

Comparison tables: BBOB 2010 function testbed in 10-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 [15, 11]. The experimental set-up is described in [14].

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. Consequently, the best (smallest) value is 1 and the value 1 appears in each column at least once. See [14] 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: 10-D, running time excess ERT/ERT_{best} 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	8.7	7.5	12	18	23	28	33	39	49	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	4.7	3.8	6.8	10	13	16	20	23	30	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	3.1	3.4	6.1	8.8	11	15	18	21	26	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	7.6	6.0	11	16	20	26	31	36	47	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	4.3	2.7	5.7	8.4	11	14	17	21	26	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	2.4	4.8	7.3	10	12	15	17	23	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	2.1	2.1	3.9	5.8	7.4	9.0	11	13	17	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	5.2	2.5	4.8	7.3	9.5	12	15	17	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	4.1	2.4	4.7	6.8	8.9	11	13	15	20	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	3.5	2.1	4.0	5.9	7.8	10	12	14	18	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.8	14	32	50	66	95	117	137	176	Artif Bee Colony [8]
avg NEWUOA	1	10	1	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.7	32	6.6	11	15	20	24	28	33	41	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.7	22	53	80	110	138	167	197	255	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.8	28	70	115	155	198	243	285	373	DE (Uniform) [9]
IPOP-aCMA-ES	1	3.4	3.6	7.3	11	15	19	22	26	33	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	2.9	2.9	6.5	10	14	18	21	25	32	IPOP-CMA-ES [22]
CMA+DE-MOS	1	2.2	11	33	41	54	72	81	95	123	CMA+DE-MOS [18]
NBC-CMA	1	2.2	9.0	15	20	26	31	36	42	53	NBC-CMA [21]
POEMS	1	632	75	142	353	605	845	1126	1382	1909	POEMS [17]
PM-AdapSS-DE	1	1.6	24	55	92	126	158	195	229	298	PM-AdapSS-DE [9, 10]
pPOEMS	1	198	72	146	600	1826	3303	4605	6045	9462	pPOEMS [17, 20]
Basic RCGA	1	1.5	19	61	120	200	594	1141	1549	2163	Basic RCGA [24]
SPSA	8.4	39	4.5	6.2	7.6	9.3	11	13	14	18	SPSA [13]

Table 2: 10-D, running time excess ERT/ERT_{best} 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											
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	22	12	8.2	6.1	5.5	5.5	5.4	5.4	5.4	5.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	12	5.7	4.2	3.2	2.8	2.8	2.7	2.7	2.7	2.6	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	11	5.0	3.5	2.7	2.4	2.4	2.3	2.3	2.3	2.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	28	14	9.2	7.0	6.2	6.2	6.1	6.1	6.1	6.0	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	7.0	3.7	2.8	2.3	2.0	2.0	1.9	1.9	1.9	1.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.3	3.0	2.5	2.0	1.8	1.8	1.7	1.7	1.7	1.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.8	2.4	1.9	1.5	1.3	1.3	1.3	1.3	1.3	1.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	5.4	3.0	2.4	1.9	1.7	1.7	1.7	1.7	1.7	1.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.4	2.0	1.5	1.4	1.2	1.2	1.2	1.2	1.2	1.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.0	1.6	1.2	1.0	1	1	1	1	1	1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2.6	1.2	1	1	1.2	1.5	2.0	2.5	2.8	3.3	Artif Bee Colony [8]
avg NEWUOA	1	1	1.5	2.6	3.7	4.9	6.5	8.1	9.3	12	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	18	8.5	5.6	4.3	3.8	3.7	3.7	3.6	3.6	3.6	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	7.7	3.6	2.6	2.3	2.2	2.5	2.7	3.0	3.2	3.7	Adap DE (F-AUC) [10]
DE (Uniform)	10	4.8	3.5	3.1	3.1	3.5	3.9	4.2	4.6	5.3	DE (Uniform) [9]
IPOP-aCMA-ES	3.1	1.7	1.3	1.1	1.0	1.0	1.0	1.1	1.1	1.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.7	2.4	1.9	1.6	1.4	1.4	1.4	1.4	1.4	1.5	IPOP-CMA-ES [22]
CMA+DE-MOS	7.9	3.6	2.8	2.4	2.4	2.6	2.8	2.9	3.1	3.5	CMA+DE-MOS [18]
NBC-CMA	5.4	3.4	2.9	2.5	2.3	2.4	2.3	2.4	2.4	2.4	NBC-CMA [21]
POEMS	53	26	19	18	18	20	23	25	27	31	POEMS [17]
PM-AdapSS-DE	8.9	4.1	2.9	2.5	2.6	2.9	3.1	3.5	3.7	4.3	PM-AdapSS-DE [9, 10]
pPOEMS	106	72	56	67	71	97	107	121	133	161	pPOEMS [17, 20]
Basic RCGA	15	8.9	8.6	10	13	17	21	23	34	73	Basic RCGA [24]
SPSA	3149	<i>69e+1/1e5</i>	.	.	.	.	.	.	.	.	SPSA [13]

Table 3: 10-D, running time excess ERT/ERT_{best} 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}	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	0.13	17	278	804	917	1035	1111	1239	1390	1627	ERT_{best}/D
(1,2)-CMA-ES	3.3	25	<i>30e+0/1e4</i>	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.2	2.2	171	<i>14e+0/1e4</i>	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	2.6	244	<i>17e+0/1e4</i>	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.0	35	249	<i>38e+0/1e4</i>	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.9	3.0	<i>15e+0/1e4</i>	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.7	1.5	57	<i>11e+0/1e4</i>	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.5	1.5	47	<i>99e-1/1e4</i>	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.3	2.5	235	<i>18e+0/1e4</i>	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.1	5.6	523	<i>18e+0/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	5.5	1	522	<i>20e+0/1e4</i>	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.7	2.5	1	1	1	1	1	1	1	1	Artif Bee Colony [8]
avg NEWUOA	8.0	6.5	<i>21e+0/7e3</i>	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	39	2.1	49	1748	1532	1358	1265	1135	1011	<i>50e-1/1e5</i>	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.6	6.2	125	543	1561	1383	1288	1156	1030	880	Adap DE (F-AUC) [10]
DE (Uniform)	1.3	8.5	132	1796	<i>30e-1/1e5</i>	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	2.6	1.2	3.5	288	1054	934	871	781	696	595	IPOP-aCMA-ES [16]
IPOP-CMA-ES	2.0	1.3	1.7	743	2281	2021	1883	1689	1505	1286	IPOP-CMA-ES [22]
CMA+DE-MOS	1.5	3.4	1.3	1.4	1.5	1.4	1.4	1.4	1.3	1.2	CMA+DE-MOS [18]
NBC-CMA	1.3	2.5	5.1	543	<i>40e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	508	18	4.3	13	21	20	19	18	17	16	POEMS [17]
PM-AdapSS-DE	1.7	7.3	58	227	254	659	1293	<i>10e-1/1e5</i>	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1.8	19	5.1	24	53	49	50	48	49	51	pPOEMS [17, 20]
Basic RCGA	1.8	5.2	5.1	60	100	116	109	98	88	76	Basic RCGA [24]
SPSA	5.00e5	5426	<i>87e+0/1e5</i>	.	.	.	.	.	.	.	SPSA [13]

Table 4: 10-D, running time excess ERT/ERT_{best} 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											ERT_{best}/D
(1,2)-CMA-ES	1.5	22	<i>41e+0/1e4</i>	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.9	2.0	241	<i>18e+0/1e4</i>	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.5	2.8	164	<i>18e+0/1e4</i>	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.8	47	<i>51e+0/1e4</i>	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.5	2.0	<i>22e+0/1e4</i>	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.6	1.7	<i>17e+0/1e4</i>	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.7	1.7	244	<i>15e+0/1e4</i>	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.4	7.4	<i>20e+0/1e4</i>	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.6	6.3	249	<i>27e+0/1e4</i>	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.9	6.8	<i>26e+0/1e4</i>	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.4	1.7	1	1	1	1	1	1	1	1	Artif Bee Colony [8]
avg NEWUOA	5.9	14	<i>27e+0/1e4</i>	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	42	1.8	284	<i>90e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.8	6.5	73	<i>60e-1/1e5</i>	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	1.4	8.3	87	<i>50e-1/1e5</i>	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	2.8	1	6.0	<i>60e-1/1e5</i>	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1.3	1.1	5.9	<i>60e-1/2e5</i>	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	1	2.8	1.5	2.1	1.9	1.7	1.6	1.5	1.5	1.4	CMA+DE-MOS [18]
NBC-CMA	1.2	1.9	6.4	<i>60e-1/3e4</i>	.	.	.	.	.	.	NBC-CMA [21]
POEMS	549	11	5.2	13	26	23	21	19	18	17	POEMS [17]
PM-AdapSS-DE	1.8	7.1	72	<i>60e-1/1e5</i>	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1.0	12	7.5	21	65	58	55	52	52	51	pPOEMS [17, 20]
Basic RCGA	1.0	6.1	84	<i>79e-1/5e4</i>	.	.	.	.	.	.	Basic RCGA [24]
SPSA	84	2906	<i>99e+0/1e5</i>	.	.	.	.	.	.	.	SPSA [13]

Table 5: 10-D, running time excess ERT/ERT_{best} 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	2.7	2.8	3.1	3.0	3.0	3.0	3.0	3.0	3.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.3	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.3	1.7	1.8	1.7	1.7	1.7	1.7	1.7	1.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.9	3.1	3.6	3.5	3.5	3.5	3.5	3.5	3.5	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.7	2.1	2.4	2.4	2.4	2.4	2.4	2.4	2.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.7	2.1	2.3	2.2	2.3	2.3	2.3	2.3	2.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.3	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.7	1.5	1.8	1.7	1.8	1.8	1.8	1.8	1.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1.1	1.0	1.2	1.3	1.3	1.3	1.3	1.3	1.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	12	25	31	32	32	32	32	32	32	Artif Bee Colony [8]
avg NEWUOA	1	2.6	1	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	4.2	2.6	2.7	2.6	2.6	2.6	2.6	2.6	2.6	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	6.3	15	17	19	19	19	19	19	19	Adap DE (F-AUC) [10]
DE (Uniform)	1	8.9	21	23	24	25	25	25	25	25	DE (Uniform) [9]
IPOP-aCMA-ES	1	2.6	2.6	2.9	2.9	2.9	2.9	2.9	2.9	2.9	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	2.7	2.4	2.6	2.6	2.6	2.6	2.6	2.6	2.6	IPOP-CMA-ES [22]
CMA+DE-MOS	1	8.2	17	24	23	23	23	23	23	23	CMA+DE-MOS [18]
NBC-CMA	1	11	18	19	18	18	18	18	18	18	NBC-CMA [21]
POEMS	1	180	97	103	112	117	118	118	118	118	POEMS [17]
PM-AdapSS-DE	1	6.4	19	23	23	23	23	23	23	23	PM-AdapSS-DE [9, 10]
pPOEMS	1	169	96	102	108	116	117	117	117	117	pPOEMS [17, 20]
Basic RCGA	1	37	192	349	529	833	1329	1855	2186	31466	Basic RCGA [24]
SPSA	1	3.1	3.0	3.6	3.7	3.7	3.7	3.7	3.7	3.7	SPSA [13]

Table 6: 10-D, running time excess ERT/ERT_{best} 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	3.9	16	40	61	85	107	138	173	204	252	ERT_{best}/D
(1,2)-CMA-ES	2.8	5.6	7.4	9.3	11	18	20	23	32	85	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.2	2.8	2.5	2.2	2.2	2.3	2.2	2.2	2.1	2.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.9	2.5	2.0	2.0	2.1	2.0	2.0	1.9	2.0	2.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.0	8.3	10	17	33	42	51	70	70	561	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.9	1.9	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.5	1.9	1.6	1.6	1.6	1.7	1.7	1.6	1.6	1.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.1	1.2	1.3	1.3	1.4	1.3	1.3	1.3	1.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.2	1.9	1.7	2.3	2.5	2.7	2.7	3.3	3.8	4.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.3	1.5	1.5	6.0	25	76	230	852	<i>26e-4/1e4</i>	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.1	1	1.2	2.6	14	72	145	851	<i>21e-4/1e4</i>	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.0	2.9	13	235	579	1972	2101	2542	7081	5904	Artif Bee Colony [8]
avg NEWUOA	1.1	1.0	1	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.7	8.5	36	74	182	261	224	192	179	196	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	8.3	9.3	12	12	12	13	12	11	11	12	Adap DE (F-AUC) [10]
DE (Uniform)	8.6	15	16	17	16	16	16	15	14	15	DE (Uniform) [9]
IPOP-aCMA-ES	1.5	2.4	1.9	1.9	1.8	1.7	1.6	1.5	1.5	1.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1.8	2.0	2.0	1.9	1.9	1.9	1.7	1.6	1.5	1.6	IPOP-CMA-ES [22]
CMA+DE-MOS	10	6.5	8.1	7.2	6.5	6.2	5.8	5.3	5.0	4.9	CMA+DE-MOS [18]
NBC-CMA	7.1	3.1	32	21	16	13	11	8.7	7.6	6.5	NBC-CMA [21]
POEMS	68	22	32	40	42	44	42	41	40	41	POEMS [17]
PM-AdapSS-DE	8.1	13	14	15	14	14	13	12	12	12	PM-AdapSS-DE [9, 10]
pPOEMS	70	22	42	72	125	134	140	138	141	157	pPOEMS [17, 20]
Basic RCGA	27	8.9	40	84	131	303	381	855	<i>56e-5/5e4</i>	.	Basic RCGA [24]
SPSA	902	42628	36837	<i>22e+1/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 8: 10-D, running time excess ERT/ERT_{best} 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												
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	11	12	11	23	23	23	23	23	23	23	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	4.0	2.5	2.4	8.7	9.2	9.3	9.4	9.4	9.4	10	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	3.2	3.9	2.9	7.7	8.0	8.0	8.1	8.1	8.1	8.2	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	7.3	10	8.5	28	27	27	27	27	27	27	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	3.6	4.0	3.0	8.0	8.1	8.1	8.1	8.1	8.2	8.3	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	2.5	1.9	1.6	7.0	7.1	7.0	7.1	7.1	7.1	7.2	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	2.4	1.4	1.2	6.1	6.0	6.0	6.0	5.9	5.9	6.0	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	2.7	2.5	3.4	5.7	6.0	6.0	6.0	6.1	6.1	6.2	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1.9	2.3	2.3	4.0	4.2	4.2	4.3	4.3	4.4	4.6	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	2.1	1.7	1.9	4.0	4.1	4.0	4.1	4.1	4.2	4.3	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	8.7	7.1	7.3	8.5	23	92	669	<i>40e-5/1e5</i>	.	.	Artif Bee Colony [8]	
avg NEWUOA	1	1	1	1	1	1	1	1	1	1	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	7.3	5.9	5.3	10	10	10	10	11	11	12	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	19	13	14	17	17	18	18	19	20	22	Adap DE (F-AUC) [10]	
DE (Uniform)	27	19	20	23	25	26	27	28	29	31	DE (Uniform) [9]	
IPOP-aCMA-ES	3.2	2.6	2.7	5.0	5.2	5.2	5.3	5.3	5.4	5.6	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	3.3	2.5	2.3	4.2	4.7	4.8	4.9	5.0	5.1	5.3	IPOP-CMA-ES [22]	
CMA+DE-MOS	13	7.9	6.8	14	14	14	15	15	15	16	CMA+DE-MOS [18]	
NBC-CMA	7.7	3.6	3.1	7.3	8.5	9.0	9.3	9.5	10	10	NBC-CMA [21]	
POEMS	60	47	65	807	1272	1775	2470	3575	<i>40e-6/3e5</i>	.	POEMS [17]	
PM-AdapSS-DE	21	16	16	22	25	26	27	28	28	30	PM-AdapSS-DE [9, 10]	
pPOEMS	61	43	164	229	238	239	252	284	330	461	pPOEMS [17, 20]	
Basic RCGA	14	18	103	2285	8024	<i>56e-1/5e4</i>	.	.	.	.	Basic RCGA [24]	
SPSA	374	1101	8859	<i>13e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]	

Table 9: 10-D, running time excess ERT/ERT_{best} 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												
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	6.4	5.6	5.6	15	16	16	16	17	17	17	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	2.8	2.2	3.9	6.0	6.6	6.7	6.8	6.9	7.0	7.1	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	4.1	4.1	4.0	5.3	5.7	5.8	6.0	6.0	6.1	6.2	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	6.6	15	12	17	18	18	18	18	18	19	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	2.1	4.4	4.1	5.2	5.6	5.7	5.8	5.8	5.9	6.0	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	2.0	4.8	4.1	4.5	4.9	4.9	5.0	5.1	5.1	5.2	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1.3	2.1	2.5	3.6	3.8	3.9	4.0	4.0	4.0	4.1	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	2.1	3.3	2.9	3.5	3.9	4.0	4.1	4.2	4.3	4.4	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1.5	2.1	2.2	4.1	4.2	4.2	4.2	4.3	4.4	4.5	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	1.3	1.6	3.0	3.3	3.4	3.4	3.5	3.5	3.6	3.7	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	7.1	8.9	11	563	3822	<i>51e-2/1e5</i>	.	.	.	.	Artif Bee Colony [8]	
avg NEWUOA	1	1	1	1	1	1	1	1	1	1	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	6.3	6.1	6.9	6.9	7.9	8.1	8.4	8.7	8.9	9.3	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	10	12	17	12	13	14	14	15	16	17	Adap DE (F-AUC) [10]	
DE (Uniform)	17	19	24	17	19	20	20	21	22	24	DE (Uniform) [9]	
IPOP-aCMA-ES	1.9	2.2	3.2	2.9	3.3	3.4	3.4	3.5	3.6	3.7	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	1.8	2.2	2.5	3.5	3.9	4.0	4.1	4.2	4.3	4.4	IPOP-CMA-ES [22]	
CMA+DE-MOS	10	5.3	5.0	6.6	7.9	8.3	8.6	8.8	9.0	9.4	CMA+DE-MOS [18]	
NBC-CMA	4.2	4.5	4.4	6.5	7.5	7.9	8.2	8.3	8.5	8.7	NBC-CMA [21]	
POEMS	46	46	90	599	1086	2162	<i>70e-4/3e5</i>	.	.	.	POEMS [17]	
PM-AdapSS-DE	13	15	20	18	20	21	22	22	23	25	PM-AdapSS-DE [9, 10]	
pPOEMS	43	61	259	151	210	314	432	550	684	1030	pPOEMS [17, 20]	
Basic RCGA	5.1	5.5	43	<i>68e-1/5e4</i>	.	.	.	.	.	.	Basic RCGA [24]	
SPSA	349	2995	8361	<i>43e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]	

Table 12: 10-D, running time excess ERT/ERT_{best} 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}	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	23	48	103	235	461	549	650	748	831	963	ERT_{best}/D	
(1,2)-CMA-ES	5.6	8.1	11	9.0	6.0	5.9	5.5	5.3	5.1	4.9	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	3.0	3.5	4.5	3.7	2.5	2.4	2.3	2.2	2.2	2.1	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	2.6	2.5	3.7	3.0	2.0	2.0	1.9	1.9	1.8	1.8	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	4.4	4.0	10	8.9	6.6	6.4	6.0	5.7	5.6	5.3	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	2.6	1.5	2.5	2.6	1.9	1.9	1.8	1.8	1.7	1.7	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	2.2	1.3	1.8	1.9	1.5	1.5	1.4	1.4	1.4	1.3	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1.7	1.3	1.8	1.8	1.4	1.4	1.3	1.3	1.3	1.2	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	2.0	1.7	3.7	2.6	1.8	1.7	1.6	1.6	1.6	1.5	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1.8	1.9	2.8	2.3	1.7	1.7	1.7	1.6	1.6	1.6	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	1.5	1.1	2.2	2.4	1.8	1.7	1.6	1.6	1.5	1.5	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	11	11	23	39	170	1276	2200	<i>41e-3/1e5</i>	.	.	Artif Bee Colony [8]	
avg NEWUOA	1	1	2.4	3.0	2.8	3.0	2.9	3.0	3.0	5.4	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	4.6	4.5	10	10	7.2	7.4	6.8	6.7	7.1	8.8	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	24	14	8.2	4.6	3.4	3.5	3.6	3.8	3.9	4.1	Adap DE (F-AUC) [10]	
DE (Uniform)	34	21	12	6.2	4.6	4.9	5.1	5.5	5.7	6.0	DE (Uniform) [9]	
IPOP-aCMA-ES	3.3	2.1	1.7	1.3	1.0	1	1	1	1	1	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	3.2	1.8	1	1	1	1.1	1.1	1.2	1.2	1.2	IPOP-CMA-ES [22]	
CMA+DE-MOS	12	7.1	4.6	3.6	2.9	2.9	2.9	2.8	2.8	2.7	CMA+DE-MOS [18]	
NBC-CMA	5.4	3.1	1.7	2.1	1.9	2.2	2.2	2.2	2.2	2.2	NBC-CMA [21]	
POEMS	147	93	1517	2578	9134	<i>40e-1/3e5</i>	.	.	.	.	POEMS [17]	
PM-AdapSS-DE	28	17	10	5.2	4.0	4.3	4.7	5.2	5.7	6.0	PM-AdapSS-DE [9, 10]	
pPOEMS	495	421	498	1283	2720	7743	6565	5716	<i>92e-2/3e5</i>	.	pPOEMS [17, 20]	
Basic RCGA	112	93	60	99	317	609	<i>39e-2/5e4</i>	.	.	.	Basic RCGA [24]	
SPSA	3216	1647	2136	<i>21e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]	

Table 14: 10-D, running time excess ERT/ERT_{best} 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	2.0	5.3	5.0	5.3	6.3	7.4	4.7	3.5	5.2	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	2.1	2.4	2.8	3.0	3.5	4.1	2.9	2.2	3.0	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.6	2.0	2.1	2.3	2.7	3.3	2.5	1.9	2.4	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	12	5.6	5.0	5.4	6.4	7.1	5.2	3.8	4.7	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	4.0	1.6	2.1	2.4	3.0	3.4	2.5	1.8	2.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.8	1.3	1.8	2.1	2.4	2.9	2.0	1.6	1.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.0	1.2	1.4	1.6	2.0	2.4	1.7	1.3	1.5	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	3.9	1.6	1.9	2.2	2.5	2.9	1.9	1.4	1.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.8	1.2	1.4	1.8	2.0	2.3	1.8	1.4	1.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1.6	1.1	1.2	1.5	1.7	2.0	1.4	1.0	1.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.0	3.7	13	17	29	656	<i>64e-5/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	1	4.9	1	1	1	1	1	1	2.0	76	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.9	38	5.4	4.3	4.6	5.1	7.8	8.8	7.5	76	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.1	5.7	14	19	19	15	7.2	3.8	3.3	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.1	5.5	19	26	27	21	10	5.4	4.8	DE (Uniform) [9]
IPOP-aCMA-ES	1	2.0	1.2	2.1	2.8	3.2	2.9	1.7	1	1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	2.9	1.3	2.2	2.9	3.4	3.5	2.2	1.4	1.5	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.6	4.4	10	10	12	12	6.9	3.9	3.8	CMA+DE-MOS [18]
NBC-CMA	1	1.2	3.1	4.3	5.0	5.2	4.8	3.0	2.0	2.2	NBC-CMA [21]
POEMS	1	454	43	40	80	117	109	86	426	<i>33e-7/3e5</i>	POEMS [17]
PM-AdapSS-DE	1	1	7.3	16	22	23	17	8.1	4.4	3.8	PM-AdapSS-DE [9, 10]
pPOEMS	1	55	42	46	146	409	532	378	282	<i>61e-8/3e5</i>	pPOEMS [17, 20]
Basic RCGA	1	1.1	3.2	23	34	75	982	6465	<i>76e-5/5e4</i>	.	Basic RCGA [24]
SPSA	21	186	56	56	46	40	49	136	299	<i>43e-7/1e5</i>	SPSA [13]

Table 16: 10-D, running time excess ERT/ERT_{best} 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}	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	0.10	0.10	67	389	1560	3820	4588	4689	4919	5084	ERT_{best}/D
(1,2)-CMA-ES	1	1.7	350	<i>11e+0/1e4</i>	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.4	17	174	<i>25e-1/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.3	20	174	<i>32e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.3	493	<i>15e+0/1e4</i>	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.5	14	82	<i>20e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.4	6.9	25	92	<i>64e-2/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.4	7.6	43	<i>13e-1/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.5	17	176	<i>28e-1/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.7	3.3	83	<i>16e-1/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1.2	2.7	176	<i>13e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.3	2.1	270	<i>92e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1.5	2.1	73	<i>13e-1/1e4</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	53	8.7	36	90	368	<i>10e-2/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.7	45	<i>51e-1/1e5</i>	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.7	66	<i>45e-1/1e5</i>	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	1	1.3	1	1.7	1.2	1	1.2	1.3	1.2	1.2	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1.3	2.2	2.2	1.3	1.0	1	1	1	1	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.3	1.7	1	1	1.4	1.5	1.6	1.5	1.6	CMA+DE-MOS [18]
NBC-CMA	1	1.5	6.0	1.3	1.3	2.2	3.3	4.8	15	26	NBC-CMA [21]
POEMS	1	1	6.7	6.8	131	512	426	417	398	385	POEMS [17]
PM-AdapSS-DE	1	1.5	44	<i>34e-1/1e5</i>	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1	1.3	10	32	91	225	271	267	256	251	pPOEMS [17, 20]
Basic RCGA	1	1.3	5.0	24	39	60	159	156	<i>87e-3/5e4</i>	.	Basic RCGA [24]
SPSA	1	1551	784	3811	<i>56e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 17: 10-D, running time excess ERT/ERT_{best} 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										
Δ_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δ_{target} ERT_{best}/D
(1,2)-CMA-ES	1	2.5	54	2798	<i>25e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	2.7	2.5	46	271	311	<i>18e-2/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.1	14	43	451	<i>34e-2/1e4</i>	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.2	92	2782	<i>24e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	4.2	68	<i>38e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.4	18	448	<i>24e-2/1e4</i>	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.1	1.2	42	296	<i>15e-2/1e4</i>	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.7	1.5	101	<i>69e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.3	7.5	368	<i>13e-1/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	2.8	597	<i>13e-1/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.2	5.1	794	<i>65e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1.1	1	822	<i>10e-1/3e4</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	24	59	2.8	1.1	1.1	1	1.9	4.9	79	514	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.1	3.3	6.6	4.5	2.5	1.6	1.5	1.7	1.4	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.1	2.4	8.7	6.3	3.6	2.4	2.3	2.3	2.0	DE (Uniform) [9]
IPOP-aCMA-ES	1	1.1	1.1	1	2.5	1.6	1.3	1.2	1.1	1.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1.6	1.2	2.2	2.1	1.1	1	1	1	1	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.4	1.5	25	14	5.6	3.2	5.3	4.3	3.2	CMA+DE-MOS [18]
NBC-CMA	1	1.1	1.3	1.5	1	1.2	1.6	8.6	36	<i>16e-6/3e4</i>	NBC-CMA [21]
POEMS	1	274	39	20	153	57	82	116	203	1544	POEMS [17]
PM-AdapSS-DE	1	1.2	2.1	7.1	5.0	2.7	1.8	1.7	1.8	1.5	PM-AdapSS-DE [9, 10]
pPOEMS	1	1.2	41	27	100	74	50	50	51	142	pPOEMS [17, 20]
Basic RCGA	1	1.1	2.6	13	66	48	39	55	126	<i>16e-5/5e4</i>	Basic RCGA [24]
SPSA	6.67e5	8.76e5	15388	27199	<i>86e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 19: 10-D, running time excess ERT/ERT_{best} 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	11	125	<i>24e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.7	26	<i>90e-2/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	3.4	38	<i>11e-1/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	5.0	249	<i>32e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1.7	34	<i>13e-1/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.4	7.7	<i>58e-2/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	1.2	7.4	<i>68e-2/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	1.7	13	<i>77e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.3	11	<i>85e-2/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	1.1	3.8	<i>55e-2/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.1	8.6	722	<i>12e-1/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	1	121	<i>83e-2/1e5</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	23	64	4.7	4.8	65	<i>20e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.2	6.3	69	<i>59e-2/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.2	8.2	143	<i>52e-2/1e5</i>	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	1.4	1.5	1.5	1.1	1.0	1.0	1.0	1.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	1.2	2.1	1.4	1	1	1	1	1	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.1	4.4	1	1	2.1	2.1	2.1	2.1	2.1	CMA+DE-MOS [18]
NBC-CMA	1	1.2	2.5	360	<i>15e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	1	253	53	89	620	<i>55e-2/3e5</i>	.	.	.	.	POEMS [17]
PM-AdapSS-DE	1	1.7	5.4	94	<i>81e-2/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1	1.2	55	61	622	<i>23e-2/3e5</i>	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	1	1.2	3.5	12	24	<i>17e-2/5e4</i>	.	.	.	.	Basic RCGA [24]
SPSA	44	126	14	1136	<i>18e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 20: 10-D, running time excess ERT/ERT_{best} 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} 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	7.6	9.2	10	57	<i>99e-2/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.2	5.2	5.7	32	<i>91e-2/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.9	4.6	4.9	13	<i>87e-2/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.4	9.0	10	53	<i>10e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.3	4.0	4.4	15	<i>89e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.7	3.5	3.7	13	<i>79e-2/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.2	2.8	3.3	14	<i>69e-2/1e4</i>	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.6	3.2	3.7	17	<i>87e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.3	2.7	3.2	22	<i>87e-2/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.7	2.1	2.4	18	<i>83e-2/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.9	7.5	8.7	1	9.0	6.6	4.9	5.0	7.0	14	Artif Bee Colony [8]
avg NEWUOA	1	1	1	209	<i>12e-1/8e3</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.1	8.5	8.9	<i>18e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	13	21	23	100	182	132	95	85	82	57	Adap DE (F-AUC) [10]
DE (Uniform)	20	28	32	84	38	28	20	18	17	12	DE (Uniform) [9]
IPOP-aCMA-ES	2.3	3.4	3.6	13	5.9	4.5	3.3	3.0	2.9	2.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	2.4	3.4	3.8	16	5.5	4.1	3.0	2.7	2.7	1.9	IPOP-CMA-ES [22]
CMA+DE-MOS	10	16	18	4.3	1	1	1	1	1	1	CMA+DE-MOS [18]
NBC-CMA	4.2	8.4	10	33	<i>77e-2/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	67	79	87	6.3	106	77	56	50	48	34	POEMS [17]
PM-AdapSS-DE	16	24	26	128	<i>36e-2/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	71	83	87	19	107	78	56	51	49	35	pPOEMS [17, 20]
Basic RCGA	7.0	10	12	2727	<i>17e-1/5e4</i>	.	.	.	.	.	Basic RCGA [24]
SPSA	8.3	12	16	<i>19e-1/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 21: 10-D, running time excess ERT/ERT_{best} 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											
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	6.7	5.0	6.1	6.0	6.0	6.0	6.0	6.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	3.2	4.0	4.0	3.9	3.9	3.9	3.9	3.9	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.6	1.9	2.1	2.0	2.0	2.0	2.0	2.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	15	6.8	5.1	5.1	5.1	5.1	5.1	5.1	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	2.4	2.2	3.1	3.1	3.1	3.1	3.1	3.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.6	2.3	1.3	1.3	1.3	1.3	1.3	1.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	1.8	1.5	1	1	1	1	1	1	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	2.7	2.2	1.9	1.9	1.9	1.9	1.9	1.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.6	2.2	1.2	1.2	1.2	1.2	1.2	1.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	1.5	2.3	1.7	1.7	1.7	1.7	1.7	1.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	3.0	1	2.4	2.8	3.4	7.5	12	58	Artif Bee Colony [8]
avg NEWUOA	1	1	1.2	2.9	1.3	1.3	1.3	1.3	1.3	1.3	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	62	4.9	35	17	17	17	17	17	18	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	8.8	40	24	24	24	24	24	23	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	10	40	33	32	32	32	32	32	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	1	11	16	16	16	16	16	16	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	2.2	4.8	15	15	15	15	15	15	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	9.4	121	144	144	144	143	143	142	CMA+DE-MOS [18]
NBC-CMA	1	1	4.6	96	53	53	53	52	52	52	NBC-CMA [21]
POEMS	1	1	1329	931	464	462	461	460	458	456	POEMS [17]
PM-AdapSS-DE	1	1	7.0	79	74	73	73	73	73	72	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	15	260	276	321	387	387	388	389	pPOEMS [17, 20]
Basic RCGA	1	1	46	42	24	25	25	26	26	27	Basic RCGA [24]
SPSA	1	102	36	457	434	434	437	890	890	904	SPSA [13]

Table 22: 10-D, running time excess ERT/ERT_{best} 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	5.3	3.6	14	14	14	14	14	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	5.1	3.6	8.3	8.2	8.2	8.1	8.0	7.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	5.5	4.1	12	12	12	12	11	11	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	17	4.5	19	19	19	19	18	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	4.3	2.7	4.6	4.5	4.5	4.5	4.4	4.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.2	2.6	5.4	5.4	5.4	5.3	5.3	5.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.3	1.6	6.8	6.7	6.7	6.6	6.6	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	4.6	3.2	6.2	6.2	6.1	6.1	6.0	5.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.6	1.8	1.9	1.9	1.9	1.9	1.8	1.8	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	6.1	1.7	2.3	2.3	2.3	2.3	2.3	2.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	4.8	1.7	16	177	<i>13e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	1	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	53	6.1	161	481	477	473	467	462	451	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	8.8	273	<i>20e-1/1e5</i>	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	8.8	157	1037	1029	1020	1006	996	973	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	12	78	312	309	306	302	299	292	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	12	35	313	311	308	304	301	294	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	48	208	596	592	587	580	574	561	CMA+DE-MOS [18]
NBC-CMA	1	1	222	86	<i>51e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	1	1	1335	1637	1445	1433	1421	1403	1390	1359	POEMS [17]
PM-AdapSS-DE	1	1	7.9	273	<i>20e-1/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	632	141	200	200	200	199	199	198	pPOEMS [17, 20]
Basic RCGA	1	1	199	79	161	253	<i>69e-2/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	3.3	69	826	321	<i>51e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 23: 10-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 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											
$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	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	27	609	<i>14e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	3.3	27	<i>35e-2/1e4</i>	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	6.2	27	<i>39e-2/1e4</i>	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	32	312	<i>14e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	5.3	13	<i>35e-2/1e4</i>	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	4.0	13	<i>34e-2/1e4</i>	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	3.6	5.7	5.9	<i>23e-2/1e4</i>	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	4.1	23	<i>60e-2/1e4</i>	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	4.6	1.8	<i>28e-2/1e4</i>	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	3.6	1.7	<i>26e-2/1e4</i>	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	1.7	13	<i>49e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	7.9	1	<i>21e-2/1e4</i>	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	35	24	155	<i>84e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	1.6	33	10	<i>15e-2/1e5</i>	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	1.1	38	18	20	20	20	20	19	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	1.3	179	<i>71e-2/2e5</i>	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	1.7	147	20	16	16	16	16	16	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	1.2	9.3	1	1	1	1	1	1	CMA+DE-MOS [18]
NBC-CMA	1	1	1	270	<i>11e-1/3e4</i>	.	.	.	.	.	NBC-CMA [21]
POEMS	1	1	6.5	10	3.2	27	<i>36e-3/3e5</i>	.	.	.	POEMS [17]
PM-AdapSS-DE	1	1	1.1	32	<i>28e-2/1e5</i>	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	4.1	63	5.0	28	58	<i>25e-3/3e5</i>	.	.	pPOEMS [17, 20]
Basic RCGA	1	1	1.7	63	29	<i>44e-2/5e4</i>	Basic RCGA [24]
SPSA	1	173	745	1485	<i>11e-1/1e5</i>	SPSA [13]

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