

Comparison tables: BBOB 2010 function testbed with BBOB 2009 as reference in 2-D

The BBOBies

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Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2010, see <http://coco.gforge.inria.fr/doku.php?id=bbob-2010>. More than 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 [16, 12]. The experimental set-up is described in [15].

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 [7]) 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 [15] 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: 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

1 Sphere											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	4.9	7.8	14	19	24	32	38	53	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.1	2.3	8.4	15	19	28	34	48	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	2.8	2.9	6.5	11	17	24	29	39	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	5.2	3.4	8.2	11	20	28	36	49	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	3.8	3.4	6.4	9.4	14	20	24	32	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	2.1	2.3	6.6	10	16	19	22	30	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.1	3.3	2.4	4.8	8.5	11	14	17	24	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	5.1	3.5	6.4	9.0	13	16	19	25	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.9	3.4	7.1	11	13	18	20	27	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	3.0	2.4	6.0	9.3	13	16	20	25	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.3	7.4	22	38	60	82	105	151	Artif Bee Colony [9]
avg NEWUOA	1	1	1.9	1.1	1.1	0.97	0.97	0.97	0.97	0.97	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	7.7	14	7.3	15	22	47	66	94	125	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	3.6	6.1	19	29	39	58	69	101	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	2.5	4.5	18	31	44	57	71	100	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	3.6	3.3	8.3	11	17	22	26	36	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	5.1	4.5	10	15	19	23	27	36	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	2.3	3.6	22	44	74	92	122	171	CMA+DE-MOS [19]
NBC-CMA	1	1	2.5	4.1	29	53	69	85	94	116	NBC-CMA [22]
POEMS	1	1	172	84	116	324	694	986	1394	1965	POEMS [18]
PM-AdapSS-DE	1	1.1	2.3	3.3	16	25	38	55	67	91	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	54	82	153	342	2401	4014	6242	12106	pPOEMS [18, 21]
Basic RCGA	1	1	2.2	9.2	46	77	188	346	466	734	Basic RCGA [25]
SPSA	1	27	42	20	26	28	33	38	46	61	SPSA [14]

Table 2: 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

2 Ellipsoid separable											
$\Delta\text{ftarget}$ ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ ERT_{best}/D
(1,2)-CMA-ES	10	42	67	80	65	66	66	65	64	67	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	30	85	99	85	86	86	83	82	85	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.8	26	55	70	61	62	63	61	61	63	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.9	46	201	214	168	166	166	160	157	156	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.0	4.8	17	26	24	26	27	26	27	28	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.3	6.2	23	29	25	25	26	26	26	28	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.5	6.0	18	19	18	19	19	19	19	20	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.6	9.3	19	26	22	23	23	23	23	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.2	8.1	11	16	14	15	15	15	16	17	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	3.5	4.8	5.8	11	11	12	12	13	13	14	(1+2ms)-CMA-ES [2]
Artif Bee Colony	14	20	22	32	38	46	52	56	62	77	Artif Bee Colony [9]
avg NEWUOA	1.2	1.1	1.9	5.6	8.5	10	14	17	20	27	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	11	269	1331	1953	4172	4065	3995	3783	3689	3624	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	8.2	10	14	16	16	19	22	23	26	31	Adap DE (F-AUC) [11]
DE (Uniform)	8.0	10	12	16	16	19	22	23	27	32	DE (Uniform) [10]
IPOP-aCMA-ES	4.6	5.1	14	18	15	16	17	17	18	19	IPOP-aCMA-ES [17]
IPOP-CMA-ES	4.2	7.5	16	21	18	19	20	20	21	22	IPOP-CMA-ES [23]
CMA+DE-MOS	13	20	24	30	34	40	45	54	59	69	CMA+DE-MOS [19]
NBC-CMA	15	21	38	102	118	157	203	253	295	305	NBC-CMA [22]
POEMS	179	330	377	408	392	450	546	568	642	807	POEMS [18]
PM-AdapSS-DE	7.5	11	12	15	15	19	22	24	25	30	PM-AdapSS-DE [10, 11]
pPOEMS	156	708	1840	2152	2416	2672	3142	3515	4175	5218	pPOEMS [18, 21]
Basic RCGA	10	18	37	56	64	125	155	266	350	543	Basic RCGA [25]
SPSA	12	149	1599	8950	13921	17255	<i>33e-2/1e5</i>	.	.	.	SPSA [14]

Table 3: 02-D, running time excess ERT/ERT_{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

3 Rastrigin separable											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1.1	3.2	14	15	47	47	47	47	47	46	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	2.1	3.3	8.4	28	35	43	43	43	42	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.3	3.0	3.4	6.2	18	25	25	25	25	25	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	4.7	18	15	44	44	43	51	51	50	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.6	2.5	10	8.8	14	14	14	14	14	14	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	3.5	3.8	5.4	6.1	6.1	6.1	6.2	6.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.3	2.0	2.1	3.0	8.5	11	11	11	11	11	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.1	4.5	5.3	7.1	20	24	24	24	24	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.6	5.6	12	26	26	26	26	26	26	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.5	9.2	6.6	8.6	8.6	8.6	8.6	8.6	8.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	1.7	5.6	1.7	1.6	2.4	2.9	3.5	4.1	5.0	Artif Bee Colony [9]
avg NEWUOA	1	2.7	5.1	1.6	3.2	3.2	3.2	3.2	3.2	3.1	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	5.1	10	96	273	443	726	1244	2884	2875	2815	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.3	1.6	5.3	2.0	1.6	2.0	2.4	2.6	2.8	3.1	Adap DE (F-AUC) [11]
DE (Uniform)	1.2	1.6	5.2	2.0	1.7	2.3	2.5	2.7	2.9	3.1	DE (Uniform) [10]
IPOP-aCMA-ES	1.1	2.5	4.2	3.5	7.1	7.4	7.6	7.7	7.8	8.0	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.2	4.2	4.2	3.3	7.7	8.0	8.7	8.9	9.0	9.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1.1	2.2	6.7	2.4	2.2	2.9	3.4	3.8	4.3	5.1	CMA+DE-MOS [19]
NBC-CMA	1.3	1.7	6.3	4.9	6.5	9.4	10	10	10	10	NBC-CMA [22]
POEMS	1	220	42	10	12	18	23	29	32	41	POEMS [18]
PM-AdapSS-DE	1.3	1.6	5.0	1.8	34	34	34	34	34	34	PM-AdapSS-DE [10, 11]
pPOEMS	1	2.1	45	22	42	103	125	157	201	267	pPOEMS [18, 21]
Basic RCGA	1.1	1.6	5.9	18	18	38	67	79	81	83	Basic RCGA [25]
SPSA	22	10266	998	943	1281	<i>14e-1/1e5</i>	.	.	.	.	SPSA [14]

Table 4: 02-D, running time excess ERT/ERT_{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

	4 Skew Rastrigin-Bueche separ										
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	0.50	0.50	11	172	230	248	261	270	272	283	ERT_{best}/D
(1,2)-CMA-ES	1	5.0	8.4	13	58	73	70	68	67	65	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.1	3.1	7.9	10	26	30	29	28	28	27	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	3.2	2.2	13	48	46	43	42	42	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	8.9	6.9	30	72	68	65	63	63	61	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	3.0	1.3	7.9	27	25	24	23	23	22	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	2.7	2.0	8.5	24	27	26	25	25	24	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	5.5	6.0	5.0	14	17	16	16	16	15	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	3.3	3.4	3.9	18	17	16	16	16	15	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	2.0	3.6	13	48	44	42	41	41	39	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.5	1.7	4.8	13	12	12	11	11	11	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.0	2.7	3.7	1.9	2.6	3.0	3.4	3.9	4.6	5.6	Artif Bee Colony [9]
avg NEWUOA	1	4.5	6.2	4.0	14	13	12	12	12	11	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	11	23	19	178	1790	5680	5391	5242	5200	4998	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	2.8	4.0	2.0	111	103	98	95	95	91	Adap DE (F-AUC) [11]
DE (Uniform)	1	2.5	4.5	1.9	111	104	142	137	136	131	DE (Uniform) [10]
IPOP-aCMA-ES	1	4.1	3.1	5.7	39	62	80	84	85	85	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.1	7.5	4.7	12	61	97	114	169	171	171	IPOP-CMA-ES [23]
CMA+DE-MOS	1.1	3.3	4.3	3.1	5.2	5.8	6.1	6.3	6.8	7.6	CMA+DE-MOS [19]
NBC-CMA	1	2.7	6.6	5.8	14	16	16	20	26	25	NBC-CMA [22]
POEMS	1	302	34	14	29	31	35	37	40	47	POEMS [18]
PM-AdapSS-DE	1	3.8	3.7	147	292	271	257	249	248	238	PM-AdapSS-DE [10, 11]
pPOEMS	1	2.6	34	31	45	103	131	150	180	216	pPOEMS [18, 21]
Basic RCGA	1.1	3.6	9.0	39	222	472	2793	<i>36e-3/5e4</i>	.	.	Basic RCGA [25]
SPSA	25	18094	4669	3783	<i>47e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 5: 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

5 Linear slope											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	5.0	8.3	9.0	9.0	9.0	9.0	9.0	9.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.6	5.3	5.5	5.5	5.5	5.5	5.5	5.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.7	2.8	2.9	3.0	3.0	3.0	3.0	3.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	2.1	5.1	5.7	5.8	5.8	5.8	5.8	5.8	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	3.0	4.2	4.6	4.6	4.6	4.6	4.6	4.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	2.5	4.6	4.8	4.8	4.8	4.8	4.8	4.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.1	3.2	3.6	3.6	3.6	3.6	3.6	3.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	2.3	5.2	5.6	5.6	5.6	5.6	5.6	5.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.2	4.5	4.8	4.8	4.8	4.8	4.8	4.8	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	1.8	2.9	3.2	3.2	3.2	3.2	3.2	3.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	4.6	19	25	26	26	26	26	26	Artif Bee Colony [9]
avg NEWUOA	1	1.2	1.1	1.5	1.6	1.6	1.6	1.6	1.6	1.6	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	1.1	3.3	7.0	7.1	7.1	7.1	7.1	7.1	7.1	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	3.3	9.0	10	10	10	10	10	10	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.1	5.1	14	15	15	15	15	15	15	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	3.2	5.7	6.1	6.1	6.1	6.1	6.1	6.1	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	3.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.2	5.9	19	23	24	24	24	24	24	CMA+DE-MOS [19]
NBC-CMA	1	1.1	4.3	61	72	75	75	75	75	75	NBC-CMA [22]
POEMS	1	1	127	141	157	167	172	173	173	173	POEMS [18]
PM-AdapSS-DE	1	1	7.0	9.2	11	11	11	11	11	11	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	63	147	160	164	165	165	165	165	pPOEMS [18, 21]
Basic RCGA	1	1	5.7	606	1162	2198	3308	4594	5752	33282	Basic RCGA [25]
SPSA	1	6.9	18	37	40	40	40	40	40	40	SPSA [14]

Table 6: 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

6 Attractive sector											
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D											ERT_{best}/D
(1,2)-CMA-ES	3.4	2.4	4.4	4.7	3.9	5.1	6.5	6.6	6.8	6.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.7	2.5	2.4	4.6	5.9	5.8	6.0	7.4	6.9	6.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.0	4.2	3.2	4.5	3.8	4.3	5.6	5.6	5.2	5.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.4	2.8	4.1	7.4	16	14	14	13	12	11	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.3	2.8	1.6	2.8	2.6	2.9	3.1	3.1	3.1	3.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	2.3	1.4	2.2	2.7	3.0	3.0	3.0	3.0	3.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.8	1.5	1.7	2.7	2.5	2.4	2.5	2.4	2.4	2.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	6.1	4.4	2.0	2.6	2.7	2.6	2.7	2.8	2.7	2.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.9	2.7	2.1	2.5	2.2	2.3	2.2	2.2	2.1	2.1	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	2.1	1.6	1.1	1.9	1.8	2.0	1.9	2.0	2.0	2.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.4	3.9	2.8	9.5	20	51	149	571	874	1167	Artif Bee Colony [9]
avg NEWUOA	1.4	2.1	3.1	4.7	3.9	4.4	4.4	4.5	4.7	4.6	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	13	132	72	909	1848	1428	1564	1318	1120	1129	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	2.8	1.9	2.9	5.9	6.3	7.3	7.8	8.5	8.6	8.9	Adap DE (F-AUC) [11]
DE (Uniform)	2.8	3.0	2.9	7.8	7.8	8.5	9.1	9.2	9.4	10	DE (Uniform) [10]
IPOP-aCMA-ES	4.2	3.0	2.1	3.2	3.2	3.5	4.0	4.0	4.0	3.8	IPOP-aCMA-ES [17]
IPOP-CMA-ES	4.6	3.5	2.3	5.0	4.2	4.7	4.5	4.6	4.4	4.5	IPOP-CMA-ES [23]
CMA+DE-MOS	3.2	2.3	2.4	12	13	16	16	18	17	18	CMA+DE-MOS [19]
NBC-CMA	3.1	2.6	3.0	8.4	33	28	24	22	20	17	NBC-CMA [22]
POEMS	204	157	61	92	99	112	121	138	136	147	POEMS [18]
PM-AdapSS-DE	2.9	2.3	1.9	4.0	6.1	8.2	8.8	9.0	8.8	8.9	PM-AdapSS-DE [10, 11]
pPOEMS	68	62	54	116	362	602	806	846	915	976	pPOEMS [18, 21]
Basic RCGA	4.3	16	6.0	121	375	596	1340	1819	3139	5724	Basic RCGA [25]
SPSA	75	4649	10152	8487	7901	8286	19888	<i>27e-2/1e5</i>	.	.	SPSA [14]

Table 7: 02-D, running time excess ERT/ERT_{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

7 Step-ellipsoid											
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	0.50	1	1.6	11	30	97	108	108	108	121	ERT_{best}/D
(1,2)-CMA-ES	1.5	3.5	6.2	6.5	24	13	37	37	37	259	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.9	2.0	5.5	9.2	10	17	23	23	23	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.5	1.9	4.3	4.5	13	24	32	32	32	69	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	2.5	3.5	21	21	15	27	35	35	35	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.4	2.5	5.1	3.6	4.1	2.8	3.0	3.0	3.0	4.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	1.8	4.9	5.7	4.8	4.9	5.3	5.3	5.3	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.3	1.5	16	6.3	4.4	2.3	2.7	2.7	2.7	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.7	2.1	3.5	5.0	3.8	3.6	5.6	5.6	5.6	7.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.1	1.2	3.7	2.7	2.0	0.72	0.70	0.70	0.70	0.72	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.3	1.6	4.7	4.3	2.6	1.1	1.0	1.0	1.0	0.99	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.5	1.8	6.4	4.2	9.5	17	60	60	60	123	Artif Bee Colony [9]
avg NEWUOA	1.7	2.7	4.0	3.7	6.8	5.0	10	10	10	9.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	268	296	861	719	589	936	1093	1093	1093	1610	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.3	1.7	3.9	2.9	2.3	1.3	1.4	1.4	1.4	1.6	Adap DE (F-AUC) [11]
DE (Uniform)	1.8	2.5	6.5	3.9	2.8	1.3	1.3	1.3	1.3	1.4	DE (Uniform) [10]
IPOP-aCMA-ES	2.4	2.7	6.2	3.8	2.6	1.0	1.1	1.1	1.1	1.4	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1.3	2.9	7.4	4.0	3.7	1.9	1.7	1.7	1.7	1.9	IPOP-CMA-ES [23]
CMA+DE-MOS	1.4	2.4	4.3	3.9	5.2	3.0	3.4	3.4	3.4	3.5	CMA+DE-MOS [19]
NBC-CMA	1.9	2.1	4.0	3.9	4.5	2.5	2.7	2.7	2.7	4.5	NBC-CMA [22]
POEMS	182	189	166	39	41	19	22	22	22	24	POEMS [18]
PM-AdapSS-DE	1.5	2.2	4.3	3.2	2.6	1.4	1.4	1.4	1.4	1.6	PM-AdapSS-DE [10, 11]
pPOEMS	1.7	33	109	41	45	69	96	96	96	125	pPOEMS [18, 21]
Basic RCGA	1.2	1.5	4.1	7.0	81	127	240	240	240	302	Basic RCGA [25]
SPSA	354	7871	17652	39270	<i>34e-1/1e5</i>	.	.	.	.	.	SPSA [14]

Table 8: 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

8 Rosenbrock original											
$\Delta\text{ftarget}$ ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ ERT_{best}/D
(1,2)-CMA-ES	6.5	6.0	26	65	36	35	22	22	23	20	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.2	4.1	24	47	27	30	18	18	18	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.3	5.4	5.7	19	15	21	12	12	12	11	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.1	4.5	53	236	123	117	87	90	96	82	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.8	3.1	5.3	22	14	13	8.0	8.2	8.4	7.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.4	3.8	5.5	8.0	6.8	7.9	5.4	5.7	6.1	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.3	2.7	2.9	10	7.0	8.7	5.1	5.0	5.2	4.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	2.6	5.6	18	11	11	7.0	7.2	7.2	6.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.1	3.1	5.2	12	6.5	6.8	4.0	4.2	4.3	4.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	2.5	1.9	3.6	6.6	5.0	5.3	3.2	3.2	3.4	3.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.7	2.6	5.7	10	18	188	822	4247	18261	<i>92e-6/1e5</i>	Artif Bee Colony [9]
avg NEWUOA	3.9	2.5	2.6	4.6	2.4	2.4	1.4	1.4	1.4	1.3	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	36	16	20	42	34	43	24	26	26	25	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	4.6	3.9	7.3	11	6.3	10	6.7	7.7	8.2	8.5	Adap DE (F-AUC) [11]
DE (Uniform)	2.9	2.9	6.6	10	399	320	173	163	161	136	DE (Uniform) [10]
IPOP-aCMA-ES	5.2	4.5	6.6	7.9	7.6	8.6	5.2	5.2	5.6	5.2	IPOP-aCMA-ES [17]
IPOP-CMA-ES	9.2	5.2	5.5	14	10	11	6.3	6.4	6.7	6.1	IPOP-CMA-ES [23]
CMA+DE-MOS	2.6	2.9	6.2	16	15	22	14	15	17	17	CMA+DE-MOS [19]
NBC-CMA	2.9	3.5	6.0	10	13	20	13	14	17	17	NBC-CMA [22]
POEMS	238	111	207	379	173	185	119	138	177	193	POEMS [18]
PM-AdapSS-DE	3.4	3.3	6.9	8.0	7.5	8.5	6.0	6.9	7.5	7.9	PM-AdapSS-DE [10, 11]
pPOEMS	40	85	111	109	128	486	463	546	796	1002	pPOEMS [18, 21]
Basic RCGA	2.6	3.1	10	16	144	478	781	1572	7166	12810	Basic RCGA [25]
SPSA	931	548	3157	7112	22724	61485	33559	<i>85e-2/1e5</i>	.	.	SPSA [14]

Table 9: 02-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 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

9 Rosenbrock rotated											
$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	2.9	8.1	69	38	55	51	36	33	32	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.7	10	24	19	26	28	21	19	19	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.2	6.1	22	15	22	22	17	16	16	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.3	6.4	21	43	108	87	65	60	59	55	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.0	10	21	8.0	11	11	8.1	7.5	7.7	7.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.7	6.9	22	3.2	11	9.5	7.5	7.1	7.1	7.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.9	8.3	29	4.0	6.1	6.2	4.7	4.5	4.5	4.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.5	9.1	15	8.3	10	10	8.0	7.5	7.6	7.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	5.3	10	21	5.5	6.4	5.7	4.2	4.1	4.2	4.1	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	3.5	6.9	26	5.0	5.3	5.1	3.7	3.6	3.6	3.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.9	10	29	6.8	14	42	242	1552	5121	9398	Artif Bee Colony [9]
avg NEWUOA	7.7	10	22	4.7	4.0	3.2	2.3	2.1	2.0	1.9	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	16	39	693	65	58	49	34	31	31	29	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	5.0	14	44	7.9	489	342	224	200	388	344	Adap DE (F-AUC) [11]
DE (Uniform)	3.1	8.9	28	7.3	10	12	10	10	10	11	DE (Uniform) [10]
IPOP-aCMA-ES	2.0	4.8	22	6.8	8.8	8.0	6.3	5.8	6.0	5.9	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.7	11	39	10	12	11	7.8	7.4	7.3	7.2	IPOP-CMA-ES [23]
CMA+DE-MOS	1.9	11	20	6.2	8.4	11	11	11	13	14	CMA+DE-MOS [19]
NBC-CMA	3.3	7.3	32	8.1	18	17	13	14	16	17	NBC-CMA [22]
POEMS	337	444	558	58	75	104	106	106	127	156	POEMS [18]
PM-AdapSS-DE	7.1	19	33	11	497	716	467	412	390	346	PM-AdapSS-DE [10, 11]
pPOEMS	159	319	558	51	173	500	609	674	894	1105	pPOEMS [18, 21]
Basic RCGA	3.3	10	49	8.0	29	206	994	1278	2857	15260	Basic RCGA [25]
SPSA	469	1759	55199	8901	<i>96e-2/1e5</i>	.	.	.	.	.	SPSA [14]

Table 10: 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

10 Ellipsoid											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	13	56	39	39	36	34	30	28	27	23	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	8.9	25	49	36	33	30	27	26	25	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.4	14	29	23	22	23	21	20	19	17	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.7	109	120	115	106	95	92	85	80	68	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.4	6.0	8.9	11	11	11	10	9.2	8.8	8.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	7.9	10	12	13	12	11	10	10	9.4	8.5	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	6.1	5.9	7.9	7.5	8.1	7.6	7.1	6.8	6.6	5.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	5.8	8.7	8.8	8.3	8.7	8.4	8.4	7.9	7.5	6.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	9.3	7.0	6.4	5.5	5.6	5.6	5.2	5.0	5.0	4.6	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	5.9	4.6	5.7	5.6	5.4	5.0	4.8	4.6	4.5	4.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	12	13	20	97	771	6940	<i>11e-3/1e5</i>	.	.	.	Artif Bee Colony [9]
avg NEWUOA	2.6	3.6	3.8	4.8	6.9	7.6	8.8	9.5	10	11	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	13	62	144	364	642	865	772	697	647	545	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	12	10	6.8	6.9	7.2	7.8	8.2	8.4	8.5	8.6	Adap DE (F-AUC) [11]
DE (Uniform)	9.1	10	7.2	7.0	7.5	8.1	8.4	8.6	9.1	9.3	DE (Uniform) [10]
IPOP-aCMA-ES	8.8	8.8	5.3	5.4	5.8	6.1	5.9	5.6	5.4	5.3	IPOP-aCMA-ES [17]
IPOP-CMA-ES	9.4	9.1	10	8.7	8.4	7.8	7.5	7.1	6.9	6.4	IPOP-CMA-ES [23]
CMA+DE-MOS	13	14	13	19	20	20	20	20	20	20	CMA+DE-MOS [19]
NBC-CMA	16	24	25	51	64	77	81	90	96	87	NBC-CMA [22]
POEMS	103	87	302	742	1322	1758	1884	2353	2694	2655	POEMS [18]
PM-AdapSS-DE	8.8	10	7.4	6.5	7.3	7.4	7.8	8.2	8.5	8.9	PM-AdapSS-DE [10, 11]
pPOEMS	90	117	155	463	837	1017	1256	1447	1579	1747	pPOEMS [18, 21]
Basic RCGA	25	27	115	1504	1874	3104	6551	19727	<i>17e-3/5e4</i>	.	Basic RCGA [25]
SPSA	29	229	874	1873	16681	24345	<i>27e-2/1e5</i>	.	.	.	SPSA [14]

Table 11: 02-D, running time excess ERT/ERT_{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

	11 Discus										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	5.1	22	26	35	35	31	28	26	25	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	12	44	33	36	34	30	28	26	25	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.6	21	24	26	27	26	25	23	22	19	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	35	53	75	105	87	85	77	72	61	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.9	11	12	12	11	10	10	9.1	8.8	7.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.9	6.6	12	13	12	11	10	10	9.3	8.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.2	6.1	6.9	8.5	9.2	8.4	8.0	7.4	7.1	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	10	18	11	10	10	8.6	8.3	7.9	7.6	6.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.5	6.9	4.2	6.5	6.7	5.8	5.5	5.3	5.1	4.8	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	3.9	5.6	3.3	5.5	5.6	5.0	4.9	4.6	4.6	4.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.3	13	11	103	813	7859	40809	<i>11e-3/1e5</i>	.	.	Artif Bee Colony [9]
avg NEWUOA	1.3	1.5	1.5	3.3	5.1	5.4	6.8	7.3	8.0	8.8	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	8.1	128	517	994	1265	1264	1159	1041	962	812	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	7.6	13	6.3	7.0	8.0	7.9	8.2	8.7	8.8	9.0	Adap DE (F-AUC) [11]
DE (Uniform)	9.0	12	6.0	6.9	7.8	8.3	8.5	8.9	9.0	9.4	DE (Uniform) [10]
IPOP-aCMA-ES	4.2	6.7	5.1	6.7	6.9	6.2	6.0	5.9	5.8	5.5	IPOP-aCMA-ES [17]
IPOP-CMA-ES	5.1	12	7.5	8.3	8.7	7.6	7.4	7.1	6.8	6.4	IPOP-CMA-ES [23]
CMA+DE-MOS	11	23	13	19	23	21	21	21	21	20	CMA+DE-MOS [19]
NBC-CMA	13	22	24	41	58	66	87	97	101	88	NBC-CMA [22]
POEMS	68	69	533	811	1297	1891	2292	2546	2824	3255	POEMS [18]
PM-AdapSS-DE	7.9	12	6.2	7.3	8.2	8.3	8.8	9.1	9.1	9.4	PM-AdapSS-DE [10, 11]
pPOEMS	76	124	113	477	866	1087	1260	1491	1643	1787	pPOEMS [18, 21]
Basic RCGA	10	23	75	958	2135	6917	<i>44e-3/5e4</i>	.	.	.	Basic RCGA [25]
SPSA	15	483	1404	4983	17942	46844	42861	38450	<i>50e-2/1e5</i>	.	SPSA [14]

Table 12: 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

	12 Bent cigar										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	5.9	12	12	24	27	31	33	31	35	30	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.4	30	32	28	26	26	24	22	20	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	21	38	42	52	43	37	34	29	25	21	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.9	37	95	170	142	116	105	88	73	57	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	9.3	12	16	21	18	16	16	14	13	11	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	8.6	11	16	21	19	18	17	16	15	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	4.5	8.0	16	22	18	16	15	14	12	10	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.9	6.8	14	20	16	15	14	13	11	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.6	7.0	8.8	10	7.7	7.0	6.7	6.1	5.6	5.2	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	4.6	3.2	4.2	7.6	6.9	6.5	6.5	6.4	5.9	5.6	(1+2ms)-CMA-ES [2]
Artif Bee Colony	8.9	7.7	13	175	568	1467	2630	3353	2793	2258	Artif Bee Colony [9]
avg NEWUOA	1.7	1.1	0.96	1.6	1.5	1.5	1.5	1.5	1.4	1.4	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	10	438	1070	8143	10929	8731	12445	22378	18388	<i>15e-1/1e5</i>	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	11	7.9	8.1	8.2	7.5	7.1	7.6	7.9	7.6	7.2	Adap DE (F-AUC) [11]
DE (Uniform)	10	7.7	8.1	320	417	334	302	253	209	165	DE (Uniform) [10]
IPOP-aCMA-ES	4.4	3.8	5.0	7.8	8.3	8.2	8.5	8.1	13	11	IPOP-aCMA-ES [17]
IPOP-CMA-ES	4.6	7.0	10	12	9.3	9.0	8.6	7.8	7.3	6.5	IPOP-CMA-ES [23]
CMA+DE-MOS	13	12	16	22	18	18	19	19	18	17	CMA+DE-MOS [19]
NBC-CMA	14	13	20	66	73	69	76	80	69	57	NBC-CMA [22]
POEMS	91	79	332	726	1039	1490	2235	2363	2530	2595	POEMS [18]
PM-AdapSS-DE	9.5	9.0	8.3	8.6	197	334	301	405	334	263	PM-AdapSS-DE [10, 11]
pPOEMS	76	78	282	408	622	667	730	788	801	843	pPOEMS [18, 21]
Basic RCGA	13	23	118	730	852	804	1022	912	1577	1575	Basic RCGA [25]
SPSA	3230	4072	15645	60799	37286	29781	<i>30e+0/1e5</i>	.	.	.	SPSA [14]

Table 13: 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

13 Sharp ridge												
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D	
(1,2)-CMA-ES	2.2	3.4	17	30	31	29	29	28	28	37	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	1.1	3.5	13	32	41	39	40	50	67	68	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	2.1	13	11	26	30	31	37	43	51	51	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	1.1	19	69	57	99	97	94	115	102	152	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	1.3	3.9	7.1	10	10	8.5	10	10	10	10	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	1.7	3.5	6.3	7.7	7.7	11	11	11	11	11	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1.5	2.4	2.9	6.5	8.2	7.2	7.4	7.4	7.3	8.0	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	1.3	6.3	9.2	10	10	10	10	10	10	10	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1.4	2.3	4.1	5.6	6.8	6.6	6.1	6.0	7.1	8.0	(1+1)-CMA-ES [8]	
(1+2ms)-CMA-ES	1.1	1.8	3.7	5.6	9.1	8.2	8.1	7.5	8.1	8.9	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	1.4	3.6	5.6	61	2262	18469	<i>23e-3/1e5</i>	.	.	.	Artif Bee Colony [9]	
avg NEWUOA	1.8	6.7	6.7	17	38	54	73	131	140	771	avg NEWUOA [24]	
CMA-EGS (IPOP,r1)	17	95	386	2717	4951	9966	<i>48e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [13]	
Adap DE (F-AUC)	1.5	4.1	4.5	6.9	8.2	8.5	9.3	9.4	9.3	9.5	Adap DE (F-AUC) [11]	
DE (Uniform)	1.5	2.8	4.5	7.1	8.5	8.2	8.8	9.5	10	10	DE (Uniform) [10]	
IPOP-aCMA-ES	1.7	4.2	4.3	6.1	6.2	5.9	6.1	5.9	5.9	5.8	IPOP-aCMA-ES [17]	
IPOP-CMA-ES	1.4	2.1	5.0	6.3	6.7	6.3	6.6	6.9	6.8	7.1	IPOP-CMA-ES [23]	
CMA+DE-MOS	1.3	2.7	7.7	17	19	19	20	20	19	19	CMA+DE-MOS [19]	
NBC-CMA	1.5	3.0	7.9	14	17	25	44	52	48	40	NBC-CMA [22]	
POEMS	125	104	54	103	146	491	1449	4402	15360	69407	POEMS [18]	
PM-AdapSS-DE	1.7	3.3	5.2	6.4	7.8	8.1	8.7	9.1	9.2	9.1	PM-AdapSS-DE [10, 11]	
pPOEMS	1.4	51	48	233	856	1073	1441	1587	1967	2202	pPOEMS [18, 21]	
Basic RCGA	1.4	3.6	85	1010	2805	7126	20886	<i>19e-2/5e4</i>	.	.	Basic RCGA [25]	
SPSA	23	27	47	332	2459	15906	20509	17764	31370	<i>21e-3/1e5</i>	SPSA [14]	

Table 14: 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

14 Sum of different powers											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1.7	9.2	10	7.4	11	18	20	22	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.1	2.1	2.3	4.5	5.5	11	14	22	30	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.7	2.6	3.9	4.7	10	13	19	24	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.9	1.9	3.9	8.3	13	29	56	64	86	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	2.0	2.6	2.8	2.8	4.3	4.8	5.8	7.3	8.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.4	1.9	1.3	3.0	3.8	6.1	6.3	7.9	10	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.2	1.9	2.3	2.5	3.1	4.1	4.4	5.3	7.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.3	2.3	2.3	2.3	3.3	5.1	5.6	7.2	8.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.8	2.1	2.7	3.2	3.1	4.0	4.5	5.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.2	1.5	1.8	3.1	3.5	3.5	3.9	3.9	4.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.3	1.6	4.7	10	18	27	607	11891	<i>22e-6/1e5</i>	Artif Bee Colony [9]
avg NEWUOA	1	1.4	3.4	2.2	1.4	1.3	1.6	1.8	2.2	6.8	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	4.3	7.9	19	17	10	15	21	25	37	581	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.1	1.1	3.6	5.6	10	10	8.4	8.7	9.0	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.5	1.7	3.6	7.8	9.5	8.5	8.1	8.9	9.3	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.1	2.3	2.7	3.3	4.9	4.9	4.9	4.8	5.9	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.3	2.2	2.9	4.6	5.1	4.7	5.2	6.0	7.2	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.2	1.8	4.3	13	17	18	18	19	20	CMA+DE-MOS [19]
NBC-CMA	1	1.3	2.0	2.9	11	17	14	13	16	22	NBC-CMA [22]
POEMS	1	185	213	74	67	141	165	177	246	2034	POEMS [18]
PM-AdapSS-DE	1	1.5	1.7	2.7	7.6	10	9.3	8.9	8.6	9.0	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.7	2.2	57	66	391	760	984	1037	1666	pPOEMS [18, 21]
Basic RCGA	1	1.2	1.5	3.6	28	33	71	284	456	1630	Basic RCGA [25]
SPSA	22	57	242	984	530	452	850	5362	41592	31154	SPSA [14]

Table 15: 02-D, running time excess ERT/ERT_{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

15 Rastrigin											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1.1	4.2	2.9	14	17	17	16	15	15	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.3	2.9	0.83	7.8	10	13	13	13	12	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	4.2	2.4	6.8	9.5	9.2	8.9	8.5	8.1	7.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	5.6	9.5	15	20	24	23	22	21	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.3	5.4	2.1	3.6	2.7	2.7	2.6	2.5	2.4	2.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	4.4	1.1	2.8	4.7	4.9	4.7	4.5	4.3	3.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.5	3.4	2.2	3.6	5.0	4.9	4.7	4.5	4.2	3.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.1	4.7	2.4	5.8	9.4	9.1	8.8	8.4	7.9	7.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	2.8	3.1	4.0	6.5	6.3	6.1	5.8	5.5	4.9	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.1	2.8	1.6	3.4	6.0	5.8	5.6	5.4	5.1	4.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	2.3	1.9	8.8	17	75	164	309	495	672	Artif Bee Colony [9]
avg NEWUOA	1	2.6	2.5	2.5	3.3	3.2	3.1	2.9	2.8	2.4	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	4.9	189	108	64	158	331	418	1128	1067	933	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.2	2.4	1.8	1.7	0.77	0.95	0.98	1.0	1.0	1.0	Adap DE (F-AUC) [11]
DE (Uniform)	1.2	2.1	1.8	1.5	0.67	0.88	0.95	0.97	1.0	1.0	DE (Uniform) [10]
IPOP-aCMA-ES	1.1	3.9	1.3	2.6	2.5	2.9	2.8	2.8	2.7	2.4	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	2.5	0.98	2.8	2.5	2.5	2.4	2.4	2.3	2.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1	2.4	1.6	4.0	2.7	3.3	3.4	3.4	3.3	3.1	CMA+DE-MOS [19]
NBC-CMA	1.1	2.8	2.2	2.7	3.2	4.2	4.2	4.2	4.0	3.6	NBC-CMA [22]
POEMS	1	143	17	20	76	76	75	74	71	65	POEMS [18]
PM-AdapSS-DE	1.1	2.3	2.1	1.7	15	14	14	13	13	11	PM-AdapSS-DE [10, 11]
pPOEMS	1	7.1	19	46	25	50	63	72	82	92	pPOEMS [18, 21]
Basic RCGA	1	1.6	3.1	32	32	40	51	62	79	114	Basic RCGA [25]
SPSA	28	962	39	1133	1352	<i>11e-1/1e5</i>	.	.	.	.	SPSA [14]

Table 16: 02-D, running time excess ERT/ERT_{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

	16 Weierstrass										Δf_{target} ERT_{best}/D
	$1e+03$	$1e+02$	$1e+01$	$1e+00$	$1e-01$	$1e-02$	$1e-03$	$1e-04$	$1e-05$	$1e-07$	
(1,2)-CMA-ES	1	1.6	3.0	14	19	44	74	120	115	125	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.1	23	14	32	21	20	21	21	19	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.2	12	20	27	21	29	34	48	41	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.5	23	39	41	74	107	725	696	530	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.9	10	13	7.1	4.2	4.4	4.9	4.8	4.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.4	4.0	9.1	5.4	4.3	4.4	4.2	7.6	5.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.6	2.6	5.9	3.6	5.3	4.9	4.6	5.3	4.2	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.5	7.6	10	10	6.2	12	12	11	21	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.5	5.6	6.8	5.6	5.6	7.4	10	12	10	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.5	3.6	7.6	5.4	7.6	7.7	11	11	10	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.5	2.2	3.4	8.7	38	202	1036	4754	3686	Artif Bee Colony [9]
avg NEWUOA	1	12	15	9.1	5.5	6.8	13	21	37	73	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1.7	8.5	166	134	236	489	2332	<i>53e-4/1e5</i>	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.6	1.5	4.9	3.5	3.6	4.0	4.1	4.1	3.5	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.2	2.8	6.8	4.0	3.8	4.6	4.6	4.7	4.0	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.1	3.8	8.3	6.1	3.7	3.6	3.4	3.3	2.7	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.4	2.5	11	5.0	3.5	4.6	4.3	4.2	3.4	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.6	5.3	6.0	3.8	5.0	5.8	5.7	6.5	6.5	CMA+DE-MOS [19]
NBC-CMA	1	1.5	2.4	5.3	12	17	22	21	23	19	NBC-CMA [22]
POEMS	1	100	67	152	81	137	132	126	125	103	POEMS [18]
PM-AdapSS-DE	1	1.2	3.1	4.2	4.6	47	44	41	39	30	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.6	39	22	58	106	162	229	264	283	pPOEMS [18, 21]
Basic RCGA	1	1.5	1.8	5.2	68	73	87	160	219	290	Basic RCGA [25]
SPSA	13	71	71	137	298	424	822	2207	7266	<i>30e-4/1e5</i>	SPSA [14]

Table 17: 02-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 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

	17 Schaffer F7, condition 10										
$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	1	1.3	38	9.1	18	17	59	393	<i>99e-5/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.3	3.7	1.6	4.6	5.2	7.4	11	60	84	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.1	1.8	2.5	2.9	4.2	14	27	62	180	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	2.9	7.4	4.5	17	48	332	<i>33e-4/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.3	3.8	2.0	3.6	3.1	5.0	5.7	13	39	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.3	3.2	1.8	2.6	2.6	2.9	3.7	12	18	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.1	1.4	2.4	5.2	3.3	2.5	3.7	11	36	32	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.3	6.2	1.8	3.7	5.3	10	27	<i>30e-6/1e4</i>	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	2.5	4.0	3.3	4.5	12	19	19	33	22	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.9	3.1	1.7	2.2	4.0	3.0	4.3	5.6	3.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.0	1.3	2.2	2.5	6.7	10	94	231	436	<i>29e-6/1e5</i>	Artif Bee Colony [9]
avg NEWUOA	1.1	1.3	12	4.6	13	33	117	<i>75e-4/5e3</i>	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	5.3	17	14	6.5	61	310	811	3768	<i>14e-4/1e5</i>	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.1	2.9	1.9	2.5	2.0	2.1	1.5	1.3	1.2	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.1	2.5	1.8	2.5	2.1	2.1	1.5	1.3	1.2	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.3	5.4	2.6	2.2	1.8	1.5	1.2	1.3	1.1	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	19	2.4	2.0	1.6	1.7	1.4	1.5	1.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.5	2.2	4.9	6.6	5.0	5.0	3.3	3.1	2.6	CMA+DE-MOS [19]
NBC-CMA	1	1	1.9	2.8	4.6	3.0	2.5	1.7	1.5	2.1	NBC-CMA [22]
POEMS	1	66	130	18	33	28	32	24	21	19	POEMS [18]
PM-AdapSS-DE	1.1	1.2	2.5	1.6	2.2	2.0	2.1	1.5	1.4	1.2	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.3	51	23	116	179	220	157	142	133	pPOEMS [18, 21]
Basic RCGA	1	1.2	2.9	5.0	47	61	103	77	124	<i>23e-7/5e4</i>	Basic RCGA [25]
SPSA	1935	16834	27903	1683	771	1105	<i>17e-3/1e5</i>	.	.	.	SPSA [14]

Table 18: 02-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

18 Schaffer F7, condition 1000											
Δf_{target} $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} $\text{ERT}_{\text{best}}/D$
	0.50		10	67	333	625	854	1036	1219	1429	
(1,2)-CMA-ES	1.1	17	8.4	7.7	16	72	82	144	<i>28e-3/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.1	25	6.5	17	17	53	168	138	<i>20e-3/1e4</i>	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.5	4.3	1.7	8.2	7.8	23	<i>13e-3/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.3	3.1	74	41	39	<i>98e-3/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.1	2.4	3.5	10	8.1	10	11	22	119	102	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	16	3.5	5.7	3.7	4.2	6.9	15	37	31	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.1	1.4	0.70	4.1	2.6	8.0	20	144	<i>14e-4/1e4</i>	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.6	1.3	0.93	6.7	6.3	12	15	144	<i>10e-4/1e4</i>	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.7	8.1	2.4	10	17	33	172	<i>16e-3/1e4</i>	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1.3	1.3	7.6	12	39	173	143	<i>16e-3/1e4</i>	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.2	1.1	2.4	8.2	20	596	2565	<i>20e-3/1e5</i>	.	.	Artif Bee Colony [9]
avg NEWUOA	1.7	7.9	5.4	9.0	6.1	62	<i>58e-3/6e3</i>	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	8.2	8.1	12	463	541	<i>27e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1.1	1.3	2.6	1.4	0.73	0.62	0.66	0.68	0.74	0.81	Adap DE (F-AUC) [11]
DE (Uniform)	1.1	0.98	2.9	1.8	0.77	0.63	0.63	0.65	0.71	0.80	DE (Uniform) [10]
IPOP-aCMA-ES	2.1	2.1	1.4	3.9	1.2	0.78	0.71	0.71	0.85	0.92	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	2.9	4.9	3.7	1.5	1.1	1.1	1.1	1.0	1.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1.5	1.3	2.5	3.8	2.6	1.9	2.1	1.9	2.6	2.5	CMA+DE-MOS [19]
NBC-CMA	1.1	1.1	2.4	8.6	2.9	2.3	2.3	2.1	2.0	2.2	NBC-CMA [22]
POEMS	36	84	31	17	10	8.9	8.9	33	32	30	POEMS [18]
PM-AdapSS-DE	1.1	0.90	2.6	1.5	0.71	0.65	0.63	0.65	0.70	0.77	PM-AdapSS-DE [10, 11]
pPOEMS	1.1	11	29	37	56	57	63	70	77	94	pPOEMS [18, 21]
Basic RCGA	1.1	1.4	2.1	114	137	352	836	<i>71e-3/5e4</i>	.	.	Basic RCGA [25]
SPSA	24	6520	3903	2418	1211	2253	<i>10e-1/1e5</i>	.	.	.	SPSA [14]

Table 19: 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

19 Griewank-Rosenbrock F8F2											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	3.9	128	18	21	31	44	52	49	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.1	2.7	30	21	19	39	43	58	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.2	3.7	56	17	13	23	30	37	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	3.1	68	12	32	41	50	56	53	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.1	4.3	28	14	15	28	36	39	36	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	4.8	35	11	9.1	10	17	16	15	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.2	6.3	42	12	17	25	28	27	29	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	9.4	57	25	14	22	22	24	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	3.1	52	76	24	23	22	21	20	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	4.7	50	16	13	12	12	11	10	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.1	6.1	56	11	7.7	16	37	73	882	Artif Bee Colony [9]
avg NEWUOA	1	1.3	8.0	106	13	22	21	20	19	18	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	4.9	8.7	87	144	24	118	281	493	1300	2054	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1.3	6.5	63	8.3	147	143	138	132	122	Adap DE (F-AUC) [11]
DE (Uniform)	1	1.3	3.9	36	8.8	72	70	67	67	62	DE (Uniform) [10]
IPOP-aCMA-ES	1	1.4	5.1	32	9.2	8.7	14	19	19	18	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1.1	6.3	22	9.0	17	17	18	18	17	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1.1	3.8	30	6.7	1.9	3.1	4.0	5.0	5.4	CMA+DE-MOS [19]
NBC-CMA	1	1.3	5.4	36	7.9	11	13	16	16	18	NBC-CMA [22]
POEMS	1	102	310	549	46	464	451	432	415	389	POEMS [18]
PM-AdapSS-DE	1	2.1	5.5	43	10	341	327	312	299	276	PM-AdapSS-DE [10, 11]
pPOEMS	1	1.3	68	539	49	38	81	122	185	258	pPOEMS [18, 21]
Basic RCGA	1	1.1	5.7	47	8.9	18	22	71	107	453	Basic RCGA [25]
SPSA	20	67	573	982	202	889	1595	2506	11291	<i>48e-4/1e5</i>	SPSA [14]

Table 20: 02-D, running time excess ERT/ERT_{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

	20 Schwefel $x*\sin(x)$										
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D											ERT_{best}/D
(1,2)-CMA-ES	6.4	4.8	6.0	15	24	37	37	37	37	37	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.3	3.0	3.2	13	24	34	34	34	34	33	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.2	2.2	2.1	17	31	54	54	54	54	53	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.7	45	98	20	38	51	52	57	57	56	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.2	3.4	3.1	9.3	6.9	7.8	7.8	7.9	7.9	7.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.8	2.3	2.4	10	12	13	13	13	13	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.2	3.6	3.7	11	14	15	17	17	17	17	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.1	1.7	1.6	8.4	10	11	12	12	12	12	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.0	3.1	3.6	16	4.9	4.9	5.0	5.0	5.1	5.1	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1.6	1.7	1.7	11	4.8	4.9	4.9	5.0	5.0	5.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2.1	2.6	2.6	4.6	2.2	4.1	6.0	7.8	10	16	Artif Bee Colony [9]
avg NEWUOA	3.0	2.2	2.1	10	4.0	4.0	4.0	4.0	4.0	3.9	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	22	17	15	60	336	1100	3695	<i>49e-3/1e5</i>	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	2.0	2.9	2.9	4.6	482	481	481	480	476	470	Adap DE (F-AUC) [11]
DE (Uniform)	1.8	2.9	2.9	4.2	276	276	276	276	274	270	DE (Uniform) [10]
IPOP-aCMA-ES	1.8	1.4	1.8	12	10	11	12	12	12	12	IPOP-aCMA-ES [17]
IPOP-CMA-ES	4.5	5.7	5.6	12	11	12	12	13	13	13	IPOP-CMA-ES [23]
CMA+DE-MOS	2.0	2.6	3.2	10	4.8	6.7	7.8	8.4	9.0	12	CMA+DE-MOS [19]
NBC-CMA	2.2	3.6	3.6	11	6.7	7.6	8.1	8.4	8.5	8.7	NBC-CMA [22]
POEMS	190	135	121	28	40	45	49	55	61	68	POEMS [18]
PM-AdapSS-DE	3.3	2.5	2.2	4.0	628	627	627	626	620	612	PM-AdapSS-DE [10, 11]
pPOEMS	75	101	92	45	43	83	132	185	228	301	pPOEMS [18, 21]
Basic RCGA	2.1	3.7	3.6	33	38	143	335	641	849	1182	Basic RCGA [25]
SPSA	65	78	101	9123	7680	7652	7654	7639	<i>11e-1/1e5</i>	.	SPSA [14]

Table 21: 02-D, running time excess ERT/ERT_{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

21 Gallagher 101 peaks											
Δft_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δft_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	1.3	15	14	16	16	17	17	17	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	1.6	7.6	8.8	8.7	13	17	17	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.8	5.5	13	13	16	16	15	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	1.5	20	14	13	20	21	20	20	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1.4	8.9	5.8	4.4	4.4	4.2	4.1	4.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.6	5.6	4.9	4.2	6.7	6.6	6.3	6.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	1.4	6.6	4.7	3.7	3.6	3.4	3.3	3.5	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	1.4	9.3	7.6	6.0	5.7	5.5	5.2	5.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.6	12	11	7.2	6.9	6.5	6.2	6.2	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	1.3	12	7.9	5.1	4.9	4.6	4.4	4.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	1.2	2.0	1.8	2.6	5.5	10	26	59	Artif Bee Colony [9]
avg NEWUOA	1	1	6.1	6.5	4.6	2.9	2.8	2.7	2.6	2.7	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	7.5	12	23	34	75	96	201	234	500	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	1.3	284	83	53	51	48	46	45	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	1.5	2.1	1.0	1.1	1.5	1.6	1.6	2.0	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	1.5	6.2	7.0	4.9	5.3	5.4	5.2	25	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	1.3	13	7.7	5.4	13	13	13	14	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	1.5	1.8	4.3	4.9	5.3	6.5	10	12	CMA+DE-MOS [19]
NBC-CMA	1	1	0.96	2.3	7.1	25	30	36	35	35	NBC-CMA [22]
POEMS	1	1	111	143	309	198	191	182	178	178	POEMS [18]
PM-AdapSS-DE	1	1	1.7	1.7	83	53	51	48	46	45	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	1.8	17	8.0	14	25	44	60	105	pPOEMS [18, 21]
Basic RCGA	1	1	1.4	14	13	34	71	96	197	285	Basic RCGA [25]
SPSA	1	21	47	94	266	218	223	297	320	753	SPSA [14]

Table 22: 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

22 Gallagher 21 peaks											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	2.1	17	6.1	9.1	8.6	8.3	12	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	1.4	34	19	24	25	22	23	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.3	15	10	11	14	20	23	22	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	1.6	31	18	18	23	28	31	30	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	2.2	10	8.3	7.0	6.5	5.9	6.6	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.6	14	11	11	11	10	9.5	9.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	3.2	19	6.5	5.7	5.3	4.7	4.6	4.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	1.5	16	5.1	6.0	5.5	4.9	5.3	5.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	6.6	19	4.4	3.6	3.3	3.0	3.0	2.9	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	1	1	1	8.5	4.4	3.5	3.2	2.8	2.8	2.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	1.4	2.7	2.8	4.2	8.9	21	47	373	Artif Bee Colony [9]
avg NEWUOA	1	1	3.0	3.8	1.3	1.1	1.1	1.1	1.1	1.3	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	1	8.5	4.8	12	34	50	119	184	274	760	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	1.9	2.2	184	143	125	110	108	103	Adap DE (F-AUC) [11]
DE (Uniform)	1	1	1.3	2.2	1.0	1.3	1.5	1.7	1.8	2.2	DE (Uniform) [10]
IPOP-aCMA-ES	1	1	1.2	4.7	5.5	4.7	7.7	7.2	7.2	15	IPOP-aCMA-ES [17]
IPOP-CMA-ES	1	1	1.6	5.9	5.0	5.0	4.8	5.3	23	72	IPOP-CMA-ES [23]
CMA+DE-MOS	1	1	1.2	3.7	2.9	3.8	4.7	5.2	6.2	8.4	CMA+DE-MOS [19]
NBC-CMA	1	1	1.3	2.2	8.4	21	31	28	28	28	NBC-CMA [22]
POEMS	1	1	66	31	604	467	412	365	364	350	POEMS [18]
PM-AdapSS-DE	1	1	1.5	2.4	86	67	59	52	51	49	PM-AdapSS-DE [10, 11]
pPOEMS	1	1	39	26	17	32	44	58	70	129	pPOEMS [18, 21]
Basic RCGA	1	1	1.4	2.1	11	25	69	119	232	604	Basic RCGA [25]
SPSA	1	22	107	284	373	750	1930	9991	9800	<i>38e-4/1e5</i>	SPSA [14]

Table 23: 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

23 Katsuuras												
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D	
(1,2)-CMA-ES	1	1	1.5	22	214	253	222	213	192	243	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	1	1	4.2	10	76	81	71	68	62	57	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	1	1	2.2	18	90	99	90	86	78	72	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	1	1	1.6	14	103	225	288	276	249	770	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	1	1	2.1	11	23	23	27	26	24	22	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	1	1	3.8	13	19	17	15	15	13	13	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1	1	4.5	8.5	13	13	12	12	11	10	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	1	1	2.2	14	29	29	26	25	22	21	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1	1	8.2	3.1	4.5	4.5	4.5	6.1	5.6	5.4	(1+1)-CMA-ES [8]	
(1+2ms)-CMA-ES	1	1	2.0	2.2	6.7	14	14	13	12	11	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	1	1	2.1	15	1791	<i>13e-2/1e5</i>	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	1	1	4.2	6.7	25	103	262	<i>49e-3/6e3</i>	.	.	avg NEWUOA [24]	
CMA-EGS (IPOP,r1)	1	2.5	4.0	12	2604	<i>17e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	1	1	1.8	2.4	5.4	7.6	9.3	11	13	15	Adap DE (F-AUC) [11]	
DE (Uniform)	1	1	2.5	2.3	6.0	8.2	10	12	13	16	DE (Uniform) [10]	
IPOP-aCMA-ES	1	1	2.8	6.6	16	19	17	16	15	14	IPOP-aCMA-ES [17]	
IPOP-CMA-ES	1	1	1.9	7.8	162	233	204	196	177	162	IPOP-CMA-ES [23]	
CMA+DE-MOS	1	1	2.0	5.5	24	40	44	46	43	42	CMA+DE-MOS [19]	
NBC-CMA	1	1	1.8	10	737	761	668	639	576	529	NBC-CMA [22]	
POEMS	1	1	13	41	253	245	233	234	225	230	POEMS [18]	
PM-AdapSS-DE	1	1	2.0	1.9	5.8	8.5	10	12	13	16	PM-AdapSS-DE [10, 11]	
pPOEMS	1	1	11	61	659	866	996	1160	1199	1404	pPOEMS [18, 21]	
Basic RCGA	1	1	1.9	5.2	256	889	4692	4487	<i>29e-3/5e4</i>	.	Basic RCGA [25]	
SPSA	1	13	18	264	<i>49e-2/1e5</i>	SPSA [14]	

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