Comparison Tables: CEC-BBOB 2015 Testbed in 2-D

The BBOBies

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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: 02-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	1.8	5.7	5.7	6.2	6.2	6.2	6.2	15/15
MATSUMOTO-	**1.7**(1)	**1.6**(0.4)	**2.6**(0.7)	**3.7**(0.8)$^{\star 3}$	**4.5**(0.8)$^{\star 3}$	**24**(30)	276(355)	1/15
R-DE-10e2-	**2.3**(2)	**2.0**(2)	8.5(6)	11(6)	18(6)	34(25)	160(178)	3/15
R-DE-10e5-	**1.7**(2)	8.1(5)	30(4)	69(8)	74(6)	81(82)	98(148)	15/15
RL-SHADE-1	**1.6**(2)	**2.7**(1)	8.0(3)	12(4)	16(6)	25(13)	66(42)	7/15
RL-SHADE-1	**1.9**(2)	4.3(8)	19(13)	37(14)	70(21)	136(10)	191(20)	15/15
R-SHADE-10	**2.1**(2)	3.2(3)	10(4)	16(6)	22(7)	116(113)	∞ *200*	0/15
R-SHADE-10	**1.5**(1)	3.7(2)	8.6(3)	13(6)	18(6)	28(3)	**39**(7)	15/15
SOO-Derbel	**1.1**(0.8)	**1.5**(1)	**3.6**(2)	**7.1**(2)	**11**(4)	**22**(3)	**42**(2)	15/15

Table 3: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ 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	16	19	25	25	26	28	29	15/15
MATSUMOTO-	11(11)	76(83)	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**5.6**(2)	**7.6**(2)	8.8(3)	16(8)	29(23)	∞	∞ *200*	0/15
R-DE-10e5-	14(3)	13(49)	12(1)	13(21)	19(37)	21(33)	**23**(19)	15/15
RL-SHADE-1	**6.0**(2)	**6.3**(3)	**5.9**(2)	**8.8**(8)	15(10)	∞	∞ *200*	0/15
RL-SHADE-1	21(12)	27(13)	30(4)	37(8)	46(7)	56(5)	68(8)	15/15
R-SHADE-10	8.9(8)	11(8)	22(21)	116(144)	∞	∞	∞ *200*	0/15
R-SHADE-10	7.0(3)	8.7(2)	8.4(4)	**9.2**(2)	**10**(1)	**12**(3)	**14**(3)	15/15
SOO-Derbel	7.0(3)	10(1)	**8.3**(2)	11(5)	**14**(1)	**18**(2)	25(4)	15/15

Table 4: 02-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	15	271	445	446	450	454	464	15/15
MATSUMOTO-	3.0(0.9)	6.1(6)	3.7(6)	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**2.8**(4)	**0.97**(1)	**1.5**(2)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	**2.7**(3)	**1.6**(2)	3.2(6)	4.0(8)	4.0(8)	4.7(4)	7.3(20)	15/15
RL-SHADE-1	**2.2**(1)	**0.70**(0.4)	**0.66**(0.5)	**1.3**(1)	6.6(9)	∞	∞ *200*	0/15
RL-SHADE-1	5.6(4)	**2.3**(1)	**2.0**(0.7)	**3.0**(0.5)	3.5(0.6)	4.3(0.5)	5.1(0.3)	15/15
R-SHADE-10	**2.4**(2)	**0.75**(0.4)	**1.0**(0.7)	6.7(6)	∞	∞	∞ *200*	0/15
R-SHADE-10	3.7(1)	**1.3**(1)	**2.0**(2)	**2.1**(3)	**2.2**(3)	**2.4**(2)	**2.5**(2)	15/15
SOO-Derbel	**2.5**(1)	**0.92**(0.6)	**0.73**(0.5)	**0.82**(0.6)	**0.92**(0.4)	**1.2**(0.3)	**1.5**(0.4)	15/15

Table 5: 02-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	22	344	459	496	523	544	566	15/15
MATSUMOTO-	**1.9**(0.7)	∞	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**1.9**(1)	**2.0**(2)	∞	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	5.1(11)	**1.4**(1.0)	4.1(4)	4.3(3)	6.7(3)	7.9(4)	8.1(5)	15/15
RL-SHADE-1	**1.8**(0.9)	**0.52**(0.3)	**0.94**(1)	**1.1**(2)	**1.9**(2)	∞	∞ *200*	0/15
RL-SHADE-1	5.2(3)	**2.2**(0.6)	**2.5**(0.7)	**2.9**(0.4)	3.1(0.5)	**4.2**(0.9)	**4.6**(0.6)	15/15
R-SHADE-10	**2.0**(1)	**2.0**(2)	3.3(4)	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.4**(2)	**1.4**(1)	**2.0**(2)	**2.0**(2)	**2.0**(2)	**2.1**(2)	**2.3**(3)	15/15
SOO-Derbel	**1.5**(0.3)	**0.86**(0.7)	7.6(16)	12(5)	11(10)	12(7)	12(13)	15/15

Table 6: 02-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	3.7	4.4	4.4	4.4	4.4	4.4	4.4	15/15
MATSUMOTO-	**1.5**(0.8)	**2.0**(0.6)$^{\star 4}$	**2.5**(1)$^{\star 4}$	**2.5**(0.9)$^{\star 4}$	**2.5**(0.5)$^{\star 4}$	**2.5**(0.8)$^{\star 4}$	**2.5**(1)$^{\star 4}$	15/15
R-DE-10e2-	4.9(4)	13(6)	21(7)	31(9)	45(6)	680(795)	∞ *200*	0/15
R-DE-10e5-	3.3(2)	12(4)	28(16)	81(4)	111(31)	206(206)	303(311)	15/15
RL-SHADE-1	5.5(6)	12(3)	**18**(6)	**25**(7)	**33**(18)	**61**(46)	213(137)	3/15
RL-SHADE-1	4.1(4)	42(12)	86(8)	122(23)	167(23)	242(23)	317(15)	15/15
R-SHADE-10	4.7(4)	13(2)	23(3)	33(4)	46(7)	∞	∞ *200*	0/15
R-SHADE-10	4.7(4)	23(9)	46(39)	63(49)	75(16)	99(51)	**121**(21)	15/15
SOO-Derbel	**2.3**(0.1)	**8.8**(0.1)	22(0.1)	41(0.1)	76(0.1)	166(0.1)	273(0.1)	15/15

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Table 7: 02-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
f6	13	23	41	54	67	95	124	15/15
MATSUMOTO-	**1.4**(0.9)	14(25)	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**1.8**(2)	**2.3**(0.8)	**3.0**(1)	**5.2**(3)	**8.4**(9)	∞	∞ *200*	0/15
R-DE-10e5-	10(4)	20(17)	19(38)	20(32)	21(29)	19(26)	20(31)	15/15
RL-SHADE-1	**2.1**(1)	4.2(2)	**3.6**(2)	6.8(7)	8.7(8)	∞	∞ *200*	0/15
RL-SHADE-1	3.5(4)	7.1(4)	8.6(5)	12(2)	13(3)	**16**(2)	**17**(2)	15/15
R-SHADE-10	**1.6**(0.7)	4.2(2)	9.1(8)	13(13)	∞	∞	∞ *200*	0/15
R-SHADE-10	**1.9**(1)	**3.2**(2)	5.5(1)	**5.6**(7)	**5.3**(3)	**4.8**(1)	**4.7**(3)	15/15
SOO-Derbel	**1.3**(2)	7.6(11)	94(127)	402(716)	1663(2632)	5292(4900)	2.4e4(4e4)	1/15

Table 8: 02-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	3.2	21	60	193	217	217	241	15/15
MATSUMOTO-	**2.8**(2)	**1.4**(0.5)	**0.97**(0.4)	**0.84**(0.7)	**2.2**(3)	**2.2**(3)	∞ *100*	0/15
R-DE-10e2-	3.1(3)	**2.7**(3)	**2.0**(0.9)	**1.2**(0.9)	**2.0**(3)	**2.0**(2)	**2.9**(2)	4/15
R-DE-10e5-	**2.2**(2)	3.6(4)	3.8(3)	**1.9**(1)	**1.7**(1)	**1.7**(0.7)	**1.8**(0.5)	15/15
RL-SHADE-1	5.9(10)	**3.0**(3)	5.0(5)	**2.9**(3)	6.8(6)	6.8(8)	∞ *200*	0/15
RL-SHADE-1	4.9(8)	3.5(4)	4.6(2)	**2.7**(2)	**3.0**(1)	**3.0**(1)	3.5(1)	15/15
R-SHADE-10	**2.9**(3)	**2.7**(3)	4.1(6)	5.0(8)	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.6**(2)	**1.8**(2)	**1.7**(1)	**0.85**(0.7)	**0.94**(0.8)	**0.94**(0.2)	**0.97**(0.5)	15/15
SOO-Derbel	**1.8**(0.6)	**1.4**(0.9)	**1.5**(0.5)	**0.83**(0.7)	**1.1**(1)	**1.1**(1)	**1.3**(1)	15/15

Table 9: 02-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	5.4	12	37	46	86	94	112	15/15
MATSUMOTO-	**2.7**(2)	**3.9**(2)	6.6(7)	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	4.8(3)	8.8(7)	27(33)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	**2.6**(3)	11(19)	13(11)	16(12)	10(5)	**12**(6)	**12**(5)	15/15
RL-SHADE-1	4.2(3)	7.6(4)	6.9(10)	63(65)	∞	∞	∞ *200*	0/15
RL-SHADE-1	7.6(5)	13(12)	14(10)	18(10)	17(5)	23(5)	23(4)	15/15
R-SHADE-10	6.9(3)	11(9)	11(14)	63(77)	∞	∞	∞ *200*	0/15
R-SHADE-10	3.9(2)	4.4(4)	**4.0**(5)	**6.1**(6)	**4.2**(5)	**5.3**(4)	**5.1**(3)	15/15
SOO-Derbel	**2.0**(2)	**2.8**(3)	**3.8**(2)	**7.5**(5)	**6.9**(7)	18(17)	26(19)	15/15

Table 10: 02-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	1	18	30	44	68	81	92	15/15
MATSUMOTO-	**16**(19)	**2.7**(2)	**4.7**(4)	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	19(18)	6.0(6)	15(19)	33(38)	∞	∞	∞ *200*	0/15
R-DE-10e5-	33(20)	7.7(10)	23(46)	26(15)	20(24)	20(13)	20(17)	15/15
RL-SHADE-1	34(27)	7.0(8)	13(10)	33(25)	44(33)	∞	∞ *200*	0/15
RL-SHADE-1	39(34)	10(7)	14(10)	19(7)	18(6)	23(5)	26(3)	15/15
R-SHADE-10	32(21)	10(11)	17(14)	68(73)	∞	∞	∞ *200*	0/15
R-SHADE-10	23(14)	3.4(5)	7.4(11)	**11**(7)	**8.0**(16)	**7.6**(9)	**7.8**(3)	15/15
SOO-Derbel	**1**(0)$^{\star 2}$	**2.0**(0.8)	**3.1**(3)	**5.8**(3)	**6.8**(3)	**14**(4)	**19**(14)	15/15

Table 11: 02-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	30	46	54	61	68	82	98	15/15
MATSUMOTO-	9.1(13)	∞	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	7.3(10)	32(59)	55(49)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	27(53)	62(105)	73(71)	68(116)	77(100)	70(107)	74(94)	15/15
RL-SHADE-1	18(19)	31(38)	53(64)	49(71)	44(26)	∞	∞ *200*	0/15
RL-SHADE-1	15(8)	17(5)	20(2)	**23**(4)	**23**(4)	**25**(4)	**26**(3)	15/15
R-SHADE-10	13(7)	64(93)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**3.2**(1)	**3.2**(1)	**3.6**(0.8)	**3.9**(1)	**4.0**(1)	**4.4**(1.0)	**4.3**(0.9)	15/15
SOO-Derbel	**3.3**(1)	**4.8**(5)	**10**(15)	29(63)	103(87)	303(525)	453(658)	15/15

Table 12: 02-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	35	45	50	62	67	81	97	15/15
MATSUMOTO-	7.9(7)	∞	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	5.1(2)	22(22)	59(60)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	18(19)	23(40)	25(53)	31(31)	39(34)	48(88)	56(48)	15/15
RL-SHADE-1	12(12)	33(38)	∞	∞	∞	∞	∞ *200*	0/15
RL-SHADE-1	14(9)	18(6)	21(4)	**22**(4)	**24**(3)	**25**(5)	**25**(3)	15/15
R-SHADE-10	11(14)	21(24)	57(66)	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**4.7**(4)	**4.9**(3)	**5.3**(2)	**4.7**(0.7)	**4.8**(3)	**4.9**(3)	**4.9**(1)	15/15
SOO-Derbel	**3.0**(0.8)	**5.2**(2)	**14**(18)	46(45)	97(126)	250(179)	488(298)	15/15

Table 13: 02-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	35	46	75	94	105	153	195	15/15
MATSUMOTO-	9.1(8)	32(63)	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	6.4(7)	12(9)	19(20)	**16**(12)	∞	∞	∞ *200*	0/15
R-DE-10e5-	15(25)	29(84)	33(41)	33(58)	37(45)	40(41)	44(45)	15/15
RL-SHADE-1	**4.2**(2)	**7.0**(9)	19(16)	31(41)	28(40)	∞	∞ *200*	0/15
RL-SHADE-1	11(6)	17(5)	15(5)	19(6)	**26**(9)	**26**(10)	**24**(11)	15/15
R-SHADE-10	7.0(9)	32(34)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	4.5(6)	12(8)	**13**(23)	**14**(33)	**15**(15)	**13**(22)	**11**(1)	15/15
SOO-Derbel	**3.9**(6)	**5.2**(3)	**10**(8)	17(9)	46(51)	65(82)	132(89)	15/15

Table 14: 02-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	23	35	46	60	71	95	122	15/15
MATSUMOTO-	**1.6**(0.8)	**3.6**(2)	18(14)	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	4.0(4)	6.0(2)	32(54)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	4.5(3)	6.1(4)	**9.3**(2)	**16**(12)	33(43)	75(60)	341(917)	14/15
RL-SHADE-1	3.9(3)	8.8(8)	32(19)	∞	∞	∞	∞ *200*	0/15
RL-SHADE-1	4.7(4)	15(3)	20(5)	22(5)	**24**(3)	**25**(2)	**25**(1)	15/15
R-SHADE-10	5.8(6)	28(39)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.6**(2)	**3.8**(3)	**5.6**(6)	**5.1**(2)	**5.2**(0.6)	**4.9**(6)	**5.0**(3)	15/15
SOO-Derbel	**2.8**(1)	4.9(5)	15(5)	24(9)	38(65)	113(138)	261(320)	15/15

Table 15: 02-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	1.4	7.4	16	24	38	67	90	15/15
MATSUMOTO-	**1.2**(1)	**1.5**(0.8)	**1.5**(0.4)	**3.1**(3)	20(14)	∞	∞ *100*	0/15
R-DE-10e2-	**1.7**(0.9)	3.1(3)	3.7(1)	4.6(2)	7.6(11)	∞	∞ *200*	0/15
R-DE-10e5-	**1.2**(0.7)	**1.9**(1)	3.6(1)	11(12)	11(18)	14(12)	38(25)	15/15
RL-SHADE-1	**1.6**(0.7)	**2.7**(3)	3.8(2)	4.2(2)	6.4(10)	∞	∞ *200*	0/15
RL-SHADE-1	**1.3**(0.5)	4.3(4)	8.8(7)	17(7)	17(5)	22(2)	24(3)	15/15
R-SHADE-10	**1.5**(0.5)	3.3(3)	5.5(4)	11(5)	19(12)	∞	∞ *200*	0/15
R-SHADE-10	**1.5**(0.7)	3.8(2)	3.9(0.8)	4.4(1)	**4.2**(0.6)	**3.9**(0.6)	**4.0**(0.4)	15/15
SOO-Derbel	**0.81**(0)	**1.8**(2)	**2.6**(1)	**3.7**(2)	**5.9**(7)	**12**(9)	**23**(8)	15/15

Table 16: 02-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	37	291	1033	1066	1113	1231	1412	5/5
MATSUMOTO-	**0.85**(1)	5.1(5)	**1.4**(1)	**1.4**(2)	∞	∞	∞ *100*	0/15
R-DE-10e2-	**1.2**(0.6)	4.8(4)	∞	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	**0.94**(1)	3.3(5)	4.7(6)	5.4(7)	5.6(6)	5.3(6)	4.7(5)	15/15
RL-SHADE-1	**1.8**(2)	**2.3**(3)	**1.4**(0.7)	**1.4**(1)	**2.7**(1)	∞	∞ *200*	0/15
RL-SHADE-1	**1.5**(2)	**2.6**(1)	**1.4**(0.4)	**1.8**(0.4)	**2.0**(0.5)	**2.2**(0.3)	**2.2**(0.3)	15/15
R-SHADE-10	**1.7**(1)	4.9(4)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**1.0**(0.5)	**1.1**(1)	**0.87**(0.6)	**0.91**(2)	**0.91**(2)	**0.89**(1)	**0.83**(0.7)	15/15
SOO-Derbel	**0.75**(0.5)	**0.82**(0.6)	**0.80**(0.4)	**0.89**(2)	**0.91**(0.4)	**1.1**(0.8)	**1.1**(0.2)	15/15

Table 17: 02-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	9.1	50	174	326	358	409	538	15/15
MATSUMOTO-	**2.0**(1)	**1.2**(0.5)	**1.2**(1)	**2.2**(3)	∞	∞	∞ *100*	0/15
R-DE-10e2-	3.3(7)	**2.8**(4)	8.3(7)	4.5(6)	∞	∞	∞ *200*	0/15
R-DE-10e5-	4.6(7)	3.8(2)	**2.9**(2)	4.3(8)	4.1(6)	4.8(3)	4.2(3)	15/15
RL-SHADE-1	**3.0**(3)	3.9(3)	5.1(5)	4.3(5)	8.3(5)	∞	∞ *200*	0/15
RL-SHADE-1	4.3(5)	4.1(3)	5.8(2)	6.6(2)	8.9(5)	10(6)	9.2(1)	15/15
R-SHADE-10	3.1(1)	**3.0**(3)	3.9(3)	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.5**(0.9)	**2.4**(2)	**2.2**(4)	**1.8**(2)	**1.8**(1.0)	**2.2**(3)	**1.8**(2)	15/15
SOO-Derbel	**2.2**(2)	**1.5**(1)	**1.8**(3)	**1.4**(4)	**1.6**(0.6)	**2.0**(2)	**2.1**(2)	15/15

Table 18: 02-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	2.7	61	133	275	396	1086	1657	5/5
MATSUMOTO-	**1.5**(0.9)	**0.88**(1)	**2.5**(3)	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	3.2(9)	**1.1**(0.8)	**1.9**(0.9)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	**1.8**(1)	**0.90**(0.8)	**1.8**(0.7)	**2.2**(2)	**2.6**(2)	3.5(4)	3.2(2)	15/15
RL-SHADE-1	**2.3**(2)	**1.3**(0.4)	**1.8**(0.9)	∞	∞	∞	∞ *200*	0/15
RL-SHADE-1	**1.9**(2)	**2.1**(1)	4.7(1)	4.4(1)	4.7(0.7)	**3.0**(0.3)	**2.6**(0.1)	15/15
R-SHADE-10	**2.8**(4)	**1.5**(2)	11(7)	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.3**(2)	**1.0**(0.2)	**1.2**(0.7)	**0.96**(0.4)	**0.93**(0.3)	**0.97**(0.5)	**0.75**(0.7)	15/15
SOO-Derbel	**1.8**(1)	**0.58**(0.4)	**0.97**(0.5)	**1.0**(0.2)	**1.3**(0.7)	**1.7**(3)	**1.6**(0.2)	15/15

Table 19: 02-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	19	134	666	1249	1708	2438	2858	15/15
MATSUMOTO-	**0.87**(0.7)	**1.7**(1)	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**1.7**(0.7)	**1.2**(1.0)	**1.4**(2)	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	4.9(0.5)	**3.0**(5)	**1.4**(2)	**1.9**(3)	**1.9**(0.4)	15(30)	14(19)	15/15
RL-SHADE-1	**1.4**(1)	**1.5**(2)	∞	∞	∞	∞	∞ *200*	0/15
RL-SHADE-1	**2.1**(1)	**2.7**(1)	**1.6**(1.0)	**1.6**(0.2)	**1.5**(0.1)	**1.6**(0.1)	**1.8**(0.1)	15/15
R-SHADE-10	**1.2**(1)	**2.7**(4)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**1.2**(2)	**2.3**(5)	**0.66**(0.3)	**0.44**(0.5)	**0.54**(0.4)	**0.81**(0.6)	**0.77**(0.5)	15/15
SOO-Derbel	**0.95**(0.4)	**0.90**(0.6)	**0.65**(0.5)	**0.91**(0.8)	**2.0**(2)	4.3(6)	9.0(4)	15/15

Table 20: 02-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	26	216	227	252	276	15/15
MATSUMOTO-	5.8(5)	40(40)	9.3(9)	6.6(5)	∞	∞	∞ *100*	0/15
R-DE-10e2-	**4.2**(4)	40(19)	**4.2**(3)	6.7(5)	13(11)	∞	∞ *200*	0/15
R-DE-10e5-	5.1(4)	**28**(35)	5.6(6)	11(11)	12(6)	22(18)	23(18)	15/15
RL-SHADE-1	5.4(5)	41(35)	7.1(10)	**6.5**(10)	13(13)	∞	∞ *200*	0/15
RL-SHADE-1	7.0(5)	54(64)	7.6(8)	9.1(6)	**10**(6)	**14**(4)	**17**(15)	15/15
R-SHADE-10	5.3(4)	42(24)	8.4(14)	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	4.7(3)	29(21)	**3.3**(3)	**5.2**(2)	**6.0**(9)	**5.8**(4)	**5.6**(7)	15/15
SOO-Derbel	**1**(0)*	**1**(0)$^{\star 3}$	5.0(3)	17(18)	30(33)	98(43)	168(217)	15/15

Table 21: 02-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	3.7	61	365	366	366	370	375	15/15
MATSUMOTO-	**1.8**(1)	5.6(5)	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**2.2**(2)	**2.8**(1)	**1.4**(0.8)	**1.9**(2)	8.2(13)	∞	∞ *200*	0/15
R-DE-10e5-	**2.9**(3)	3.2(6)	5.1(6)	6.0(5)	6.6(6)	8.2(8)	8.6(8)	15/15
RL-SHADE-1	3.1(4)	4.1(2)	3.9(2)	8.0(5)	8.2(8)	∞	∞ *200*	0/15
RL-SHADE-1	3.6(3)	5.0(2)	17(1.0)	18(28)	19(28)	20(54)	21(27)	15/15
R-SHADE-10	3.6(5)	4.4(6)	3.9(6)	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.9**(3)	4.1(7)	**3.2**(2)	**3.5**(3)	**3.7**(4)	**3.9**(2)	**4.1**(2)	15/15
SOO-Derbel	3.9(0.1)	**1.9**(8e-3)	5.1(5e-3)	5.4(1e-2)	**5.6**(8e-3)	**5.8**(9e-3)	**6.3**(7e-3)	15/15

Table 22: 02-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	1.7	51	174	276	290	324	330	15/15
MATSUMOTO-	**1.1**(0.6)	**0.82**(0.4)	**0.51**(0.7)	**0.78**(0.8)	**1.6**(4)	∞	∞ *100*	0/15
R-DE-10e2-	**1.6**(2)	**1.9**(2)	**1.7**(2)	**1.4**(2)	**2.2**(1)	**2.9**(3)	4.4(7)	2/15
R-DE-10e5-	**1.3**(0.8)	7.2(15)	3.3(3)	**2.6**(3)	**2.9**(2)	3.0(3)	3.3(2)	15/15
RL-SHADE-1	**1.1**(1)	**0.89**(0.6)	**0.75**(0.4)	**1.1**(1.0)	**1.5**(2)	4.5(6)	9.1(10)	1/15
RL-SHADE-1	**1.6**(0.8)	**1.2**(2)	**0.98**(0.6)	**1.1**(2)	**1.7**(1)	3.0(0.5)	3.7(0.7)	15/15
R-SHADE-10	**1.5**(0.9)	**1.1**(1)	**0.80**(1)	**1.1**(0.8)	4.7(3)	∞	∞ *200*	0/15
R-SHADE-10	**1.3**(0.3)	**1.3**(1)	**2.0**(4)	**1.5**(3)	**1.5**(1)	**1.6**(2)	**1.7**(1)	15/15
SOO-Derbel	**0.88**(0.8)	**0.69**(0.5)	**0.43**(0.4)	**0.38**(0.1)	**0.57**(0.4)	**0.74**(0.7)	**1.0**(0.7)	15/15

Table 23: 02-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	5.1	27	168	218	249	289	306	15/15
MATSUMOTO-	**1.7**(2)	**1.1**(0.8)	**0.90**(0.9)	3.4(4)	6.2(3)	∞	∞ *100*	0/15
R-DE-10e2-	**1.2**(0.6)	**2.1**(3)	**0.64**(0.5)	**1.1**(0.4)	**1.7**(2)	5.1(4)	10(8)	1/15
R-DE-10e5-	**1.5**(1)	11(29)	3.0(3)	**2.6**(2)	**2.4**(4)	**2.3**(2)	**2.6**(2)	15/15
RL-SHADE-1	**1.5**(0.7)	**2.2**(4)	**0.90**(1)	**2.3**(3)	3.5(4)	4.9(3)	4.7(5)	2/15
RL-SHADE-1	**0.43**(0.5)	**2.5**(3)	17(60)	13(47)	13(2)	12(36)	13(2)	15/15
R-SHADE-10	**0.62**(0.5)	**2.9**(4)	**1.5**(4)	**1.6**(1)	3.8(4)	∞	∞ *200*	0/15
R-SHADE-10	**0.92**(0.8)	4.0(2)	**1.9**(4)	**1.7**(2)	**1.7**(1.0)	**1.6**(2)	**1.7**(1)	15/15
SOO-Derbel	**1**(0.7)	**0.91**(0.9)	**0.71**(1)	**0.83**(0.7)	**1.7**(3)	4.1(0.8)	4.2(9)	15/15

Table 24: 02-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	7.8	193	234	263	299	348	379	15/15
MATSUMOTO-	**1.2**(2)	∞	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**1.8**(2)	**3.3**(3)	∞	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	**1.7**(1)	23(31)	282(311)	266(196)	286(214)	352(219)	475(672)	9/15
RL-SHADE-1	**1.9**(2)	∞	∞	∞	∞	∞	∞ *200*	0/15
RL-SHADE-1	**2.0**(3)	6.6(3)	41(89)	146(115)	148(200)	129(115)	120(158)	15/15
R-SHADE-10	**2.4**(2)	15(10)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**2.3**(3)	4.0(6)	**16**(16)	**15**(9)	**13**(22)	**12**(11)	**11**(15)	15/15
SOO-Derbel	**2.6**(2)	**2.0**(1)	**2.7**(0.8)	**3.5**(2)	**4.4**(3)	**6.8**(3)	**9.3**(3)	15/15

Table 25: 02-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	18	857	8515	23399	24113	24721	24721	5/15
MATSUMOTO-	**1.5**(2)	∞	∞	∞	∞	∞	∞ *100*	0/15
R-DE-10e2-	**1.0**(0.9)	∞	∞	∞	∞	∞	∞ *200*	0/15
R-DE-10e5-	**1.1**(0.6)	12(6)	10(9)	6.9(9)	8.6(14)	8.4(6)	8.4(9)	9/15
RL-SHADE-1	**1.6**(1.0)	∞	∞	∞	∞	∞	∞ *200*	0/15
RL-SHADE-1	**1.2**(0.5)	49(58)	**5.1**(2)	**2.0**(2)	**2.0**(3)	**1.9**(0.8)	**1.9**(2)	15/15
R-SHADE-10	**1.7**(2)	**3.4**(5)	∞	∞	∞	∞	∞ *200*	0/15
R-SHADE-10	**1.0**(0.3)	**3.2**(5)	**1.3**(1)	**1.4**(0.9)	**1.5**(2)	**1.5**(0.8)	**1.5**(2)	15/15
SOO-Derbel	**1.5**(1)	4.1(19)	5.9(6)	56(43)	54(52)	53(45)	53(47)	2/15

References

[1] Anne Auger, Steffen Finck, Nikolaus Hansen, and Raymond Ros. BBOB 2009: Comparison tables of all algorithms on all noiseless functions. Technical Report RT-0383, INRIA, April 2010.

[2] Dimo Brockhoff. Comparison of the matsumoto library for expensive optimization on the noiseless black-box optimization benchmarking testbed. In *Proceedings of the IEEE Congress on Evolutionary Computation, CEC 2015, 25-28 May, Sendai, Japan*, 2015.

[3] Bilel Derbel and Philippe Preux. Simultaneous optimistic optimization on the noiseless bbob testbed. In *Proceedings of the IEEE Congress on Evolutionary Computation, CEC 2015, 25-28 May, Sendai, Japan*, 2015.

[4] S. Finck, N. Hansen, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Presentation of the noiseless functions. Technical Report 2009/20, Research Center PPE, 2009. Updated February 2010.

[5] N. Hansen, A. Auger, S. Finck, and R. Ros. Real-parameter black-box optimization benchmarking 2012: Experimental setup. Technical report, INRIA, 2012.

[6] N. Hansen, S. Finck, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Noiseless functions definitions. Technical Report RR-6829, INRIA, 2009. Updated February 2010.

[7] Ryoji Tanabe and Alex Fukunaga. Parameter tuning for differential evolution for cheap, medium, and expensive computational budgets. In *Proceedings of the IEEE Congress on Evolutionary Computation, CEC 2015, 25-28 May, Sendai, Japan*, 2015.