Comparison Tables: CEC BBOB 2015 Testbed in 3-D

The BBOBies

May 27, 2015

Abstract

This document provides tabular results of the special session on Black-Box Optimization Benchmarking at CEC 2015, see `http://coco.gforge.inria.fr/doku.php?id=cec-bbob-2015`. Overall, eight algorithms have been tested on 24 benchmark functions in dimensions between 2 and 20. 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 [1]) 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 at CEC 2015.

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

algorithm short name	paper	reference
MATSuMoTo	Comparison of the MATSuMoTo Library for Expensive Optimization on the Noiseless Black-Box Optimization Benchmarking Testbed	[2]
R-DE-10e2	Parameter Tuning for Differential Evolution for Cheap, Medium, and Expensive Computational Budgets	[7]
R-DE-10e5	Parameter Tuning for Differential Evolution for Cheap, Medium, and Expensive Computational Budgets	[7]
R-SHADE-10e2	Parameter Tuning for Differential Evolution for Cheap, Medium, and Expensive Computational Budgets	[7]
R-SHADE-10e5	Parameter Tuning for Differential Evolution for Cheap, Medium, and Expensive Computational Budgets	[7]
RL-SHADE-10e2	Parameter Tuning for Differential Evolution for Cheap, Medium, and Expensive Computational Budgets	[7]
RL-SHADE-10e5	Parameter Tuning for Differential Evolution for Cheap, Medium, and Expensive Computational Budgets	[7]
SOO	Simultaneous Optimistic Optimization on the Noiseless BBOB Testbed	[3]

Table 2: 03-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	3.6	8.0	8.0	8.0	8.0	8.0	8.0	15/15
MATSUMOTO-	**1.9**(2)	**2.2**(1)	**2.9**(0.9)$^{\star 3}$	**4.4**(0.6)$^{\star 4}$	**5.5**(2)$^{\star 4}$	71(42)	∞ *150*	0/15
R-DE-10e2-	**2.6**(2)	4.7(3)	10(4)	16(4)	22(3)	41(19)	∞ *300*	0/15
R-DE-10e5-	**2.5**(3)	5.5(2)	9.2(4)	15(4)	22(6)	**36**(5)	**64**(80)	15/15
RL-SHADE-1	**1.5**(1)	5.6(4)	12(4)	18(7)	22(5)	**40**(21)	276(262)	2/15
RL-SHADE-1	**2.1**(2)	15(6)	47(17)	79(32)	147(12)	251(17)	344(21)	15/15
R-SHADE-10	**2.9**(3)	5.4(3)	14(8)	22(6)	29(6)	280(356)	∞ *300*	0/15
R-SHADE-10	3.0(2)	7.3(3)	14(3)	21(4)	30(5)	48(6)	**64**(4)	15/15
SOO-Derbel	**1.1**(0.8)	**2.4**(1)	**6.4**(2)	**14**(2)	**20**(5)	44(5)	79(5)	15/15

Table 3: 03-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
f2	38	42	43	44	45	47	48	15/15
MATSUMOTO-	57(31)	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**4.1**(1)	5.8(4)	7.3(6)	12(12)	25(37)	∞	∞ *300*	0/15
R-DE-10e5-	**3.9**(1)	**5.0**(2)	**5.8**(3)	18(86)	20(44)	**21**(43)	**26**(78)	15/15
RL-SHADE-1	4.1(0.7)	**4.5**(1)	**6.4**(2)	**7.3**(4)	**10**(5)	96(85)	∞ *300*	0/15
RL-SHADE-1	24(4)	31(5)	40(5)	50(5)	56(6)	71(6)	85(6)	15/15
R-SHADE-10	5.6(1)	7.1(3)	17(14)	102(94)	∞	∞	∞ *300*	0/15
R-SHADE-10	6.2(1)	7.8(2)	8.5(1)	**10**(2)	**12**(3)	**14**(2)	**17**(2)	15/15
SOO-Derbel	7.2(2)	8.6(3)	13(3)	15(3)	17(5)	25(6)	35(3)	15/15

Table 4: 03-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
f3	38	822	830	835	842	847	853	15/15
MATSUMOTO-	**1.8**(1)	**2.7**(4)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	4.6(5)	**2.7**(1)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	3.1(0.7)	**1.4**(1)	7.7(6)	9.1(3)	9.2(8)	9.2(9)	11(9)	15/15
RL-SHADE-1	**2.4**(1)	**0.39**(0.4)	**0.83**(0.9)	**1.0**(0.7)	5.3(7)	∞	∞ *300*	0/15
RL-SHADE-1	8.7(4)	**2.2**(0.8)	**3.3**(0.8)	3.9(0.5)	**4.6**(0.3)	**5.5**(0.5)	**6.4**(0.5)	15/15
R-SHADE-10	**2.6**(1)	**1.7**(2)	5.3(6)	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	4.3(7)	**1.2**(0.6)	3.5(2)	**3.6**(2)	**3.7**(2)	**3.9**(3)	**4.0**(3)	15/15
SOO-Derbel	4.0(4)	**2.6**(3)	9.1(11)	9.2(10)	9.3(9)	10(11)	10(11)	15/15

Table 5: 03-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
f4	40	808	866	921	952	1015	1044	15/15
MATSUMOTO-	5.7(4)	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**3.0**(1)	**2.7**(2)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	3.5(2)	3.8(5)	14(27)	14(25)	15(8)	18(34)	17(7)	15/15
RL-SHADE-1	**2.4**(1)	**1.1**(1)	**2.6**(3)	**4.9**(4)	∞	∞	∞ *300*	0/15
RL-SHADE-1	12(3)	3.0(0.8)	**3.7**(0.3)	**4.5**(0.5)	**4.8**(0.3)	**5.5**(0.4)	**6.2**(0.4)	15/15
R-SHADE-10	3.1(3)	**1.3**(0.7)	5.2(11)	4.9(4)	∞	∞	∞ *300*	0/15
R-SHADE-10	7.3(20)	**2.6**(3)	8.8(5)	8.4(6)	**8.2**(8)	**7.9**(5)	**7.8**(5)	15/15
SOO-Derbel	4.4(6)	14(37)	226(287)	349(513)	353(410)	465(515)	572(754)	6/15

Table 6: 03-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	6.6	6.6	6.6	6.6	6.6	6.6	6.6	15/15
MATSUMOTO-	**1.3**(0.1)	**1.8**(0.4)$^{\star 4}$	**1.9**(0.4)$^{\star 4}$	**1.9**(0.6)$^{\star 4}$	**1.9**(0.3)$^{\star 4}$	**1.9**(0.6)$^{\star 4}$	**1.9**(0.4)$^{\star 4}$	15/15
R-DE-10e2-	6.2(2)	16(6)	26(7)	34(6)	62(51)	∞	∞ *300*	0/15
R-DE-10e5-	6.1(4)	20(18)	46(20)	66(75)	98(87)	157(55)	188(81)	15/15
RL-SHADE-1	5.3(4)	**14**(3)	**20**(4)	**26**(4)	**31**(4)	**46**(5)	224(205)	3/15
RL-SHADE-1	17(16)	78(11)	123(11)	172(7)	218(8)	307(11)	393(13)	15/15
R-SHADE-10	6.3(2)	15(3)	25(6)	34(4)	49(25)	∞	∞ *300*	0/15
R-SHADE-10	8.9(7)	32(33)	48(7)	61(15)	76(13)	107(16)	**135**(38)	15/15
SOO-Derbel	**3.1**(0.1)	15(0.1)	40(0.1)	81(0.1)	135(0.1)	261(0.1)	430(0.1)	15/15

Table 7: 03-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.

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Δf_{opt}	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f6	34	56	90	117	149	215	265	15/15
MATSUMOTO-	6.3(5)	42(32)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**1.9**(7)	**3.3**(4)	**3.5**(3)	7.6(12)	∞	∞	∞ *300*	0/15
R-DE-10e5-	**2.2**(1)	3.5(2)	3.9(2)	19(38)	27(24)	33(54)	31(47)	15/15
RL-SHADE-1	**2.7**(0.9)	3.5(2)	6.1(3)	**7.2**(6)	**15**(14)	∞	∞ *300*	0/15
RL-SHADE-1	4.9(5)	10(4)	14(3)	17(2)	16(4)	**17**(2)	**18**(1)	15/15
R-SHADE-10	**2.6**(2)	5.1(4)	24(26)	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**2.3**(3)	**3.2**(2)	**3.2**(0.8)	**3.4**(0.3)	**3.5**(0.9)	**3.6**(1)	**3.9**(1.0)	15/15
SOO-Derbel	**1.9**(2)	97(341)	527(398)	3211(5562)	8850(1e4)	∞	∞ *3e5*	0/15

Table 8: 03-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
f7	11	65	342	464	482	482	535	15/15
MATSUMOTO-	**2.3**(2)	**2.1**(3)	3.6(3)	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**2.2**(1)	**1.8**(4)	**0.92**(1.0)	**1.3**(1)	**1.8**(0.8)	**1.8**(2)	**2.7**(4)	3/15
R-DE-10e5-	**1.7**(1)	**2.3**(0.8)	**1.8**(1)	**2.3**(2)	3.1(3)	3.1(3)	**2.9**(2)	15/15
RL-SHADE-1	3.5(3)	**2.5**(1.0)	**0.86**(0.6)	**2.3**(2)	3.1(5)	3.1(4)	8.3(6)	1/15
RL-SHADE-1	6.6(9)	4.7(2)	**2.4**(0.5)	3.1(1)	3.8(0.9)	3.8(0.4)	3.9(0.8)	15/15
R-SHADE-10	3.4(3)	**2.7**(2)	**3.0**(3)	10(4)	∞	∞	∞ *300*	0/15
R-SHADE-10	3.7(2)	**2.0**(4)	**0.82**(1.0)	**0.77**(0.7)	**0.78**(0.4)	**0.78**(0.8)	**0.81**(0.6)	15/15
SOO-Derbel	**2.3**(7)	**2.7**(6)	**2.1**(3)	**2.3**(4)	3.3(3)	3.3(2)	3.5(1)	15/15

Table 9: 03-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
f8	27	45	152	179	188	198	208	15/15
MATSUMOTO-	3.2(3)	51(40)	15(13)	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	4.0(2)	**6.2**(4)	5.6(3)	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	3.6(2)	23(45)	14(11)	22(28)	24(19)	31(24)	36(18)	15/15
RL-SHADE-1	3.5(2)	9.3(5)	14(6)	25(20)	∞	∞	∞ *300*	0/15
RL-SHADE-1	10(6)	22(5)	14(4)	16(3)	18(3)	**23**(3)	**25**(4)	15/15
R-SHADE-10	4.8(5)	15(18)	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**3.0**(2)	9.2(4)	**4.6**(3)	**4.7**(2)	**4.9**(3)	**5.3**(3)	**6.0**(2)	15/15
SOO-Derbel	**1.8**(1.0)	**4.1**(3)	**4.6**(2)	**8.9**(12)	**13**(13)	32(22)	49(17)	15/15

Table 10: 03-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
f9	21	65	127	149	159	169	178	15/15
MATSUMOTO-	**2.5**(2)	5.9(6)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	4.5(3)	5.6(8)	35(37)	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	8.1(16)	33(69)	34(29)	36(40)	37(14)	41(35)	45(29)	15/15
RL-SHADE-1	5.1(3)	7.2(5)	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	14(9)	16(8)	16(6)	18(3)	21(4)	**26**(4)	**29**(3)	15/15
R-SHADE-10	6.2(3)	23(22)	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	3.7(1)	**3.4**(2)	**3.6**(3)	**4.2**(1)	**4.7**(3)	**5.4**(3)	**6.0**(2)	15/15
SOO-Derbel	**2.2**(1)	**2.4**(1)	**5.4**(6)	**9.4**(5)	**15**(8)	27(24)	42(38)	15/15

Table 11: 03-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	114	152	168	180	194	218	242	15/15
MATSUMOTO-	∞	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	39(24)	29(18)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	33(34)	52(55)	135(116)	188(219)	237(287)	604(779)	1003(978)	10/15
RL-SHADE-1	∞	∞	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	**13**(3)	**14**(3)	**16**(1)	**17**(3)	**18**(1)	**20**(2)	**22**(2)	15/15
R-SHADE-10	∞	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.9**(0.6)	**2.2**(0.2)	**3.0**(2)	**3.2**(1)	**3.4**(2)	**3.8**(1)	**4.2**(1)	15/15
SOO-Derbel	18(3)	92(97)	525(920)	1027(903)	1750(1555)	9406(1e4)	∞ *3e5*	0/15

Table 12: 03-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	67	105	227	263	277	302	327	15/15
MATSUMOTO-	11(8)	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	11(9)	41(45)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	18(5)	90(289)	205(278)	517(343)	588(393)	2685(2077)	6686(3713)	2/15
RL-SHADE-1	12(13)	**14**(10)	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	13(9)	15(3)	**11**(1)	**11**(0.8)	**12**(0.8)	**14**(2)	**16**(1)	15/15
R-SHADE-10	12(18)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**3.3**(2)	**4.7**(6)	**2.8**(0.7)	**3.0**(4)	**3.1**(6)	**3.4**(1)	**3.6**(5)	15/15
SOO-Derbel	**4.6**(4)	41(95)	300(683)	2112(1406)	∞	∞	∞ *3e5*	0/15

Table 13: 03-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	65	168	338	401	445	696	790	15/15
MATSUMOTO-	**11**(13)	14(28)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	∞	∞	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	62(177)	76(66)	74(50)	86(58)	93(64)	96(81)	113(80)	15/15
RL-SHADE-1	13(11)	∞	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	33(9)	20(10)	13(4)	13(5)	**14**(6)	**11**(4)	**11**(3)	15/15
R-SHADE-10	68(61)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	11(28)	**8.2**(13)	**6.2**(15)	**6.3**(13)	**6.5**(8)	**5.8**(5)	**6.1**(7)	15/15
SOO-Derbel	**5.4**(1)	**4.3**(2)	**4.1**(2)	**9.5**(14)	22(15)	46(28)	189(170)	13/15

Table 14: 03-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	49	85	108	136	215	281	365	15/15
MATSUMOTO-	**2.2**(0.5)*	8.1(6)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**3.8**(3)	25(18)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	6.0(7)	13(9)	22(13)	42(22)	59(62)	689(825)	1444(1196)	7/15
RL-SHADE-1	4.5(2)	26(37)	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	16(12)	21(2)	25(4)	25(3)	**19**(1)	**20**(2)	**19**(2)	15/15
R-SHADE-10	8.1(7)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	3.9(1)	**4.0**(2)	**4.4**(2)	**4.6**(1)	**3.5**(0.4)	**3.9**(1)	**3.8**(0.7)	15/15
SOO-Derbel	3.8(1.0)	**7.0**(2)	**13**(4)	**19**(12)	25(31)	81(135)	223(161)	15/15

Table 15: 03-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
f14	2.2	17	28	43	71	110	194	15/15
MATSUMOTO-	**1.5**(0.9)	**1.4**(0.6)	**2.0**(1)	9.4(10)	31(40)	∞	∞ *150*	0/15
R-DE-10e2-	**1.8**(1)	**2.1**(2)	3.6(2)	**4.3**(1)	11(10)	∞	∞ *300*	0/15
R-DE-10e5-	**2.8**(2)	**2.8**(4)	5.0(5)	14(0.6)	19(22)	121(111)	529(462)	15/15
RL-SHADE-1	**1.7**(2)	**2.6**(2)	3.7(1)	**3.9**(0.9)	**4.7**(2)	∞	∞ *300*	0/15
RL-SHADE-1	**1.3**(2)	4.1(3)	17(3)	23(4)	23(5)	**28**(4)	**22**(2)	15/15
R-SHADE-10	3.5(7)	**2.9**(0.9)	4.8(2)	7.2(6)	∞	∞	∞ *300*	0/15
R-SHADE-10	**2.7**(0.8)	**2.8**(2)	4.0(1)	4.8(1)	**4.2**(3)	**5.0**(0.5)	**4.0**(1)	15/15
SOO-Derbel	**1.3**(0.9)	**1.4**(0.6)	**2.9**(0.6)	6.1(4)	12(13)	286(317)	674(790)	13/15

Table 16: 03-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	121	1372	6285	8282	8429	8787	9041	15/15
MATSUMOTO-	**0.76**(0.6)	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**0.92**(1)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	3.1(8)	7.1(6)	10(9)	9.2(5)	9.0(7)	11(11)	11(8)	15/15
RL-SHADE-1	**1.0**(0.7)	3.2(6)	**0.71**(1)	**0.54**(0.4)	∞	∞	∞ *300*	0/15
RL-SHADE-1	**2.7**(1)	**2.7**(1)	**2.1**(5)	**1.7**(0.1)	**1.8**(4)	**1.8**(2)	**1.8**(2)	15/15
R-SHADE-10	**1.5**(1)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.7**(1)	**1.0**(0.8)	**0.84**(1)	**0.64**(0.5)	**0.64**(0.9)	**0.63**(0.6)	**0.63**(0.3)	15/15
SOO-Derbel	**0.95**(0.3)	**1.5**(2)	3.0(6)	**2.3**(3)	**2.5**(4)	**2.5**(2)	**2.4**(5)	15/15

Table 17: 03-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	41	319	582	789	1864	3204	3361	15/15
MATSUMOTO-	**1.3**(1)	**1.6**(2)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**1.8**(2)	3.2(6)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	**1.7**(2)	4.0(7)	7.7(2)	9.3(7)	4.5(2)	3.8(3)	5.2(4)	15/15
RL-SHADE-1	**1.3**(0.9)	**2.6**(2)	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	**1.9**(2)	4.4(4)	11(5)	11(5)	8.6(14)	5.9(10)	5.9(9)	15/15
R-SHADE-10	**0.98**(1)	14(9)	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.0**(1)	**1.7**(2)	**1.6**(0.6)	**1.5**(0.5)	**0.82**(0.4)	**0.54**(0.4)	**0.63**(0.5)	15/15
SOO-Derbel	**0.91**(0.9)	**0.48**(0.3)	**0.84**(0.8)	**1.0**(0.5)	**0.64**(0.6)	**1.4**(0.6)	**2.2**(3)	15/15

Table 18: 03-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	3.6	78	282	491	1134	2347	3469	15/15
MATSUMOTO-	**2.6**(2)	**1.2**(0.9)	8.4(16)	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**2.2**(2)	**1.7**(0.8)	**2.5**(2)	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	**2.1**(0.9)	**1.5**(1)	**2.0**(1)	6.6(3)	7.8(5)	9.2(28)	17(16)	15/15
RL-SHADE-1	**2.5**(2)	**2.3**(2)	5.2(6)	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	**2.1**(4)	4.7(4)	5.3(1)	5.9(1)	3.9(0.2)	3.1(0.3)	**2.7**(0.2)	15/15
R-SHADE-10	**2.6**(1)	**2.5**(2)	16(15)	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.8**(2)	**1.3**(0.8)	**1.1**(0.4)	**1.1**(0.1)	**0.66**(0.1)	**0.67**(0.1)	**0.84**(0.3)	15/15
SOO-Derbel	**1.2**(1)	**0.90**(0.5)	**0.98**(0.3)	**1.8**(1)	**1.3**(1.0)	**1.6**(1)	**2.0**(0.8)	15/15

Table 19: 03-D, running time excess ERT/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	40	145	1289	3084	3523	4738	5527	15/15
MATSUMOTO-	**1.1**(1)	16(29)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**1.3**(0.7)	**2.0**(1)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	**1.3**(0.8)	7.4(7)	5.3(13)	4.0(4)	12(11)	28(33)	46(27)	10/15
RL-SHADE-1	**2.2**(3)	7.3(6)	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	**2.9**(3)	7.1(2)	**2.0**(0.2)	**1.3**(0.2)	**1.5**(0.1)	**1.7**(0.1)	**1.9**(0.0)	15/15
R-SHADE-10	**2.4**(2)	7.4(8)	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.2**(1)	**1.7**(0.8)	**0.64**(1)	**0.42**(0.4)	**0.61**(0.7)	**0.68**(0.5)	**0.89**(0.5)	15/15
SOO-Derbel	**0.97**(0.6)	**1.4**(0.2)	**0.74**(0.5)	**1.0**(0.7)	**1.6**(0.9)	3.7(3)	6.1(6)	15/15

Table 20: 03-D, running time excess ERT/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	109	6764	7367	7399	7441	15/15
MATSUMOTO-	8.9(4)	286(338)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	8.4(6)	177(198)	39(102)	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	**6.9**(5)	**142**(90)	31(58)	7.5(10)	11(12)	22(9)	22(17)	12/15
RL-SHADE-1	15(9)	228(504)	41(44)	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	7.7(4)	191(213)	25(19)	**2.6**(4)	**4.1**(7)	**7.4**(15)	**8.3**(9)	15/15
R-SHADE-10	9.0(6)	274(398)	38(38)	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	7.1(5)	178(76)	**24**(40)	**1.9**(1)	**2.2**(1)	**2.2**(4)	**2.3**(4)	15/15
SOO-Derbel	**1**(0)$^{\star 2}$	**1**(0)$^{\star 3}$	**2.8**(1)	7.2(4)	23(20)	77(52)	134(137)	4/15

Table 21: 03-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
f20	8.3	385	2291	2398	2481	2573	2776	15/15
MATSUMOTO-	**1.6**(0.6)	**2.9**(2)	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	3.5(2)	**0.89**(0.9)	**1.9**(2)	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	26(178)	**2.7**(4)	**2.3**(1)	**2.7**(3)	**2.8**(3)	**5.9**(9)	**6.9**(9)	15/15
RL-SHADE-1	**2.5**(2)	**0.62**(0.6)	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	3.3(3)	**2.7**(1)	8.0(13)	8.2(13)	8.2(7)	8.3(12)	7.9(0.2)	15/15
R-SHADE-10	3.9(3)	**1.3**(1)	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**2.6**(2)	**1.8**(3)	**3.0**(2)	**2.9**(2)	**2.8**(2)	**2.8**(2)	**2.6**(3)	15/15
SOO-Derbel	3.4(0.1)	**0.19**(1e-3)⋆2	18(1)	18(0.7)	17(1)	17(3)	15(3)	15/15

Table 22: 03-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
f21	5.9	184	425	439	458	469	482	15/15
MATSUMOTO-	**1.6**(0.9)	**0.70**(0.2)	**1.5**(1)	5.0(9)	∞	∞	∞ *150*	0/15
R-DE-10e2-	**1.3**(2)	**1.5**(3)	**1.5**(2)	**3.0**(2)	3.1(1)	4.7(4)	∞ *300*	0/15
R-DE-10e5-	**1.8**(3)	7.4(14)	6.0(11)	6.2(9)	6.1(6)	6.5(6)	7.1(4)	15/15
RL-SHADE-1	**1.2**(1)	**2.1**(3)	5.2(5)	10(31)	∞	∞	∞ *300*	0/15
RL-SHADE-1	**1.3**(1.0)	3.1(5)	20(1)	21(35)	21(67)	22(65)	23(64)	15/15
R-SHADE-10	**2.6**(1.0)	3.2(4)	**2.5**(3)	3.3(1)	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.4**(0.9)	**2.8**(4)	**2.4**(3)	**2.5**(2)	**2.5**(3)	**2.6**(2)	**2.7**(2)	15/15
SOO-Derbel	**1.3**(1)	**0.56**(0.8)	**0.66**(0.6)	**1.4**(2)	**1.9**(4)	**2.1**(4)	**2.6**(4)	15/15

Table 23: 03-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
f22	18	170	354	362	384	401	414	15/15
MATSUMOTO-	**1.4**(2)	**1.5**(1)	3.0(4)	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**1.7**(1.0)	**1.5**(2)	**2.9**(4)	12(21)	11(14)	11(15)	∞ *300*	0/15
R-DE-10e5-	8.2(27)	5.7(11)	6.3(10)	6.5(9)	6.3(7)	**7.1**(8)	**7.6**(7)	15/15
RL-SHADE-1	**2.9**(4)	**1.5**(1)	4.1(3)	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	**2.0**(3)	**2.4**(3)	25(1)	26(83)	26(80)	27(77)	28(75)	15/15
R-SHADE-10	**2.2**(2)	**1.6**(3)	**2.0**(3)	6.1(7)	12(14)	∞	∞ *300*	0/15
R-SHADE-10	**0.87**(0.8)	**1.9**(0.4)	**2.8**(3)	**3.1**(4)	**3.1**(3)	**3.2**(2)	**3.3**(2)	15/15
SOO-Derbel	**0.71**(0.7)	**0.47**(0.1)	**1.2**(1)	**3.0**(2)	**4.5**(7)	30(7)	44(85)	15/15

Table 24: 03-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
f23	2.6	407	906	1215	2214	2293	2393	15/15
MATSUMOTO-	4.3(3)	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	**3.1**(2)	11(8)	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	4.6(3)	24(29)	4863(2897)	3626(6418)	1991(813)	1922(2256)	1843(2758)	1/15
RL-SHADE-1	3.4(3)	∞	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	3.3(2)	8.2(5)	20(19)	19(26)	11(14)	11(14)	**11**(7)	15/15
R-SHADE-10	4.1(4)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**2.8**(3)	**5.4**(3)	**8.7**(9)	**6.6**(2)	**3.7**(3)	**3.7**(2)	**3.7**(3)	15/15
SOO-Derbel	4.4(5)	**1.4**(0.7)	**4.3**(6)	**5.8**(6)	**4.8**(5)	**9.3**(7)	13(5)	15/15

Table 25: 03-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
f24	97	10391	1.0e5	3.6e5	3.6e5	3.6e5	3.6e5	2/15
MATSUMOTO-	7.1(9)	∞	∞	∞	∞	∞	∞ *150*	0/15
R-DE-10e2-	3.4(3)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-DE-10e5-	**2.5**(2)	12(13)	∞	∞	∞	∞	∞ *3e5*	0/15
RL-SHADE-1	**2.3**(4)	∞	∞	∞	∞	∞	∞ *300*	0/15
RL-SHADE-1	3.2(4)	20(35)	**2.6**(2)	**0.81**(1)	**0.82**(0.6)	**0.82**(0.3)	**0.82**(1.0)	9/15
R-SHADE-10	3.0(1)	∞	∞	∞	∞	∞	∞ *300*	0/15
R-SHADE-10	**1.7**(1)	**1.6**(2)	**2.5**(2)	**3.7**(5)	**3.7**(5)	**3.7**(3)	**3.7**(1)	3/15
SOO-Derbel	**2.3**(2)	**2.3**(2)	8.5(20)	5.7(8)	5.7(14)	5.7(6)	5.7(8)	2/15

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