Comparison tables: BBOB 2010 function testbed 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 [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: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	1.7	3.0	3.0	3.0	3.0	3.0	3.0	3.0	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**2.6**	7.3	13	20	25	33	39	55	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.1**	**2.2**	7.9	16	20	29	35	50	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.5**	**2.7**	6.1	11	17	25	30	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**2.8**	3.2	7.7	11	20	29	38	50	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.0**	3.2	6.1	10	15	20	25	33	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.1**	**2.2**	6.2	11	17	20	23	31	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**1.8**	**2.3**	**4.5**	**8.8**	**12**	**15**	**18**	**24**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**2.7**	3.3	6.1	**9.3**	13	17	**20**	**26**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.5**	3.2	6.7	11	14	18	21	28	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.6**	**2.2**	**5.7**	10	**13**	**16**	20	26	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.2**	7.0	21	39	62	85	109	156	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	7.7	7.4	6.9	14	23	49	68	97	129	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.9**	5.7	18	30	41	59	71	104	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.3**	4.3	17	32	45	59	73	103	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.9**	3.1	7.8	11	17	22	27	37	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**2.7**	4.3	10	15	20	23	28	37	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.2**	3.4	20	46	77	95	126	177	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.3**	3.9	28	55	71	88	98	120	NBC-CMA [21]
POEMS	**1**	**1**	91	79	110	335	717	1019	1441	2031	POEMS [17]
PM-AdapSS-DE	**1**	**1.1**	**1.2**	3.1	15	26	39	57	69	94	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	29	78	145	354	2481	4148	6450	12509	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.2**	8.7	44	80	194	358	482	759	Basic RCGA [24]
SPSA	**1**	27	22	19	25	29	34	39	48	63	SPSA [13]

Table 2: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$	6.0	6.9	16	53	105	132	161	174	182	201	$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$
(1,2)-CMA-ES	8.3	38	34	14	7.7	6.3	5.3	5.1	5.0	4.7	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	12	27	43	18	10	8.2	6.9	6.6	6.3	6.0	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.9	24	28	13	7.2	5.9	5.1	4.8	4.7	4.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.0	42	103	38	20	16	13	13	12	11	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.5**	**4.4**	8.7	4.6	**2.8**	**2.5**	**2.1**	**2.1**	**2.0**	**2.0**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	5.7	12	5.3	**2.9**	**2.4**	**2.1**	**2.0**	**2.0**	**2.0**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.9**	5.5	9.3	3.5	**2.2**	**1.8**	**1.5**	**1.5**	**1.5**	**1.4**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**3.0**	8.5	10	4.6	**2.6**	**2.2**	**1.8**	**1.8**	**1.8**	**1.7**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.4	7.4	**5.8**	**3.0**	**1.7**	**1.4**	**1.2**	**1.2**	**1.2**	**1.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.9**	**4.4**	**3.0**	**1.9**	**1.3**	**1.1**	**1**	**1**	**1**	**1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	18	11	5.7	4.4	4.4	4.2	4.4	4.8	5.4	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1**	**1**	**1**	**1**	**1.1**	**1.4**	**1.5**	**1.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	9.2	244	684	351	492	389	320	297	284	257	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.7	8.7	7.4	**2.8**	**1.9**	**1.8**	**1.7**	**1.8**	**2.0**	**2.2**	Adap DE (F-AUC) [10]
DE (Uniform)	6.6	9.4	6.3	**2.8**	**1.9**	**1.8**	**1.8**	**1.8**	**2.0**	**2.3**	DE (Uniform) [9]
IPOP-aCMA-ES	3.8	4.6	7.0	3.2	**1.8**	**1.5**	**1.3**	**1.3**	**1.4**	**1.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.5	6.8	8.1	3.8	**2.2**	**1.9**	**1.6**	**1.6**	**1.6**	**1.6**	IPOP-CMA-ES [22]
CMA+DE-MOS	11	18	12	5.4	4.0	3.8	3.6	4.2	4.5	4.9	CMA+DE-MOS [18]
NBC-CMA	13	19	20	18	14	15	16	20	23	22	NBC-CMA [21]
POEMS	147	300	193	73	46	43	44	45	49	57	POEMS [17]
PM-AdapSS-DE	6.1	10	6.3	**2.7**	**1.8**	**1.8**	**1.8**	**1.9**	**2.0**	**2.1**	PM-AdapSS-DE [9, 10]
pPOEMS	127	642	945	387	285	256	252	276	321	371	pPOEMS [17, 20]
Basic RCGA	8.0	17	19	10	7.5	12	12	21	27	39	Basic RCGA [24]
SPSA	10	136	821	1610	1641	1650	*33e-2/1e5*	.	.	.	SPSA [13]

Table 3: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.77	15	215	363	451	531	588	627	718	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1.1**	**2.9**	6.5	10	29	23	20	18	17	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.0**	**1.6**	5.3	17	18	18	17	16	14	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.3**	**2.7**	**1.6**	3.9	11	13	11	10	9.2	8.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	4.3	8.6	9.4	27	22	18	20	19	16	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.6**	**2.3**	4.7	5.5	8.7	7.0	6.0	5.4	5.1	4.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.7**	**2.4**	3.3	3.0	**2.6**	**2.4**	**2.2**	**2.0**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.3**	**1.8**	**1**	**1.9**	5.2	5.3	4.5	4.1	3.9	3.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.1**	4.1	**2.5**	4.5	12	12	10	9.3	8.8	7.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.4**	**2.7**	7.4	16	13	11	10	9.4	8.3	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.4**	4.4	4.2	5.3	4.3	3.6	3.3	3.1	**2.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**1.6**	**2.7**	**1.1**	**1.0**	**1.2**	**1.2**	**1.3**	**1.5**	**1.6**	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.4**	**2.4**	**1**	**2.0**	**1.6**	**1.4**	**1.2**	**1.1**	**1.0**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.1	8.8	46	172	272	360	527	1109	1042	909	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**1.4**	**2.5**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	**1.5**	**2.5**	**1.3**	**1.0**	**1.1**	**1.1**	**1.0**	**1.0**	**1.0**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	**2.3**	**2.0**	**2.2**	4.3	3.7	3.2	**3.0**	**2.8**	**2.6**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.2**	3.8	**2.0**	**2.1**	4.7	4.0	3.7	3.4	3.3	**3.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.0**	3.2	**1.5**	**1.3**	**1.4**	**1.4**	**1.5**	**1.5**	**1.6**	CMA+DE-MOS [18]
NBC-CMA	**1.3**	**1.6**	**3.0**	3.1	4.0	4.6	4.1	3.8	3.6	3.2	NBC-CMA [21]
POEMS	**1**	201	20	6.5	7.2	8.7	10	11	12	13	POEMS [17]
PM-AdapSS-DE	**1.3**	**1.5**	**2.4**	**1.2**	21	17	14	13	12	11	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.9**	21	14	26	51	53	60	73	86	pPOEMS [17, 20]
Basic RCGA	**1.1**	**1.4**	**2.8**	11	11	19	28	30	29	27	Basic RCGA [24]
SPSA	22	9373	475	593	786	*14e-1/1e5*	.	.	.	.	SPSA [13]

Table 4: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.77	15	322	586	747	880	1041	1238	1595	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	3.3	6.3	6.8	23	24	21	18	15	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	**2.0**	5.9	5.5	10	10	8.5	7.2	6.1	4.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**2.1**	**1.7**	7.0	19	15	13	11	9.2	7.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	5.8	5.2	16	28	23	19	16	14	11	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**2.0**	**1**	4.2	10	8.3	7.0	6.0	5.0	3.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.8**	**1.5**	4.5	10	9.0	7.6	6.5	5.5	4.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	3.6	4.5	**2.7**	5.4	5.6	4.8	4.1	3.4	**2.7**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**2.2**	**2.6**	**2.1**	6.9	5.7	4.8	4.1	3.4	**2.7**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.3**	**2.7**	7.1	19	15	13	11	8.9	6.9	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.3**	**2.5**	**5.1**	**4.0**	**3.4**	**2.9**	**2.5**	**1.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.0**	**1.8**	**2.8**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	Artif Bee Colony [8]
avg NEWUOA	**1**	**3.0**	4.6	**2.1**	5.4	4.3	3.6	3.1	**2.6**	**2.0**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	15	14	95	702	1885	1601	1358	1142	886	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.8**	**3.0**	**1.1**	43	34	29	25	21	16	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.7**	3.4	**1.0**	43	34	42	36	30	23	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.7**	**2.4**	3.0	15	21	24	22	19	15	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.1**	4.9	3.5	6.4	24	32	34	44	38	30	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.2**	3.2	**1.7**	**2.1**	**1.9**	**1.8**	**1.6**	**1.5**	**1.3**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.8**	4.9	3.1	5.4	5.5	4.7	5.2	5.7	4.4	NBC-CMA [21]
POEMS	**1**	197	25	7.5	11	10	10	10	8.8	8.3	POEMS [17]
PM-AdapSS-DE	**1**	**2.5**	**2.8**	79	115	90	76	65	54	42	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.7**	25	16	17	34	39	39	39	38	pPOEMS [17, 20]
Basic RCGA	**1.1**	**2.3**	6.8	21	87	157	829	*36e-3/5e4*	.	.	Basic RCGA [24]
SPSA	25	11800	3504	2022	*47e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 5: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	2.1	3.4	3.5	3.5	3.5	3.5	3.5	3.5	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	4.5	5.4	5.7	5.6	5.6	5.6	5.6	5.6	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.3**	3.5	3.5	3.5	3.5	3.5	3.5	3.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.5**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.9**	3.3	3.6	3.6	3.6	3.6	3.6	3.6	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.6**	**2.7**	**2.9**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**2.2**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**1.9**	**2.1**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**2.0**	3.4	3.5	3.5	3.5	3.5	3.5	3.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.0**	**2.9**	3.0	3.0	3.0	3.0	3.0	3.0	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.6**	**1.9**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	4.1	12	16	16	16	16	16	16	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	**1.1**	**3.0**	4.5	4.5	4.4	4.4	4.4	4.4	4.4	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**2.9**	5.9	6.1	6.1	6.2	6.2	6.2	6.2	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	4.5	9.2	9.4	9.3	9.3	9.3	9.3	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**2.9**	3.8	3.8	3.8	3.8	3.8	3.8	3.8	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**2.7**	4.6	5.0	5.0	5.0	5.0	5.0	5.0	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	5.3	13	14	15	15	15	15	15	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	3.8	40	45	47	47	47	47	47	NBC-CMA [21]
POEMS	**1**	**1**	113	92	99	104	107	108	108	108	POEMS [17]
PM-AdapSS-DE	**1**	**1**	6.2	6.0	6.8	6.8	6.8	6.8	6.8	6.8	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	56	96	100	102	103	103	103	103	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	5.0	396	730	1369	2060	2860	3581	20723	Basic RCGA [24]
SPSA	**1**	6.9	16	24	25	25	25	25	25	25	SPSA [13]

Table 6: 02-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	1.1	2.2	7.0	22	36	52	65	80	94	123	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**2.5**	**1.6**	4.0	**2.5**	**2.2**	**2.6**	3.3	3.3	3.4	3.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.0**	**1.6**	**2.2**	**2.4**	3.4	**3.0**	3.1	3.7	3.5	3.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.2**	**2.7**	**2.9**	**2.4**	**2.1**	**2.2**	**2.9**	**2.8**	**2.6**	**2.7**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.5**	**1.8**	3.7	3.9	9.1	7.3	7.3	6.5	5.9	5.8	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.4**	**1.8**	**1.4**	**1.4**	**1.5**	**1.5**	**1.6**	**1.5**	**1.6**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.6**	**1.5**	**1.3**	**1.2**	**1.6**	**1.5**	**1.6**	**1.5**	**1.5**	**1.5**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**1**	**1.6**	**1.4**	**1.4**	**1.3**	**1.3**	**1.2**	**1.2**	**1.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.5	**2.8**	**1.8**	**1.4**	**1.5**	**1.4**	**1.4**	**1.4**	**1.3**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.9**	**1.7**	**1.9**	**1.3**	**1.2**	**1.2**	**1.1**	**1.1**	**1.1**	**1.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.5**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.0	**2.5**	**2.5**	5.0	11	26	77	285	441	589	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.4**	**2.8**	**2.5**	**2.2**	**2.2**	**2.3**	**2.3**	**2.4**	**2.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	85	65	477	1051	732	808	656	565	569	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.1**	**1.2**	**2.6**	3.1	3.6	3.7	4.0	4.3	4.3	4.5	Adap DE (F-AUC) [10]
DE (Uniform)	**2.1**	**1.9**	**2.6**	4.1	4.4	4.4	4.7	4.6	4.8	4.9	DE (Uniform) [9]
IPOP-aCMA-ES	3.1	**1.9**	**1.9**	**1.7**	**1.8**	**1.8**	**2.0**	**2.0**	**2.0**	**1.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.4	**2.3**	**2.1**	**2.6**	**2.4**	**2.4**	**2.3**	**2.3**	**2.2**	**2.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.4**	**1.5**	**2.2**	6.3	7.5	8.4	8.5	8.8	8.7	9.1	CMA+DE-MOS [18]
NBC-CMA	**2.3**	**1.7**	**2.7**	4.4	19	14	12	11	10	8.3	NBC-CMA [21]
POEMS	150	102	55	48	56	57	63	69	69	74	POEMS [17]
PM-AdapSS-DE	**2.1**	**1.5**	**1.7**	**2.1**	3.5	4.2	4.6	4.5	4.4	4.5	PM-AdapSS-DE [9, 10]
pPOEMS	50	40	48	61	206	308	417	421	461	492	pPOEMS [17, 20]
Basic RCGA	3.1	10	5.4	64	213	305	692	906	1584	2887	Basic RCGA [24]
SPSA	55	3004	9142	4452	4491	4246	10276	*27e-2/1e5*	.	.	SPSA [13]

Table 7: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.53	1.2	5.6	29	60	69	76	76	76	86	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1.4**	3.0	**1.8**	**2.4**	12	18	53	53	53	361	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.8**	**1.7**	**1.6**	3.3	4.9	23	33	33	33	76	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.4**	**1.6**	**1.2**	**1.6**	6.6	33	45	45	45	96	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.3**	3.0	6.2	7.8	7.4	37	50	50	50	124	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.2**	**2.1**	**1.5**	**1.3**	**2.1**	4.0	4.2	4.2	4.2	6.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	**1.5**	**1.4**	**2.1**	**2.4**	6.8	7.5	7.5	7.5	7.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.2**	**1.3**	4.5	**2.3**	**2.2**	3.1	3.9	3.9	3.9	8.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.6**	**1.8**	**1**	**1.8**	**1.9**	5.0	8.0	8.0	8.0	11	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.2**	**1.4**	**1.4**	**1.6**	**1.3**	**1.5**	**1.4**	**1.4**	**1.4**	**1.4**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.4**	**1.5**	**1.8**	**1.5**	4.8	24	86	86	86	172	Artif Bee Colony [8]
avg NEWUOA	**1.6**	**2.3**	**1.1**	**1.3**	3.4	7.0	14	14	14	13	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	251	254	248	262	296	1304	1554	1554	1554	2245	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.2**	**1.4**	**1.1**	**1.1**	**1.2**	**1.7**	**1.9**	**1.9**	**1.9**	**2.2**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.7**	**2.1**	**1.9**	**1.4**	**1.4**	**1.8**	**1.8**	**1.8**	**1.8**	**2.0**	DE (Uniform) [9]
IPOP-aCMA-ES	**2.2**	**2.3**	**1.8**	**1.4**	**1.3**	**1.4**	**1.6**	**1.6**	**1.6**	**1.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.2**	**2.5**	**2.1**	**1.5**	**1.9**	**2.6**	**2.5**	**2.5**	**2.5**	**2.6**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.3**	**2.0**	**1.2**	**1.4**	**2.6**	4.2	4.8	4.8	4.8	4.9	CMA+DE-MOS [18]
NBC-CMA	**1.8**	**1.8**	**1.2**	**1.4**	**2.3**	3.4	3.8	3.8	3.8	6.2	NBC-CMA [21]
POEMS	170	162	48	14	21	26	31	31	31	34	POEMS [17]
PM-AdapSS-DE	**1.4**	**1.9**	**1.2**	**1.2**	**1.3**	**2.0**	**2.0**	**2.0**	**2.0**	**2.3**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.6**	28	31	15	22	97	137	137	137	175	pPOEMS [17, 20]
Basic RCGA	**1.1**	**1.3**	**1.2**	**2.5**	41	177	342	342	342	422	Basic RCGA [24]
SPSA	332	6747	5074	14296	*34e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 8: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	1.5	3.0	7.0	28	43	54	59	65	68	72	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**2.6**	3.3	10	14	15	15	16	16	16	16	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.1**	**2.2**	9.3	10	12	13	13	13	13	13	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.1**	**2.9**	**2.2**	4.1	6.2	8.7	9.1	8.6	8.6	8.9	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.4**	**2.4**	21	51	52	50	64	64	67	64	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.9**	**1.7**	**2.0**	4.8	5.8	5.6	5.9	5.8	5.8	6.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.4**	**2.0**	**2.1**	**1.7**	**2.9**	3.3	4.0	4.0	4.2	4.4	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.3**	**1.4**	**1.1**	**2.1**	**3.0**	3.7	3.7	3.6	3.6	3.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.2**	**1.4**	**2.2**	3.9	4.8	4.7	5.2	5.1	5.0	5.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.6**	**1.7**	**2.0**	**2.6**	**2.7**	**2.9**	**3.0**	**3.0**	**3.0**	**3.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.4**	**1.4**	**2.1**	**2.3**	**2.3**	**2.3**	**2.3**	**2.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.5**	**1.4**	**2.2**	**2.2**	7.7	80	605	3029	12690	*92e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1.6**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	15	8.7	7.6	9.1	15	18	18	18	18	19	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.8**	**2.1**	**2.8**	**2.5**	**2.7**	4.4	5.0	5.5	5.7	6.6	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	**1.5**	**2.6**	**2.1**	169	136	128	116	112	107	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	**2.4**	**2.5**	**1.7**	3.2	3.6	3.8	3.7	3.9	4.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.7	**2.8**	**2.1**	**3.0**	4.0	4.5	4.6	4.5	4.6	4.8	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.0**	**1.6**	**2.4**	3.4	6.3	9.2	10	11	12	13	CMA+DE-MOS [18]
NBC-CMA	**1.2**	**1.9**	**2.3**	**2.2**	5.4	8.3	10	10	12	13	NBC-CMA [21]
POEMS	95	60	80	82	73	78	88	98	123	151	POEMS [17]
PM-AdapSS-DE	**1.4**	**1.8**	**2.7**	**1.7**	3.2	3.6	4.4	4.9	5.2	6.2	PM-AdapSS-DE [9, 10]
pPOEMS	16	46	43	24	54	206	341	390	553	783	pPOEMS [17, 20]
Basic RCGA	**1.0**	**1.7**	3.8	3.4	61	203	575	1121	4980	10010	Basic RCGA [24]
SPSA	372	295	1218	1535	9611	26076	24712	*85e-2/1e5*	.	.	SPSA [13]

Table 9: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.97	2.4	7.7	28	60	71	77	81	83	86	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1.5**	**1.7**	4.5	12	14	16	16	16	15	16	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.4**	**2.1**	**1.6**	5.8	6.5	8.6	9.1	9.2	9.4	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.7**	**1.3**	**1.4**	4.7	5.5	6.9	7.4	7.5	7.7	8.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.7**	**1.3**	**1.4**	13	27	27	28	29	29	30	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.1	**2.2**	**1.4**	**2.5**	**2.7**	3.4	3.5	3.6	3.8	3.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.4**	**1.4**	**1.4**	**1**	**2.7**	**2.9**	3.3	3.4	3.5	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	**1.7**	**1.9**	**1.3**	**1.5**	**1.9**	**2.1**	**2.2**	**2.2**	**2.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**1.9**	**1**	**2.6**	**2.5**	3.1	3.5	3.6	3.7	3.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.8**	**2.2**	**1.4**	**1.7**	**1.6**	**1.8**	**1.9**	**1.9**	**2.0**	**2.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.8**	**1.4**	**1.7**	**1.6**	**1.3**	**1.6**	**1.6**	**1.7**	**1.8**	**2.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.0**	**2.1**	**1.9**	**2.1**	3.4	13	106	739	2509	5039	Artif Bee Colony [8]
avg NEWUOA	4.0	**2.2**	**1.4**	**1.5**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.5	8.1	45	20	15	15	15	15	15	16	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.6**	**2.9**	**2.8**	**2.5**	123	106	99	95	190	184	Adap DE (F-AUC) [10]
DE (Uniform)	**1.6**	**1.8**	**1.8**	**2.3**	**2.5**	3.8	4.3	4.8	5.1	6.1	DE (Uniform) [9]
IPOP-aCMA-ES	**1.0**	**1**	**1.4**	**2.1**	**2.2**	**2.5**	**2.8**	**2.8**	**2.9**	3.2	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.9**	**2.3**	**2.5**	3.1	**3.0**	3.3	3.4	3.5	3.6	3.9	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**2.3**	**1.3**	**1.9**	**2.1**	3.3	4.7	5.2	6.2	7.5	CMA+DE-MOS [18]
NBC-CMA	**1.7**	**1.5**	**2.1**	**2.5**	4.5	5.4	5.9	6.5	7.9	9.1	NBC-CMA [21]
POEMS	174	92	36	18	19	32	47	50	62	84	POEMS [17]
PM-AdapSS-DE	3.7	3.9	**2.1**	3.4	125	221	205	196	191	185	PM-AdapSS-DE [9, 10]
pPOEMS	82	66	36	16	44	155	267	321	438	592	pPOEMS [17, 20]
Basic RCGA	**1.7**	**2.1**	3.2	**2.5**	7.3	64	437	608	1400	8182	Basic RCGA [24]
SPSA	243	366	3569	2799	*96e-2/1e5*	.	.	.	.	.	SPSA [13]

Table 10: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	7.6	20	56	111	145	153	165	174	185	204	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	5.0	16	10	8.1	6.7	6.7	6.3	6.1	5.9	5.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	3.4	7.1	13	7.4	6.1	5.9	5.7	5.7	5.6	5.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.4**	3.8	7.6	4.7	4.0	4.6	4.4	4.4	4.2	4.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.5**	31	32	24	20	19	19	19	18	16	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.4**	**1.7**	**2.3**	**2.2**	**2.0**	**2.1**	**2.0**	**2.0**	**2.0**	**1.9**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.0	**2.9**	3.2	**2.7**	**2.2**	**2.2**	**2.2**	**2.1**	**2.1**	**2.0**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.3**	**1.7**	**2.1**	**1.6**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.4**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.2**	**2.4**	**2.3**	**1.7**	**1.6**	**1.7**	**1.7**	**1.7**	**1.7**	**1.6**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.5	**2.0**	**1.7**	**1.1**	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.2**	**1.3**	**1.5**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.5	3.7	5.4	20	143	1381	*11e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1**	**1**	**1.3**	**1.5**	**1.8**	**2.1**	**2.2**	**2.7**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.1	17	38	75	119	172	160	152	143	130	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.4	**2.7**	**1.8**	**1.4**	**1.3**	**1.5**	**1.7**	**1.8**	**1.9**	**2.1**	Adap DE (F-AUC) [10]
DE (Uniform)	3.4	**2.9**	**1.9**	**1.4**	**1.4**	**1.6**	**1.7**	**1.9**	**2.0**	**2.2**	DE (Uniform) [9]
IPOP-aCMA-ES	3.3	**2.5**	**1.4**	**1.1**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.6	**2.5**	**2.6**	**1.8**	**1.6**	**1.6**	**1.6**	**1.5**	**1.5**	**1.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	5.0	3.9	3.4	3.8	3.7	4.1	4.1	4.4	4.4	4.7	CMA+DE-MOS [18]
NBC-CMA	6.2	6.6	6.7	11	12	15	17	20	21	21	NBC-CMA [21]
POEMS	39	24	80	153	245	350	390	511	595	633	POEMS [17]
PM-AdapSS-DE	3.3	**2.9**	**2.0**	**1.3**	**1.3**	**1.5**	**1.6**	**1.8**	**1.9**	**2.1**	PM-AdapSS-DE [9, 10]
pPOEMS	34	33	41	96	155	202	260	315	349	417	pPOEMS [17, 20]
Basic RCGA	10	7.5	30	311	348	618	1357	4288	*17e-3/5e4*	.	Basic RCGA [24]
SPSA	11	64	231	387	3094	4844	*27e-2/1e5*	.	.	.	SPSA [13]

Table 11: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	6.1	8.5	27	75	130	154	165	173	186	204	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	3.9	15	17	10	6.8	6.1	5.8	5.7	5.4	5.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	9.3	29	22	11	6.5	5.9	5.7	5.6	5.4	5.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.6	14	16	7.6	5.3	5.3	5.1	5.0	4.7	4.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.1	23	35	22	20	17	17	17	16	15	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.0	7.6	7.6	3.5	**2.2**	**2.1**	**2.0**	**2.0**	**1.9**	**1.9**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.8	4.4	7.9	3.8	**2.3**	**2.2**	**2.1**	**2.1**	**2.0**	**2.0**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.5**	**4.1**	4.5	**2.5**	**1.8**	**1.7**	**1.6**	**1.6**	**1.5**	**1.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	7.8	12	7.2	**3.0**	**1.9**	**1.7**	**1.7**	**1.7**	**1.7**	**1.6**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.5	4.6	**2.8**	**2.0**	**1.3**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**3.0**	**3.7**	**2.2**	**1.6**	**1.1**	**1**	**1**	**1**	**1**	**1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.6	8.7	7.4	31	158	1576	8347	*11e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1**	**1**	**1**	**1.1**	**1.4**	**1.6**	**1.7**	**2.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.3	86	343	297	246	253	237	226	211	193	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	5.9	8.5	4.2	**2.1**	**1.5**	**1.6**	**1.7**	**1.9**	**1.9**	**2.1**	Adap DE (F-AUC) [10]
DE (Uniform)	7.0	8.3	4.0	**2.1**	**1.5**	**1.7**	**1.7**	**1.9**	**2.0**	**2.2**	DE (Uniform) [9]
IPOP-aCMA-ES	3.2	4.5	3.4	**2.0**	**1.3**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.9	7.7	5.0	**2.5**	**1.7**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	8.5	15	8.6	5.6	4.4	4.3	4.3	4.6	4.5	4.7	CMA+DE-MOS [18]
NBC-CMA	10	15	16	12	11	13	18	21	22	21	NBC-CMA [21]
POEMS	52	46	353	243	252	379	469	554	618	773	POEMS [17]
PM-AdapSS-DE	6.1	7.8	4.1	**2.2**	**1.6**	**1.7**	**1.8**	**2.0**	**2.0**	**2.2**	PM-AdapSS-DE [9, 10]
pPOEMS	59	83	75	143	168	218	258	324	360	425	pPOEMS [17, 20]
Basic RCGA	8.0	15	50	287	415	1387	*44e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	12	323	929	1490	3487	9393	8766	8361	*50e-2/1e5*	.	SPSA [13]

Table 12: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	8.6	10	17	38	56	71	80	95	108	135	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	3.4	11	13	15	18	21	22	21	25	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	3.2	28	33	17	17	17	16	14	14	15	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	12	36	44	32	29	24	22	19	18	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.5	35	99	104	95	76	69	58	51	41	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.4	11	16	13	12	11	10	9.4	8.9	8.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.0	10	16	13	13	12	11	11	10	9.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.6**	7.6	16	13	12	11	10	9.0	8.4	7.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	6.5	14	12	11	10	9.2	8.2	7.8	7.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.7**	6.6	9.2	5.9	5.1	**4.6**	**4.4**	**4.0**	**3.9**	**3.7**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.7**	**3.0**	**4.4**	**4.7**	**4.6**	**4.3**	**4.3**	**4.2**	**4.1**	**4.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.2	7.3	14	107	380	967	1728	2209	1969	1623	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.8	414	1118	4971	7306	5754	8177	14741	12961	*15e-1 / 1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.2	7.5	8.4	5.0	**5.0**	4.7	5.0	5.2	5.3	5.2	Adap DE (F-AUC) [10]
DE (Uniform)	5.6	7.3	8.4	196	279	220	198	167	147	118	DE (Uniform) [9]
IPOP-aCMA-ES	**2.6**	**3.6**	**5.3**	**4.7**	5.6	5.4	5.6	5.3	8.9	8.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.7**	6.6	10	7.2	6.2	5.9	5.6	5.1	5.1	4.6	IPOP-CMA-ES [22]
CMA+DE-MOS	7.3	11	17	13	12	12	13	13	12	12	CMA+DE-MOS [18]
NBC-CMA	8.4	12	21	40	49	46	50	52	49	41	NBC-CMA [21]
POEMS	53	75	347	443	695	982	1468	1556	1784	1865	POEMS [17]
PM-AdapSS-DE	5.5	8.5	8.6	5.2	132	220	198	267	235	189	PM-AdapSS-DE [9, 10]
pPOEMS	44	73	295	249	416	440	480	519	564	606	pPOEMS [17, 20]
Basic RCGA	7.4	22	124	446	570	530	671	601	1112	1132	Basic RCGA [24]
SPSA	1885	3848	16353	37113	24923	19627	*30e+0 / 1e5*	.	.	.	SPSA [13]

Table 13: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.53	4.1	32	98	143	177	214	246	281	352	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**2.1**	**1.9**	5.9	5.4	5.1	4.9	4.7	4.7	4.7	6.4	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.9**	4.4	5.8	6.7	6.6	6.6	8.5	11	12	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.0**	7.3	3.9	4.7	4.8	5.2	6.2	7.3	8.6	8.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.1**	11	24	10	16	16	16	19	17	26	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.2**	**2.2**	**2.5**	**1.8**	**1.6**	**1.4**	**1.6**	**1.6**	**1.7**	**1.7**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.6**	**1.9**	**2.2**	**1.4**	**1.3**	**1.8**	**1.8**	**1.8**	**1.9**	**1.8**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**1.4**	**1**	**1.2**	**1.3**	**1.2**	**1.2**	**1.3**	**1.2**	**1.4**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.2**	3.5	3.2	**1.7**	**1.6**	**1.7**	**1.7**	**1.7**	**1.6**	**1.7**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.3**	**1.3**	**1.4**	**1.0**	**1.1**	**1.1**	**1**	**1.0**	**1.2**	**1.4**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	**1**	**1.3**	**1**	**1.5**	**1.4**	**1.3**	**1.3**	**1.4**	**1.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.3**	**2.0**	**2.0**	11	367	3126	*23e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.7**	3.7	**2.3**	3.0	6.1	9.1	12	22	24	134	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	16	53	135	486	804	1687	*48e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.4**	**2.3**	**1.6**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.6**	**1.6**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.4**	**1.5**	**1.6**	**1.3**	**1.4**	**1.4**	**1.5**	**1.6**	**1.6**	**1.7**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.6**	**2.4**	**1.5**	**1.1**	**1**	**1**	**1.0**	**1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	**1.2**	**1.8**	**1.1**	**1.1**	**1.1**	**1.1**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.2**	**1.5**	**2.7**	3.1	3.0	3.3	3.4	3.3	3.3	3.3	CMA+DE-MOS [18]
NBC-CMA	**1.4**	**1.7**	**2.8**	**2.5**	**2.8**	4.2	7.3	8.7	8.1	6.9	NBC-CMA [21]
POEMS	117	58	19	18	24	83	239	743	2595	12026	POEMS [17]
PM-AdapSS-DE	**1.6**	**1.8**	**1.8**	**1.1**	**1.3**	**1.4**	**1.4**	**1.5**	**1.6**	**1.6**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.3**	29	17	42	139	182	238	268	332	382	pPOEMS [17, 20]
Basic RCGA	**1.3**	**2.0**	30	181	456	1206	3451	*19e-2/5e4*	.	.	Basic RCGA [24]
SPSA	21	15	17	59	400	2692	3388	2999	5299	*21e-3/1e5*	SPSA [13]

Table 14: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	0.77	4.9	11	16	29	50	73	181	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1.7**	8.4	7.3	5.2	8.5	12	11	10	7.2	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.1**	**1.9**	**1.8**	3.2	4.3	6.9	7.9	10	7.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.5**	**2.0**	**2.8**	3.6	6.2	7.4	8.6	6.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.9**	**1.7**	**3.0**	5.9	10	18	31	30	21	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**2.0**	**2.4**	**2.1**	**2.0**	3.3	3.1	3.3	3.4	**2.2**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.4**	**1.7**	**1**	**2.1**	**3.0**	3.9	3.5	3.7	**2.4**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.2**	**1.7**	**1.7**	**1.7**	**2.4**	**2.7**	**2.4**	**2.4**	**1.7**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	**2.1**	**1.7**	**1.6**	**2.6**	3.3	3.1	3.3	**2.0**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.7**	**1.6**	**1.9**	**2.4**	**2.0**	**2.2**	**2.1**	**1.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	**1.4**	**1.4**	**2.2**	**2.7**	**2.3**	**2.2**	**1.8**	**1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.3**	**1.5**	3.6	7.2	14	18	338	5530	*22e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.4**	3.1	**1.6**	**1**	**1**	**1**	**1**	**1**	**1.7**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.3	7.9	17	13	7.4	12	13	14	17	144	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	**1**	**2.7**	4.0	7.8	6.2	4.7	4.1	**2.2**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.5**	**1.5**	**2.8**	5.5	7.3	5.5	4.5	4.1	**2.3**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	**2.1**	**2.1**	**2.3**	3.7	3.1	**2.7**	**2.2**	**1.5**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	**2.0**	**2.2**	3.2	3.9	3.0	**2.9**	**2.8**	**1.8**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	**1.6**	3.2	9.3	13	11	10	8.7	4.9	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	**1.8**	**2.2**	8.1	13	9.0	7.3	7.3	5.5	NBC-CMA [21]
POEMS	**1**	185	195	56	47	109	106	99	115	506	POEMS [17]
PM-AdapSS-DE	**1**	**1.5**	**1.6**	**2.0**	5.4	7.5	6.0	4.9	4.0	**2.2**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.7**	**2.0**	43	47	302	488	549	482	414	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	**1.3**	**2.8**	20	26	46	158	212	405	Basic RCGA [24]
SPSA	22	57	221	748	376	348	546	2991	19343	7743	SPSA [13]

Table 15: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.93	15	222	347	470	527	567	620	708	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1.1**	**2.7**	3.6	9.4	26	19	17	16	15	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.3**	**1.9**	**1**	5.1	14	14	14	13	12	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**2.7**	**2.9**	4.5	14	10	9.4	8.8	8.0	7.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	3.6	11	10	30	27	24	22	20	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.3**	3.5	**2.6**	**2.4**	4.1	3.1	**2.7**	**2.6**	**2.4**	**2.1**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	**2.9**	**1.4**	**1.8**	7.1	5.6	5.0	4.7	4.3	3.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	**2.2**	**2.7**	**2.4**	7.4	5.5	4.9	4.6	4.2	3.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.1**	**3.0**	**2.9**	3.8	14	10	9.2	8.6	7.9	6.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.8**	3.8	**2.6**	10	7.2	6.4	6.0	5.5	4.8	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	**1.8**	**1.9**	**2.2**	8.9	6.6	5.9	5.5	5.0	4.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**1.5**	**2.3**	5.8	25	85	174	318	491	670	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.6**	**3.0**	**1.6**	4.9	3.6	3.2	3.0	**2.7**	**2.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.9	122	131	42	236	376	441	1159	1059	930	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.2**	**1.6**	**2.2**	**1.1**	**1.1**	**1.1**	**1.0**	**1.1**	**1.0**	**1.0**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	**1.4**	**2.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	**2.5**	**1.6**	**1.7**	3.7	3.3	**3.0**	**2.9**	**2.7**	**2.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.6**	**1.2**	**1.8**	**3.7**	**2.8**	**2.6**	**2.5**	**2.3**	**2.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.6**	**2.0**	**2.6**	4.0	3.7	3.5	3.5	3.3	3.1	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**1.8**	**2.6**	**1.8**	4.8	4.8	4.4	4.3	4.0	3.6	NBC-CMA [21]
POEMS	**1**	92	21	13	114	86	79	76	70	65	POEMS [17]
PM-AdapSS-DE	**1.1**	**1.5**	**2.5**	**1.1**	22	16	15	14	13	11	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	4.5	24	30	37	57	66	74	81	92	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	3.8	21	48	46	53	64	79	114	Basic RCGA [24]
SPSA	28	619	47	742	2016	*11e-1/1e5*	.	.	.	.	SPSA [13]

Table 16: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.60	7.1	85	302	579	642	666	678	725	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1.6**	**1.9**	4.0	5.6	12	21	35	35	46	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	15	4.1	9.2	5.8	5.6	6.3	6.3	7.0	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.1**	7.6	5.8	7.7	6.1	8.0	10	14	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.4**	15	11	12	21	30	213	210	196	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.8**	6.5	3.8	**2.1**	**1.2**	**1.2**	**1.5**	**1.4**	**1.5**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	**2.6**	**2.7**	**1.6**	**1.2**	**1.2**	**1.2**	**2.3**	**2.2**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.6**	**1.7**	**1.7**	**1.0**	**1.5**	**1.4**	**1.3**	**1.6**	**1.6**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.4**	4.9	3.1	**2.8**	**1.7**	3.3	3.5	3.5	7.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.4**	3.6	**2.0**	**1.6**	**1.6**	**2.1**	**2.9**	3.5	3.8	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.4**	**2.3**	**2.2**	**1.6**	**2.1**	**2.2**	3.1	3.4	3.6	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	**1.4**	**1**	**2.5**	11	56	304	1434	1366	Artif Bee Colony [8]
avg NEWUOA	**1**	11	10	**2.7**	**1.6**	**1.9**	3.6	6.1	11	27	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.7**	8.0	107	39	68	138	650	*53e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.5**	**1**	**1.4**	**1**	**1.0**	**1.1**	**1.2**	**1.2**	**1.3**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	**1.8**	**2.0**	**1.1**	**1.1**	**1.3**	**1.3**	**1.4**	**1.5**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	**2.5**	**2.4**	**1.8**	**1.1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	**1.6**	3.3	**1.5**	**1**	**1.3**	**1.3**	**1.3**	**1.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.5**	3.4	**1.8**	**1.1**	**1.4**	**1.6**	**1.7**	**2.0**	**2.4**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.4**	**1.5**	**1.6**	3.6	4.7	6.1	6.3	6.8	6.9	NBC-CMA [21]
POEMS	**1**	95	43	45	24	38	37	37	38	38	POEMS [17]
PM-AdapSS-DE	**1**	**1.1**	**2.0**	**1.2**	**1.3**	13	12	12	12	11	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.6**	25	6.5	17	30	45	67	80	105	pPOEMS [17, 20]
Basic RCGA	**1**	**1.4**	**1.1**	**1.5**	20	21	24	47	66	108	Basic RCGA [24]
SPSA	13	67	46	40	86	119	229	648	2192	*30e-4/1e5*	SPSA [13]

Table 17: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	2.3	48	132	222	290	434	706	913	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1.3**	22	5.7	8.9	10	40	338	*99e-5/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	**2.1**	**1**	**2.3**	3.2	5.0	10	46	77	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.1**	**1**	**1.5**	**1.4**	**2.6**	10	23	48	163	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**2.9**	4.2	**2.8**	8.4	29	227	*33e-4/1e4*	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.3**	**2.2**	**1.2**	**1.8**	**1.9**	3.4	4.9	10	36	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	**1.8**	**1.1**	**1.3**	**1.6**	**2.0**	3.2	9.5	16	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.1**	**1.4**	**1.4**	3.3	**1.6**	**1.6**	**2.5**	9.2	28	29	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	3.6	**1.1**	**1.9**	3.3	6.9	24	*30e-6/1e4*	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**2.5**	**2.3**	**2.1**	**2.3**	7.7	13	17	26	20	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.9**	**1.8**	**1.1**	**1.1**	**2.5**	**2.1**	3.7	4.3	3.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.0**	**1.3**	**1.3**	**1.6**	3.4	6.0	64	198	335	*29e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**1.3**	7.0	**2.9**	6.4	21	80	*75e-4/5e3*	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.3	17	7.8	4.1	31	192	554	3234	*14e-4/1e5*	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	**1.7**	**1.2**	**1.3**	**1.2**	**1.4**	**1.3**	**1.0**	**1.1**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	**1.4**	**1.1**	**1.3**	**1.3**	**1.4**	**1.3**	**1.0**	**1.1**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.3**	3.1	**1.7**	**1.1**	**1.1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	11	**1.5**	**1**	**1**	**1.2**	**1.2**	**1.1**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.5**	**1.3**	3.1	3.3	3.1	3.4	**2.8**	**2.4**	**2.3**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.1**	**1.8**	**2.3**	**1.8**	**1.7**	**1.4**	**1.2**	**1.9**	NBC-CMA [21]
POEMS	**1**	66	74	11	17	17	22	20	16	17	POEMS [17]
PM-AdapSS-DE	**1.1**	**1.2**	**1.4**	**1.0**	**1.1**	**1.3**	**1.4**	**1.3**	**1.0**	**1.1**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	29	15	59	111	150	135	109	121	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	**1.7**	3.2	24	38	70	66	96	*23e-7/5e4*	Basic RCGA [24]
SPSA	1935	16834	15945	1058	388	684	*17e-3/1e5*	.	.	.	SPSA [13]

Table 18: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	1.4	6.7	96	237	384	535	675	855	1105	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1.1**	19	12	5.4	22	116	130	221	*28e-3/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	28	9.2	12	23	86	267	212	*20e-3/1e4*	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	4.8	**2.4**	5.7	11	37	*13e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.3**	3.5	105	29	55	*98e-3/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.1**	**2.7**	4.9	7.0	11	16	18	34	170	131	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	17	5.1	4.0	5.2	6.8	11	22	52	40	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.1**	**1.6**	**1**	**2.9**	3.6	13	31	221	*14e-4/1e4*	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.6**	**1.4**	**1.3**	4.7	8.9	20	24	221	*10e-4/1e4*	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.7**	9.1	3.4	6.8	23	54	274	*16e-3/1e4*	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.5**	**1.9**	5.3	17	64	277	219	*16e-3/1e4*	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.2**	**1.2**	3.3	5.7	29	969	4091	*20e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.7**	8.9	7.8	6.3	8.6	101	*58e-3/6e3*	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.2	9.0	17	322	760	*27e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.1**	**1.5**	3.8	**1**	**1.0**	**1**	**1.1**	**1.0**	**1.1**	**1.0**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.1**	**1.1**	4.2	**1.2**	**1.1**	**1.0**	**1.0**	**1**	**1.0**	**1.0**	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	**2.3**	**2.0**	**2.7**	**1.7**	**1.3**	**1.1**	**1.1**	**1.2**	**1.2**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	3.2	6.9	**2.6**	**2.1**	**1.8**	**1.7**	**1.6**	**1.5**	**1.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.5**	**1.5**	3.6	**2.7**	3.6	3.1	3.3	**2.9**	3.7	3.2	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**1.2**	3.5	6.0	4.0	3.7	3.7	3.3	**2.8**	**2.9**	NBC-CMA [21]
POEMS	36	94	44	12	14	14	14	51	45	39	POEMS [17]
PM-AdapSS-DE	**1.1**	**1**	3.7	**1.1**	**1**	**1.1**	**1**	**1.0**	**1**	**1**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	12	42	26	79	93	100	108	109	122	pPOEMS [17, 20]
Basic RCGA	**1.1**	**1.5**	3.1	79	193	571	1334	*71e-3/5e4*	.	.	Basic RCGA [24]
SPSA	24	7278	5562	1683	1703	3661	*10e-1/1e5*	.	.	.	SPSA [13]

Table 19: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	1.4	11	89	208	351	481	627	745	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1.4**	5.8	**2.7**	11	10	11	11	9.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.1**	**1**	**1.4**	3.2	10	13	11	12	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.2**	**1.4**	**2.6**	**2.6**	6.7	7.6	7.5	7.4	7.4	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.1**	3.1	**1.8**	17	13	12	11	10	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	**1.6**	**1.3**	**2.1**	7.7	9.1	9.0	7.8	6.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.8**	**1.6**	**1.6**	4.7	**3.1**	4.1	3.2	**2.8**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.2**	**2.3**	**1.9**	**1.7**	8.9	8.1	7.1	5.5	5.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	3.4	**2.6**	3.8	7.3	7.0	5.6	4.8	4.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.1**	**2.4**	11	13	7.5	5.5	4.3	3.6	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.7**	**2.3**	**2.3**	6.6	**3.9**	**2.9**	**2.2**	**1.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	**2.2**	**2.6**	**1.6**	**4.0**	5.0	9.2	15	163	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.3**	**2.9**	4.8	**2.0**	12	6.9	5.1	3.9	3.3	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.9	8.7	32	6.6	3.5	62	91	123	262	380	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.3**	**2.4**	**2.9**	**1.2**	76	46	34	27	23	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.3**	**1.4**	**1.6**	**1.3**	37	23	17	13	11	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.4**	**1.9**	**1.5**	**1.4**	**4.5**	4.5	4.7	3.8	3.3	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.1**	**2.3**	**1**	**1.3**	9.0	5.6	4.6	3.6	3.2	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	**1.4**	**1.4**	**1**	**1**	**1**	**1**	**1**	**1**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	**2.0**	**1.6**	**1.2**	5.6	4.1	**3.9**	**3.1**	3.4	NBC-CMA [21]
POEMS	**1**	102	113	25	6.9	241	146	108	83	72	POEMS [17]
PM-AdapSS-DE	**1**	**2.1**	**2.0**	**1.9**	**1.5**	178	106	78	60	51	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	25	25	7.3	20	26	31	37	48	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	**2.1**	**2.2**	**1.3**	10	7.2	18	21	84	Basic RCGA [24]
SPSA	20	67	209	45	30	463	516	626	2273	*48e-4/1e5*	SPSA [13]

Table 20: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	1.8	2.2	3.1	120	398	730	731	733	734	736	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	4.0	3.5	3.6	3.8	11	9.3	9.3	9.4	9.4	9.4	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.5**	**2.2**	**2.0**	3.2	11	8.4	8.4	8.5	8.5	8.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.4**	**1.6**	**1.3**	4.3	14	14	14	14	14	14	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.5	32	60	5.0	17	13	13	14	14	14	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.0**	**2.5**	**1.9**	**2.4**	3.2	**1.9**	**2.0**	**2.0**	**2.0**	**2.0**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.2**	**1.7**	**1.5**	**2.5**	5.4	3.2	3.3	3.3	3.3	3.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.0**	**2.6**	**2.2**	**2.8**	6.3	3.7	4.3	4.3	4.3	4.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.3**	**1.2**	**1**	**2.1**	4.7	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.8**	**2.3**	**2.2**	3.9	**2.2**	**1.2**	**1.2**	**1.3**	**1.3**	**1.3**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.3**	**1.1**	**2.7**	**2.2**	**1.2**	**1.2**	**1.2**	**1.3**	**1.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.3**	**1.9**	**1.6**	**1.2**	**1**	**1.0**	**1.5**	**2.0**	**2.5**	4.2	Artif Bee Colony [8]
avg NEWUOA	**1.9**	**1.6**	**1.3**	**2.5**	**1.8**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	14	13	9.4	15	154	276	925	*49e-3/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**2.1**	**1.8**	**1.2**	221	121	120	120	120	120	Adap DE (F-AUC) [10]
DE (Uniform)	**1.1**	**2.1**	**1.8**	**1.1**	127	69	69	69	69	69	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	**1**	**1.1**	3.0	4.8	**2.8**	**2.9**	**3.0**	3.0	3.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.8**	4.2	3.4	3.1	5.0	**3.0**	3.1	3.2	3.3	3.4	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.3**	**1.9**	**1.9**	**2.6**	**2.2**	**1.7**	**1.9**	**2.1**	**2.3**	**3.0**	CMA+DE-MOS [18]
NBC-CMA	**1.4**	**2.6**	**2.2**	**2.7**	3.1	**1.9**	**2.0**	**2.1**	**2.1**	**2.2**	NBC-CMA [21]
POEMS	118	98	74	7.0	18	11	12	14	15	17	POEMS [17]
PM-AdapSS-DE	**2.1**	**1.8**	**1.3**	**1**	288	157	157	157	156	156	PM-AdapSS-DE [9, 10]
pPOEMS	47	73	56	11	20	21	33	46	57	77	pPOEMS [17, 20]
Basic RCGA	**1.3**	**2.7**	**2.2**	8.2	18	36	84	160	214	301	Basic RCGA [24]
SPSA	41	57	62	2300	3519	1919	1917	1912	*11e-1/1e5*	.	SPSA [13]

Table 21: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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

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	0.50	0.50	0.80	43	90	153	212	248	260	323	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1.4**	8.7	14	15	11	11	10	8.4	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.6**	4.5	8.5	7.9	9.2	11	10	8.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.8**	3.3	12	11	11	10	10	7.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.5**	12	14	12	13	13	12	10	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1.5**	5.3	5.6	4.0	**3.0**	**2.6**	**2.5**	**2.1**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.6**	3.3	4.8	3.8	4.6	4.1	3.9	3.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**1.4**	3.9	4.6	3.4	**2.5**	**2.1**	**2.1**	**1.8**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.5**	5.5	7.4	5.4	3.9	3.4	3.2	**2.6**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.7**	7.2	11	6.5	4.7	4.0	3.9	3.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.3**	6.9	7.7	4.6	3.3	**2.9**	**2.8**	**2.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.3**	**1.2**	**1.7**	**2.4**	3.8	6.0	16	30	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	6.3	3.8	4.5	**2.7**	**1.9**	**1.7**	**1.6**	**1.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	7.5	12	14	33	68	66	124	146	255	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.4**	168	80	48	35	30	29	23	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.6**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.6**	3.7	6.8	4.4	3.6	3.3	3.2	13	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.4**	7.9	7.5	4.9	8.9	8.3	8.0	6.9	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.6**	**1.1**	**4.2**	4.5	3.6	4.0	6.2	5.9	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1**	**1.3**	6.9	23	21	22	22	18	NBC-CMA [21]
POEMS	**1**	**1**	115	85	300	180	131	113	111	91	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.8**	**1**	80	48	35	30	28	23	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	**1.9**	10	7.8	13	17	27	38	53	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.5**	8.6	13	31	48	59	122	145	Basic RCGA [24]
SPSA	**1**	21	49	56	258	197	153	183	199	384	SPSA [13]

Table 22: 02-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	2.5	28	85	119	134	150	159	193	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**2.1**	8.3	6.0	8.3	8.0	7.8	10	10	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.4**	16	18	22	23	21	20	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.3**	7.1	10	10	13	19	21	18	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.6**	15	18	17	21	27	28	24	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.2**	4.8	8.2	6.4	6.1	5.5	6.0	5.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.6**	6.7	11	10	10	9.0	8.6	7.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	3.2	8.9	6.4	5.2	4.9	4.4	4.2	3.5	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.5**	7.5	5.0	5.5	5.1	4.7	4.8	4.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	6.6	9.2	4.4	3.3	3.0	**2.8**	**2.7**	**2.3**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1**	4.0	4.3	**3.2**	**3.0**	**2.7**	**2.6**	**2.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.4**	**1.3**	**2.8**	3.8	8.3	19	42	296	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**3.0**	**1.8**	**1.3**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	8.5	4.8	6.0	33	46	111	174	249	602	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.9**	**1.1**	182	130	117	104	98	82	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.3**	**1.1**	**1**	**1.2**	**1.4**	**1.6**	**1.6**	**1.7**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.2**	**2.2**	5.4	4.3	7.2	6.8	6.5	12	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.6**	**2.8**	4.9	4.5	4.4	5.0	21	57	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.2**	**1.8**	**2.9**	3.5	4.4	4.9	5.7	6.7	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.3**	**1.1**	8.3	19	29	26	26	22	NBC-CMA [21]
POEMS	**1**	**1**	66	15	595	426	384	345	331	277	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.5**	**1.1**	85	61	55	49	46	39	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	39	12	16	29	41	54	64	102	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.4**	**1**	11	23	65	112	211	478	Basic RCGA [24]
SPSA	**1**	22	107	136	368	684	1800	9424	8895	*38e-4/1e5*	SPSA [13]

Table 23: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	6.0	183	525	585	670	959	980	1024	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1**	12	48	57	50	35	34	45	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.7**	5.5	17	18	16	11	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.4**	9.5	20	22	20	14	14	13	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.0**	7.4	23	51	64	45	44	143	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1.4**	5.7	5.1	5.1	6.1	4.3	4.3	4.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**2.5**	6.7	4.2	3.8	3.4	**2.4**	**2.4**	**2.4**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.9**	4.5	**2.9**	**2.9**	**2.7**	**1.9**	**1.9**	**1.8**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.4**	7.4	6.5	6.5	5.7	4.0	4.0	3.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	5.3	**1.7**	**1**	**1**	**1**	**1**	**1**	**1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.3**	**1.1**	**1.5**	3.2	3.0	**2.1**	**2.1**	**2.1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.4**	8.0	399	*13e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**2.7**	3.5	5.7	23	59	*49e-3/6e3*	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	**2.5**	**2.6**	6.6	580	*17e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.2**	**1.2**	**1.2**	**1.7**	**2.1**	**1.9**	**2.2**	**2.7**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.6**	**1.2**	**1.3**	**1.8**	**2.3**	**2.0**	**2.3**	**2.9**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.8**	3.5	3.5	4.2	3.7	**2.7**	**2.7**	**2.7**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.2**	4.1	36	52	46	32	31	30	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.3**	**2.9**	5.3	9.0	10	7.5	7.6	7.8	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.1**	5.2	164	171	149	104	102	98	NBC-CMA [21]
POEMS	**1**	**1**	8.2	22	56	55	52	38	40	43	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.3**	**1**	**1.3**	**1.9**	**2.3**	**1.9**	**2.3**	**2.9**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	7.2	32	147	194	223	189	213	260	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.2**	**2.7**	57	200	1048	733	*29e-3/5e4*	.	Basic RCGA [24]
SPSA	**1**	13	12	139	*49e-2/1e5*	.	.	.	.	.	SPSA [13]

Table 24: 02-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.50	0.50	11	834	5810	31748	31759	31779	31794	31817	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.7	6.1	*40e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.3**	**2.9**	25	*43e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.1**	4.0	24	*46e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**2.0**	10	25	4.7	4.7	4.7	4.7	4.7	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1**	4.4	12	*22e-2/1e4*	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**2.0**	**2.3**	**2.4**	**2.2**	**2.2**	**2.1**	**2.1**	**2.1**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.4**	3.0	4.2	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.3**	**2.5**	5.7	4.6	4.6	4.6	4.6	4.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	31	3.1	5.5	**1**	**1**	**1**	**1**	**1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	3.6	**2.0**	**3.9**	4.5	4.5	4.5	4.5	4.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.8**	**2.1**	12	45	*62e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**2.8**	**1**	**1**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	19	19	3.3	25	44	*16e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.3**	480	69	13	13	13	13	13	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.8**	180	26	6.3	6.3	6.3	6.3	6.3	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.4**	41	274	176	176	176	176	176	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.1**	14	275	*31e-2/4e5*	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.5**	**1.9**	4.7	**1.1**	**1.5**	**1.6**	**1.6**	**2.0**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.6**	25	24	8.7	11	14	14	14	NBC-CMA [21]
POEMS	**1**	**1**	24	2340	353	65	65	65	65	65	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.5**	180	26	4.8	4.8	4.8	4.8	4.8	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.1**	20	260	41	10	10	11	11	11	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.1**	38	57	22	22	22	22	22	Basic RCGA [24]
SPSA	41	51	1466	*31e-1/1e5*	.	.	.	.	.	.	SPSA [13]

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