Comparison tables: BBOB 2010 function testbed in 10-D

The BBOBies

August 30, 2010

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$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.27	3.8	3.9	3.9	4.0	4.0	4.0	4.0	4.0	ERT$_{\text{best}}$/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$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	37	114	205	289	342	351	365	374	382	398	ERT$_{\text{best}}$/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	*69e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 3: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.13	17	278	804	917	1035	1111	1239	1390	1627	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	3.3	25	*30e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.2**	**2.2**	171	*14e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**2.6**	244	*17e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.0	35	249	*38e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.9	3.0	*15e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.7**	**1.5**	57	*11e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.5**	**1.5**	47	*99e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.3**	**2.5**	235	*18e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.1	5.6	523	*18e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	5.5	**1**	522	*20e+0/1e4*	.	.	.	.	.	.	(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	*21e+0/7e3*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	39	**2.1**	49	1748	1532	1358	1265	1135	1011	*50e-1/1e5*	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	*30e-1/1e5*	.	.	.	.	.	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	*40e-1/3e4*	.	.	.	.	.	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	*10e-1/1e5*	.	.	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	*87e+0/1e5*	.	.	.	.	.	.	.	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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.22	30	284	1154	1596	1899	2123	2361	2514	2860	ERT_{best}/D
(1,2)-CMA-ES	**1.5**	22	*41e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.9**	**2.0**	241	*18e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.5	**2.8**	164	*18e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.8	47	*51e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.5**	**2.0**	*22e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.6**	**1.7**	*17e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.7	**1.7**	244	*15e+0/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.4**	7.4	*20e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.6**	6.3	249	*27e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.9**	6.8	*26e+0/1e4*	.	.	.	.	.	.	.	(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	*27e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	42	**1.8**	284	*90e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.8**	6.5	73	*60e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1.4**	8.3	87	*50e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**2.8**	**1**	6.0	*60e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	**1.1**	5.9	*60e-1/2e5*	.	.	.	.	.	.	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	*60e-1/3e4*	.	.	.	.	.	.	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	*60e-1/1e5*	.	.	.	.	.	.	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	*79e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	84	2906	*99e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 5: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	1.2	4.1	4.6	4.7	4.7	4.7	4.7	4.7	4.7	ERT$_{\text{best}}$/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/$\mathrm{ERT}_{\mathrm{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	3.9	16	40	61	85	107	138	173	204	252	$\mathrm{ERT}_{\mathrm{best}}$/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	*26e-4/1e4*	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	**1**	**1.2**	**2.6**	14	72	145	851	*21e-4/1e4*	.	(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	*56e-5/5e4*	.	Basic RCGA [24]
SPSA	902	42628	36837	*22e+1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 7: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.21	4.6	45	192	313	393	398	398	398	406	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.9**	11	21	*35e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.2**	3.6	4.5	40	219	*73e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	4.4	3.4	39	*59e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.3**	12	39	*40e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.9**	**2.6**	**2.0**	44	*65e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.2	**2.2**	**1.4**	21	451	*56e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.8**	**2.3**	**1.9**	18	216	*69e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.6**	**1.6**	4.2	63	454	*10e-1/1e4*	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.9**	**1.9**	6.8	5.3	8.8	13	16	16	16	16	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.5**	**1.5**	5.5	4.7	10	17	17	17	17	17	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.3**	5.8	10	430	2179	*95e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.5**	**1**	6.0	32	*73e-2/1e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	31	7.7	3.9	2091	*31e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.1**	7.9	3.8	**1.7**	**1.6**	**1.7**	**1.8**	**1.8**	**1.8**	**1.9**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.4**	10	4.6	**2.4**	**2.3**	**2.4**	**2.5**	**2.5**	**2.5**	**2.6**	DE (Uniform) [9]
IPOP-aCMA-ES	3.5	**2.4**	**1.0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.3**	**2.0**	**1**	**1.6**	**2.0**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.3**	5.5	**3.0**	**2.5**	3.0	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	CMA+DE-MOS [18]
NBC-CMA	**1.3**	3.6	**1.3**	**1.2**	5.4	17	20	20	20	21	NBC-CMA [21]
POEMS	383	56	13	10	197	160	159	159	159	155	POEMS [17]
PM-AdapSS-DE	**1.2**	8.3	4.0	**2.0**	**1.8**	**1.9**	**2.0**	**2.0**	**2.0**	**2.0**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	59	15	30	38	56	59	59	59	58	pPOEMS [17, 20]
Basic RCGA	**1.5**	5.9	31	68	399	*12e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	189	45	31169	*28e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 8: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	5.2	16	32	81	93	101	104	106	108	110	ERT$_{\text{best}}$/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	*40e-5/1e5*	.	.	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	*40e-6/3e5*	.	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	*56e-1/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	374	1101	8859	*13e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 9: 10-D, running time excess ERT/$\mathrm{ERT_{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT_{best}}$/D	6.9	15	25	115	127	134	138	140	142	144	$\mathrm{ERT_{best}}$/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	*51e-2/1e5*	.	.	.	.	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	*70e-4/3e5*	.	.	.	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	*68e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	349	2995	8361	*43e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 10: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	60	133	256	302	334	343	354	363	371	387	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	18	11	6.7	6.4	6.0	5.9	5.9	5.8	5.8	5.7	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	7.9	5.2	3.4	3.1	**2.9**	**2.9**	**2.9**	**2.8**	**2.8**	**2.8**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.9	4.6	3.1	**2.7**	**2.5**	**2.5**	**2.5**	**2.4**	**2.4**	**2.4**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	14	10	6.1	6.3	6.0	6.0	5.9	5.9	5.9	5.8	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.2	**3.0**	**2.1**	**2.1**	**2.1**	**2.1**	**2.0**	**2.0**	**2.0**	**2.0**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.3	**2.6**	**1.9**	**1.9**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.7**	**2.1**	**1.5**	**1.4**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**	**1.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.2	**2.7**	**1.8**	**1.8**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.0**	**1.5**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.6**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2951	*11e+2/1e5*	.	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1.4**	**2.5**	3.9	5.2	7.1	8.4	10	13	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	13	7.5	4.4	4.0	3.8	3.8	3.7	3.7	3.7	3.6	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.8	3.1	**2.1**	**2.2**	**2.3**	**2.6**	**2.8**	3.1	3.4	3.9	Adap DE (F-AUC) [10]
DE (Uniform)	6.0	4.1	**2.8**	**2.9**	3.2	3.6	4.0	4.4	4.8	5.5	DE (Uniform) [9]
IPOP-aCMA-ES	**1.9**	**1.4**	**1.1**	**1.0**	**1.0**	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.1	**2.0**	**1.4**	**1.5**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	6.8	4.7	3.2	3.2	3.1	3.2	3.3	3.3	3.3	3.4	CMA+DE-MOS [18]
NBC-CMA	3.8	**2.9**	**2.3**	**2.3**	**2.3**	**2.5**	**2.5**	**2.5**	**2.6**	**2.6**	NBC-CMA [21]
POEMS	271	1204	17455	*33e+0/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	5.5	3.5	**2.4**	**2.5**	**2.7**	**3.0**	3.3	3.6	3.9	4.4	PM-AdapSS-DE [9, 10]
pPOEMS	150	282	862	4323	6377	*27e-1/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	1158	*99e+1/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	11600	*19e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 11: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	4.4	49	187	211	231	250	266	281	297	330	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	25	16	5.4	5.9	6.0	6.1	6.0	5.8	5.7	5.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	25	11	3.6	3.7	3.7	3.6	3.5	3.4	3.3	3.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	24	10	3.2	3.2	3.2	3.1	**3.0**	**2.9**	**2.9**	**2.7**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	53	19	6.2	6.3	6.4	6.5	6.5	6.4	6.3	5.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	18	7.4	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.6**	**2.6**	**2.4**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	23	8.4	**2.8**	**2.8**	**2.8**	**2.7**	**2.7**	**2.6**	**2.5**	**2.4**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	15	5.6	**1.9**	**1.9**	**1.9**	**1.8**	**1.8**	**1.8**	**1.7**	**1.6**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	13	6.7	**2.2**	**2.2**	**2.2**	**2.2**	**2.1**	**2.1**	**2.0**	**1.9**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.0**	**1.6**	**1.5**	**2.0**	**2.4**	**2.5**	**2.5**	**2.4**	**2.4**	**2.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.7**	**1.3**	**1.8**	**2.1**	**2.1**	**2.1**	**2.1**	**2.0**	**1.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.5**	**1.4**	*18e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	4.6	11	5.2	9.1	11	14	17	19	21	22	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	30	29	13	48	45	42	41	39	37	34	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	3.1	**1.5**	**1.3**	**1.8**	**2.1**	**2.5**	**2.7**	3.0	3.3	3.6	Adap DE (F-AUC) [10]
DE (Uniform)	3.5	**2.4**	**1.6**	**2.3**	**2.8**	3.3	3.8	4.2	4.6	5.2	DE (Uniform) [9]
IPOP-aCMA-ES	**1.5**	**2.4**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.0**	4.8	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**1.8**	**1.8**	**1.7**	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.0**	**1.4**	3.8	4.0	4.0	4.0	3.9	3.9	3.8	3.7	CMA+DE-MOS [18]
NBC-CMA	**1.8**	**1.4**	23	21	19	18	17	16	15	14	NBC-CMA [21]
POEMS	42	7.6	30	101	172	216	258	299	339	383	POEMS [17]
PM-AdapSS-DE	**2.8**	**2.0**	**1.5**	**2.0**	**2.4**	**2.8**	3.1	3.4	3.7	4.2	PM-AdapSS-DE [9, 10]
pPOEMS	37	10	29	84	132	178	208	242	270	312	pPOEMS [17, 20]
Basic RCGA	3.9	**1**	543	*11e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	34	*34e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 12: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	23	48	103	235	461	549	650	748	831	963	ERT$_{\text{best}}$/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	*41e-3/1e5*	.	.	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	*40e-1/3e5*	.	.	.	.	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	*92e-2/3e5*	.	pPOEMS [17, 20]
Basic RCGA	112	93	60	99	317	609	*39e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	3216	1647	2136	*21e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 13: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.2	11	93	210	255	333	457	543	646	846	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	7.6	7.0	7.1	8.1	16	28	42	128	224	*44e-4/1e4*	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.5**	3.8	4.1	7.2	12	16	24	57	104	*37e-5/1e4*	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.3**	4.8	**1.7**	4.4	6.2	14	26	81	106	167	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.5	6.5	7.9	13	31	57	100	275	*18e-3/1e4*	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.1**	3.2	**2.7**	4.3	5.6	5.1	9.3	14	20	25	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.5**	**2.8**	**2.1**	3.7	4.4	4.1	5.5	6.3	14	36	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.2**	**2.3**	**1.6**	**1.8**	3.7	3.5	4.3	4.8	5.9	18	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**2.5**	**2.7**	3.9	4.1	4.9	6.3	6.6	10	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.5**	**2.3**	**1.3**	**1.8**	**1.9**	**2.9**	**2.5**	**2.4**	3.9	5.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.9**	**1.8**	**1.7**	**2.2**	**2.7**	**2.8**	**2.9**	**2.6**	6.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.7	19	7.9	57	765	*18e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	**1**	**1.3**	3.8	9.5	23	32	68	267	*39e-5/1e4*	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.4	5.2	**2.6**	6.0	99	270	197	374	430	1659	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.0	23	5.1	3.3	3.7	3.5	3.0	**3.0**	**2.8**	**2.7**	Adap DE (F-AUC) [10]
DE (Uniform)	6.4	31	7.3	4.8	5.3	5.0	4.4	4.3	4.1	4.0	DE (Uniform) [9]
IPOP-aCMA-ES	**1.6**	3.5	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.1**	3.9	**1.6**	**1.4**	**1.6**	**1.3**	**1.2**	**1.2**	**1.5**	**1.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	3.4	14	3.0	3.3	4.5	3.8	3.2	3.2	**3.0**	**2.8**	CMA+DE-MOS [18]
NBC-CMA	**2.8**	6.7	**1.8**	**2.8**	3.4	**2.7**	**2.8**	**2.6**	3.1	3.2	NBC-CMA [21]
POEMS	71	99	36	977	4728	5882	*61e-2/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	7.4	26	5.8	3.8	4.2	4.0	3.5	3.4	3.3	3.1	PM-AdapSS-DE [9, 10]
pPOEMS	68	119	122	230	995	3816	9400	7964	6748	*70e-3/3e5*	pPOEMS [17, 20]
Basic RCGA	4.3	63	66	349	835	2170	*17e-1/5e4*	.	.	.	Basic RCGA [24]
SPSA	35	639	5184	*13e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 14: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.19	6.3	13	17	25	42	109	240	362	ERT$_{\text{best}}$/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	*64e-5/1e5*	.	.	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	*33e-7/3e5*	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	*61e-8/3e5*	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	3.2	23	34	75	982	6465	*76e-5/5e4*	.	Basic RCGA [24]
SPSA	21	186	56	56	46	40	49	136	299	*43e-7/1e5*	SPSA [13]

Table 15: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	19	436	3945	6020	6150	6270	6385	6515	6753	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	8.3	18	*31e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	**2.0**	79	*14e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	**2.0**	68	*12e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.5	39	*29e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.4**	4.8	160	*15e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.6**	**1.1**	61	*11e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.6**	26	*90e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	4.2	150	*13e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.5	3.6	162	*16e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	4.8	5.2	156	*16e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.7**	7.3	*14e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	5.5	4.3	253	*25e+0/7e3*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	61	**1.8**	19	369	*30e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.8**	6.1	71	110	237	232	227	223	219	211	Adap DE (F-AUC) [10]
DE (Uniform)	**2.2**	7.8	75	50	114	112	109	108	105	102	DE (Uniform) [9]
IPOP-aCMA-ES	**2.3**	**1**	**1**	**1**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.1	**1.2**	**1.4**	**1.0**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.1**	4.5	**1.5**	**1.6**	**1.6**	**1.5**	**1.6**	**1.5**	**1.5**	**1.5**	CMA+DE-MOS [18]
NBC-CMA	**1.7**	**2.2**	**2.7**	107	*30e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	438	18	351	*80e-1/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**2.1**	7.1	78	18	21	31	71	227	*66e-3/1e5*	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1.8**	18	154	*60e-1/3e5*	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1.4**	5.0	18	86	120	118	116	114	111	108	Basic RCGA [24]
SPSA	6.71e5	3815	*72e+0/1e5*	.	.	.	.	.	.	.	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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
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	*11e+0/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.4**	17	174	*25e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	20	174	*32e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	493	*15e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.5**	14	82	*20e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.4**	6.9	25	92	*64e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.4**	7.6	43	*13e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.5**	17	176	*28e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.7**	3.3	83	*16e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	**2.7**	176	*13e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.3**	**2.1**	270	*92e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.5**	**2.1**	73	*13e-1/1e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	53	8.7	36	90	368	*10e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.7**	45	*51e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.7**	66	*45e-1/1e5*	.	.	.	.	.	.	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	*34e-1/1e5*	.	.	.	.	.	.	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	*87e-3/5e4*	.	Basic RCGA [24]
SPSA	**1**	1551	784	3811	*56e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 17: 10-D, running time excess ERT/$\mathrm{ERT_{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT_{best}}$/D	0.10	0.10	5.9	52	159	467	1010	1381	1772	2731	$\mathrm{ERT_{best}}$/D
(1,2)-CMA-ES	**1**	**2.5**	54	2798	*25e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.7**	**2.5**	46	271	311	*18e-2/1e4*	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.1**	14	43	451	*34e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.2**	92	2782	*24e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	4.2	68	*38e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.4**	18	448	*24e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**1.2**	42	296	*15e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.7**	**1.5**	101	*69e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.3**	7.5	368	*13e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**2.8**	597	*13e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.2**	5.1	794	*65e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.1**	**1**	822	*10e-1/3e4*	.	.	.	.	.	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	*16e-6/3e4*	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	*16e-5/5e4*	Basic RCGA [24]
SPSA	6.67e5	8.76e5	15388	27199	*86e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 18: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.30	25	128	381	1506	2082	2574	2988	3772	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.6**	12	131	*78e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.7**	**1.7**	111	*11e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	5.7	7.2	146	*13e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.9**	12	281	*74e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	6.6	58	250	*18e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	3.7	12	53	378	*58e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.2**	6.1	89	*83e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	4.2	37	528	*23e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.4**	4.2	88	*48e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.6**	59	*39e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	3.0	59	5159	*18e-1/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	6.5	69	*32e-1/9e4*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	40	29	**1.7**	3.1	6.9	4.5	30	166	*54e-5/1e5*	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.8**	7.2	4.3	**2.6**	**1.0**	**1**	**1**	**1.1**	**1.1**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.3**	**2.2**	9.0	5.9	3.6	**1.4**	**1.4**	**1.4**	**1.5**	**1.6**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	5.0	**1.2**	**1.0**	**1.5**	**1.0**	**1.0**	**1.1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.4**	**1**	**1.1**	**1.8**	**1**	**1.1**	**1.3**	**1.2**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**1.8**	5.1	**2.3**	**1.6**	**1.3**	**1.2**	**1.3**	**1.4**	**1.5**	CMA+DE-MOS [18]
NBC-CMA	**1**	**2.0**	**1.9**	**1**	**1**	**2.5**	12	171	147	*31e-5/3e4*	NBC-CMA [21]
POEMS	**1**	395	19	186	299	304	581	1636	*25e-3/3e5*	.	POEMS [17]
PM-AdapSS-DE	**1.1**	**1.1**	8.0	4.8	**2.9**	**1.1**	**1.1**	**1.1**	**1.2**	**1.2**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	48	19	76	77	48	71	114	153	260	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	7.8	74	66	51	77	281	*14e-3/5e4*	.	Basic RCGA [24]
SPSA	8.78e5	6.71e5	*66e+1/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 19: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.10	4.8	585	6862	54255	71840	72500	73039	74120	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	11	125	*24e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.7**	26	*90e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	3.4	38	*11e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	5.0	249	*32e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1.7**	34	*13e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.4**	7.7	*58e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**1.2**	7.4	*68e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.7**	13	*77e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.3**	11	*85e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.1**	3.8	*55e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	8.6	722	*12e-1/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1**	121	*83e-2/1e5*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	23	64	4.7	4.8	65	*20e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	6.3	69	*59e-2/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	8.2	143	*52e-2/1e5*	.	.	.	.	.	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	*15e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	253	53	89	620	*55e-2/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1.7**	5.4	94	*81e-2/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.2**	55	61	622	*23e-2/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	3.5	12	24	*17e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	44	126	14	1136	*18e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 20: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.8	3.8	3.8	274	7839	10807	15033	16771	17441	24973	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	7.6	9.2	10	57	*99e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.2	5.2	5.7	32	*91e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.9	4.6	4.9	13	*87e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.4	9.0	10	53	*10e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.3	4.0	4.4	15	*89e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.7**	3.5	3.7	13	*79e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.2**	**2.8**	3.3	14	*69e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.6**	3.2	3.7	17	*87e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**2.7**	**3.2**	22	*87e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.7**	**2.1**	**2.4**	18	*83e-2/1e4*	.	.	.	.	.	(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	*12e-1/8e3*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.1	8.5	8.9	*18e-1/1e5*	.	.	.	.	.	.	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	*77e-2/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	67	79	87	**6.3**	106	77	56	50	48	34	POEMS [17]
PM-AdapSS-DE	16	24	26	128	*36e-2/1e5*	.	.	.	.	.	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	*17e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	8.3	12	16	*19e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 21: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

∆ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	∆ftarget
ERT$_{\text{best}}$/D	0.10	0.10	34	641	1560	1567	1573	1579	1585	1595	ERT$_{\text{best}}$/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$_{\text{best}}$ 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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.10	35	734	1351	1362	1374	1393	1407	1441	ERT$_{\text{best}}$/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	*13e-3/1e5*	.	.	.	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	*20e-1/1e5*	.	.	.	.	.	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	*51e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	**1**	1335	1637	1445	1433	1421	1403	1390	1359	POEMS [17]
PM-AdapSS-DE	**1**	**1**	7.9	273	*20e-1/1e5*	.	.	.	.	.	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	*69e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	3.3	69	826	321	*51e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 23: 10-D, running time excess ERT/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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.10	0.39	234	25135	73833	74265	74646	75018	75731	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	27	609	*14e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	3.3	27	*35e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	6.2	27	*39e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	32	312	*14e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	5.3	13	*35e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	4.0	13	*34e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	3.6	5.7	5.9	*23e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	4.1	23	*60e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	4.6	**1.8**	*28e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	3.6	**1.7**	*26e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.7**	13	*49e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	7.9	**1**	*21e-2/1e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	35	24	155	*84e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.6**	33	10	*15e-2/1e5*	.	.	.	.	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	*71e-2/2e5*	.	.	.	.	.	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	*11e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	**1**	6.5	10	**3.2**	27	*36e-3/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.1**	32	*28e-2/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	4.1	63	**5.0**	28	58	*25e-3/3e5*	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.7**	63	29	*44e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	**1**	173	745	1485	*11e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 24: 10-D, running time excess ERT/ERT$_{\text{best}}$ 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

24 Lunacek bi-Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	9.5	35175	3.03e5	1.94e6	1.94e6	1.94e6	1.94e6	1.94e6	1.94e6	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	38	*50e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	3.3	*23e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	4.2	*22e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	50	*53e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	3.4	4.1	*25e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.6**	**1.4**	*12e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.9**	*17e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	3.4	*23e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	6.3	*24e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**3.0**	**1.4**	*18e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	17	*24e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	*21e+0/8e3*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	78	3.4	**1**	*41e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	11	13	*14e+0/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	14	13	*16e+0/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.5**	14	**11**	*10e+0/2e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.4**	6.7	**2.4**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	*81e-1/2e5*	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	8.0	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	CMA+DE-MOS [18]
NBC-CMA	**1**	3.4	*32e+0/3e4*	.	.	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	34	34	*16e+0/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	11	19	*12e+0/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	33	6.8	*89e-1/3e5*	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	5.1	10	*12e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	118	*32e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

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