

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 (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 at CEC 2015.

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

algorithm name	short	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) ^{*3}	4.5 (0.8) ^{*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 $ERT/ERT_{\text{best 2009}}$ 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
<i>f2</i>	16	19	25	25	26	28	29	15/15
MATSUMOTO	11(11)	76(83)	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	5.6 (2)	7.6 (2)	8.8(3)	16(8)	29(23)	∞	∞ <i>200</i>	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)	∞	∞ <i>200</i>	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)	∞	∞	∞ <i>200</i>	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
<i>f3</i>	15	271	445	446	450	454	464	15/15
MATSUMOTO	3.0(0.9)	6.1(6)	3.7(6)	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	2.8 (4)	0.97 (1)	1.5 (2)	∞	∞	∞	∞ <i>200</i>	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)	∞	∞ <i>200</i>	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)	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	1.9 ⁽¹⁾	2.0 ⁽²⁾	∞	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞ <i>200</i>	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) *4	2.5 ₍₁₎ *4	2.5 _(0.9) *4	2.5 _(0.5) *4	2.5 _(0.8) *4	2.5 ₍₁₎ *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

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.

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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
<i>f7</i>	3.2	21	60	193	217	217	241	15/15
MATSUMOTO-R-DE-10e2-	2.8 (2)	1.4 (0.5)	0.97 (0.4)	0.84 (0.7)	2.2 (3)	2.2 (3)	∞ <i>100</i>	0/15
RL-SHADE-1	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
R-SHADE-10	2.9 (3)	2.7 (3)	4.1(6)	5.0(8)	∞	∞	∞ <i>200</i>	0/15
SOO-Derbel	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

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)	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	4.8(3)	8.8(7)	27(33)	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞ <i>200</i>	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)	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	19(18)	6.0(6)	15(19)	33(38)	∞	∞	∞ <i>200</i>	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)	∞	∞ <i>200</i>	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)	∞	∞	∞ <i>200</i>	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) ^{*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 $\text{ERT}/\text{ERT}_{\text{best } 2009}$ 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⁾	∞	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	7.3 ⁽¹⁰⁾	32 ⁽⁵⁹⁾	55 ⁽⁴⁹⁾	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞	∞	100/15
R-DE-10e2-	5.1(2)	22(22)	59(60)	∞	∞	∞	∞	200/15
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)	∞	∞	∞	∞	∞	200/15
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)	∞	∞	∞	∞	200/15
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 15: 02-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}} 2009$ 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 $\text{ERT}/\text{ERT}_{\text{best}} 2009$ 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)	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	1.2 (0.6)	4.8(4)	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	3.3(7)	2.8 (4)	8.3(7)	4.5(6)	∞	∞	∞ <i>200</i>	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)	∞	∞ <i>200</i>	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)	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	3.2 ⁽⁹⁾	1.1 ^(0.8)	1.9 ^(0.9)	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	1.7 ^(0.7)	1.2 ^(1.0)	1.4 ⁽²⁾	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞	∞ <i>200</i>	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⁾	∞	∞	∞	∞	∞ <i>200</i>	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 $\text{ERT}/\text{ERT}_{\text{best 2009}}$ 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	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)* 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)	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	2.2 (2)	2.8 (1)	1.4 (0.8)	1.9 (2)	8.2(13)	∞	∞ <i>200</i>	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)	∞	∞ <i>200</i>	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)	∞	∞	∞	∞ <i>200</i>	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 $\text{ERT}/\text{ERT}_{\text{best}} 2009$ 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⁾	∞	∞ <i>100</i>	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⁾	∞	∞ <i>200</i>	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 $\text{ERT}/\text{ERT}_{\text{best } 2009}$ 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)	∞	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	1.8 (2)	3.3 (3)	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞ <i>200</i>	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 $\text{ERT}/\text{ERT}_{\text{best}} 2009$ 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)	∞	∞	∞	∞	∞	∞ <i>100</i>	0/15
R-DE-10e2-	1.0 (0.9)	∞	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞	∞ <i>200</i>	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)	∞	∞	∞	∞	∞ <i>200</i>	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

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