2 (2)	5.8(8)	8.0(11)	8.1(11)	8.0(11)	8.0(11)	8.0(11)	15/15
BIPOP-saAC	2.7 (2)	1.5 (1)	4.1(7)	4.0(7)	4.0(7)	4.0(7)	3.9(7)	15/15
CMAES hut	2.2 (2)	1.1 (1)	2.1 (2)	2.1 (2)	2.1 (2)	2.1 (2)	4.3(4)	1/15
DE pal	2.5 (2)	1.9 (2)	23(31)	24(32)	24(32)	24(31)	24(31)	11/15
HCMA los	1.2 (1)	5.2(6)	11(27)	11(27)	11(27)	11(26)	11(26)	15/15
HMLSL pal	2.3 (3)	0.88 (0.7)	1.1 (0.6)	1.1 (0.6)	1.1 (0.6)	1.1 (0.6)	1.1 (0.6)	15/15
IPOP-10DDr	1.6 (1)	11(12)	14(18)	14(18)	14(15)	14(17)	14(17)	15/15
IPOP-500 l	1.6 (1)	8.6(9)	51(11)	51(11)	50(12)	50(12)	50(12)	15/15
IPOP-tany	1.6 (1)	3.8(5)	9.3(8)	9.3(8)	9.3(8)	9.2(8)	9.2(8)	15/15
IPOP-texp	1.1 (0.6)	13(16)	23(24)	23(24)	23(24)	23(24)	23(23)	15/15
IPOP lia	1.6 (1)	8.7(9)	290(491)	362(1013)	458(1467)	452(1446)	445(1423)	13/15
MLSL pal	2.8 (5)	0.74 (0.7)	1.3 (2)	1.3 (2)	1.3 (2)	1.4 (2)	1.4 (2)	15/15
OQNLP pal	1.6 (2)	1.3 (2)	1.8 (2)	1.8 (2)	1.8 (2)	1.8 (2)	8.8(10)	4/15
P-DCN tra	1.9e4(6e4)	1.2e4(2e4)	∞	∞	∞	∞	∞	0/15
P-zero tra	8713(3)	1.2e4(2e4)	∞	∞	∞	∞	∞	0/15
SMAC hut	1.2 (1)	0.48 (0.5)	0.65 (0.7)	1.4 (1)	4.3(5)	∞	∞	0/15
U-DCN tra	2.7 (3)	435(447)	906(1582)	897(1566)	892(1533)	885(1491)	880(1503)	12/15
U-zero tra	2.9 (1)	236(396)	1409(1931)	1395(1761)	1386(1897)	1376(1871)	1398(1834)	11/15
fmincon pa	2.6 (4)	0.82 (0.8)	0.94 (1)	0.94 (1)	0.95 (1)	0.97 (1)	1.0 (1)	15/15
fminunc pa	2.3 (5)	0.84 (0.7)	0.98 (1)	1.00 (1)	1.0 (1)	1.1 (1.0)	1.1 (1.0)	15/15
gal00 hol	3.8(4)	65(109)	133(224)	133(149)	133(149)	139(151)	163(163)	8/15
grid100 ho	3.2(3)	170(220)	244(316)	318(376)	421(513)	647(723)	2119(2206)	1/15
grid16 hol	2.6 (3)	267(356)	414(523)	411(517)	420(513)	436(508)	963(1138)	2/15
hill hol	6.8(6)	345(433)	416(523)	412(517)	410(451)	411(517)	428(514)	4/15
lmmCMA aug	2.1 (1)	1.3 (1)	1.5 (2)	1.5 (2)	1.6 (2)	1.9 (2)	1.9 (2)	8/15
memPSODE v	5.0(5)	14(15)	11(11)	11(10)	10(10)	10(10)	14(22)	15/15
prcga saw	2.9 (4)	31(71)	38(77)	39(77)	42(80)	52(84)	70(78)	13/15
ring100 ho	5.3(5)	2.6 (1)	3.5(2)	7.1(3)	11(5)	29(17)	81(48)	14/15
ring16 hol	2.7 (2)	95(118)	86(118)	86(148)	87(147)	95(144)	119(143)	10/15
simplex pa	16(15)	2.3 (1)	3.6(4)	3.5(4)	3.5(4)	3.5(4)	3.5(4)	15/15

Table 23: 05-D, running time excess $ERT/ERT_{\text{best } 2009}$ on f_{22} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_{22}	71	386	938	980	1008	1040	1068	14/15
BIPOP-aCMA	8.1(11)	20(36)	21(33)	21(32)	21(31)	20(31)	20(30)	15/15
BIPOP-saAC	9.1(13)	6.5(9)	23(16)	23(16)	22(15)	21(15)	21(15)	15/15
CMAES hut	1.9 (1)	4.2(5)	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	3.5(2)	69(132)	96(160)	93(153)	92(101)	91(144)	91(95)	8/15
HCMA los	3.3(6)	5.5(5)	13(24)	18(30)	17(30)	17(29)	25(47)	15/15
HMLSL pal	3.6(3)	2.1 (2)	1.3 (0.8)	1.3 (0.8)	1.3 (0.7)	1.4 (0.7)	1.5 (0.8)	15/15
IPOP-10DDr	7.4(11)	42(53)	43(59)	41(56)	40(55)	39(53)	39(52)	15/15
IPOP-500 l	7.4(11)	92(27)	580(280)	989(2552)	962(2482)	933(2403)	910(2344)	13/15
IPOP-tany	12(9)	29(51)	91(93)	87(89)	85(87)	82(84)	80(82)	15/15
IPOP-texp	22(9)	13(24)	18(20)	18(19)	18(19)	17(19)	17(18)	15/15
IPOP lia	7.4(11)	33(27)	1315(2668)	4602(7653)	5753(7455)	5578(7225)	5438(7042)	7/15
MLSL pal	2.7 (3)	1.8 (3)	1.4 (1)	1.3 (1)	1.3 (1)	1.4 (1)	1.5 (1)	15/15
OQNLP pal	2.8 (2)	2.5 (3)	2.9 (4)	2.8 (3)	2.8 (3)	2.7 (4)	9.4(11)	6/15
P-DCN tra	2.6e4(4e4)	1.9e4(3e4)	2.1e4(3e4)	2.0e4(2e4)	2.0e4(2e4)	1.9e4(2e4)	1.9e4(2e4)	3/15
P-zero tra	2.6e4(4e4)	3.6e4(5e4)	2.1e4(2e4)	2.0e4(3e4)	2.0e4(2e4)	1.9e4(2e4)	1.9e4(2e4)	3/15
SMAC hut	0.90 (0.8)	0.91 (1)	3.7(4)	3.6(4)	7.4(8)	∞	∞ <i>500</i>	0/15
U-DCN tra	1.9 (1)	327(164)	1146(2675)	1125(2555)	1129(2500)	1256(2453)	1469(2390)	13/15
U-zero tra	4.8(6)	1106(458)	1458(2726)	1511(2634)	1832(2618)	5409(6139)	3.5e4(4e4)	2/15
fmincon pa	2.2 (3)	1.3 (1)	1.0 (1)	0.99 (1.0)	1.00 (0.9)	1.1 (0.8)	1.2 (0.9)	15/15
fminunc pa	3.3(3)	1.2 (1)	1.4 (1)	1.4 (1)	1.4 (1)	1.5 (1)	1.5 (1)	15/15
ga100 hol	5.9(5)	241(327)	439(535)	524(641)	525(644)	816(886)	∞ <i>2e5</i>	0/15
grid100 ho	5.5(6)	128(326)	544(799)	731(891)	1680(1984)	∞	∞ <i>2e5</i>	0/15
grid16 hol	5.1(7)	685(886)	663(748)	1162(1187)	3483(4154)	3457(4206)	∞ <i>2e5</i>	0/15
hill hol	6.7(10)	455(649)	321(401)	452(520)	731(989)	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	2.5 (3)	3.8(4)	13(13)	13(14)	12(14)	12(14)	12(13)	3/15
memPSODE v	4.6(3)	7.9(10)	42(36)	42(35)	41(34)	40(33)	52(44)	15/15
prcga saw	3.3(3)	109(243)	298(370)	416(514)	420(446)	888(878)	2323(2445)	2/15
ring100 ho	5.5(3)	11(11)	36(33)	116(144)	201(203)	829(870)	∞ <i>2e5</i>	0/15
ring16 hol	2.5 (2)	93(307)	320(413)	421(526)	753(894)	3373(3725)	3323(3630)	1/15
simplex pa	11(10)	5.1(3)	3.3(3)	3.2(3)	3.1(3)	3.1(3)	3.0 (3)	15/15

Table 24: 05-D, running time excess $ERT/ERT_{\text{best 2009}}$ on f_{23} , in *italics* is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f_{23}	3.0	518	14249	27890	31654	33030	34256	15/15
BIPOP-aCMA	1.8 (2)	8.6(6)	1.7 (2)	0.94 (0.9)	0.93 (0.8)	0.91 (0.8)	0.90 (0.8)	15/15
BIPOP-saAC	2.0 (2)	12(14)	1.0 (0.9)	0.88 (0.6)	0.79 (0.5)	1.0 (0.9)	1.1 (1)	15/15
CMAES hut	1.6 (1)	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	1.9 (2)	31(27)	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
HCMA los	8.1(8)	13(10)	1.2 (0.9)	0.69 (0.5)	0.63 (0.4)	1.0 (0.8)	1.1 (1)	15/15
HMLSL pal	9.2(11)	2.4 (2)	1.7 (2)	11(12)	45(52)	∞	∞ <i>1e5</i>	0/15
IPOP-10DDr	2.1 (2)	7.2(5)	1.7 (1)	1.1 (0.9)	0.96 (0.8)	0.94 (0.8)	0.93 (0.8)	15/15
IPOP-500 l	2.1 (2)	7.2(5)	2.0 (1)	1.2 (0.9)	1.1 (0.8)	1.1 (0.8)	1.1 (0.8)	15/15
IPOP-tany	1.7 (1)	7.5(6)	5.2(5)	3.1(3)	2.7 (2)	2.7 (2)	2.6 (2)	15/15
IPOP-texp	3.0 (3)	7.0(7)	6.4(8)	4.2(4)	3.8(4)	3.6(3)	3.5(3)	15/15
IPOP lia	2.1 (2)	7.2(5)	2.0 (1)	1.2 (0.9)	1.1 (0.8)	1.1 (0.8)	1.1 (0.8)	15/15
MLSL pal	9.2(11)	1.9 (2)	2.0 (2)	9.2(9)	22(24)	∞	∞ <i>1e5</i>	0/15
OQNLP pal	29(47)	5.6(4)	8.0(8)	∞	∞	∞	∞ <i>4e4</i>	0/15
P-DCN tra	3.6(3)	3.2 (4)	970(1228)	∞	∞	∞	∞ <i>5e6</i>	0/15
P-zero tra	3.6(3)	29(62)	2398(2672)	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	1.6 (2)	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	3.4(2)	10(17)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	3.2(2)	43(50)	1527(1755)	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	7.2(6)	1.6 (2)	1.2 (2)	3.8(4)	10(12)	∞	∞ <i>1e5</i>	0/15
fminunc pa	9.1(16)	10(10)	82(84)	∞	∞	∞	∞ <i>8e4</i>	0/15
ga100 hol	2.3 (2)	45(46)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	3.0 (2)	60(74)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	2.2 (3)	40(30)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	2.5 (3)	49(45)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	1.9 (2)	10(11)	2.9 (3)	1.5 (2)	1.3 (2)	1.3 (1)	1.2 (1)	1/15
memPSODE v	3.4(3)	3.4(3)	3.4(3)	3.8(4)	3.5(4)	11(22)	10(21)	15/15
prcga saw	1.9 (2)	39(50)	201(228)	∞	∞	∞	∞ <i>2e5</i>	0/15
ring100 ho	1.8 (2)	23(27)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	3.0 (2)	26(29)	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	63(104)	3.0 (1)	2.2 (2)	7.4(8)	23(25)	22(23)	43(48)	1/15

Table 25: 05-D, running time excess $ERT/ERT_{\text{best 2009}}$ on f_{24} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension.

Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
<i>f₂₄</i>	1622	2.2e5	6.4e6	9.6e6	9.6e6	1.3e7	1.3e7	3/15
BIPOP-aCMA	2.5 (2)	1.7 (3)	0.62 (0.6)	0.65 (0.6)	0.90 (0.9)	1.0 (1.0)	1.0 (1)	5/15
BIPOP-saAC	2.1 (2)	0.85 (1)	0.86 (0.9)	0.91 (1)	0.90 (1)	0.68 (0.8)	0.68 (0.8)	6/15
CMAES hut	∞	∞	∞	∞	∞	∞	∞ <i>506</i>	0/15
DE pal	9.5(8)	∞	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
HCMA los	1.4 (1)	2.7 (5)	0.73 (0.8)	0.88 (0.9)	1.1 (1)	0.80 (0.9)	0.80 (0.9)	6/15
HMLSL pal	1.8 (2)	∞	∞	∞	∞	∞	∞ <i>1e5</i>	0/15
IPOP-10DDr	2.0 (2)	104(104)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
IPOP-500 l	2.0 (2)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
IPOP-tany	2.2 (2)	20(18)	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
IPOP-texp	1.4 (1)	0.76 (1)	0.50 (0.5)	1.1 (1)	1.1 (1)	0.80 (0.8)	0.80 (0.8)	6/15
IPOP lia	2.0 (2)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
MLSL pal	3.4(2)	4.2(5)	∞	∞	∞	∞	∞ <i>6e4</i>	0/15
OQNLP pal	0.73 (0.5)	0.17 (0.2)	0.02 (0.0)	0.01 (0.0)	0.01 (0.0)	0.01 (0.0)	0.01 (0.0)	2/15
P-DCN tra	1155(1589)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
P-zero tra	∞	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
SMAC hut	∞	∞	∞	∞	∞	∞	∞ <i>500</i>	0/15
U-DCN tra	709(989)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
U-zero tra	575(655)	∞	∞	∞	∞	∞	∞ <i>5e6</i>	0/15
fmincon pa	3.0(3)	∞	∞	∞	∞	∞	∞ <i>7e4</i>	0/15
fminunc pa	5.8(6)	∞	∞	∞	∞	∞	∞ <i>7e4</i>	0/15
ga100 hol	15(16)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid100 ho	93(102)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
grid16 hol	106(154)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
hill hol	38(72)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
lmmCMA aug	0.88 (0.9)	∞	∞	∞	∞	∞	∞ <i>2806</i>	0/15
memPSODE v	6.8(7)	4.4(6)	0.20 (0.3)	0.27 (0.3)	0.27 (0.2)	0.20 (0.2)	0.23 (0.2)	9/15
prcga saw	6.5(2)	3.0(3)	∞	∞	∞	∞	∞ <i>3e5</i>	0/15
ring100 ho	19(17)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
ring16 hol	13(12)	∞	∞	∞	∞	∞	∞ <i>2e5</i>	0/15
simplex pa	13(7)	5.9(6)	∞	∞	∞	∞	∞ <i>9e4</i>	0/15

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