Comparison tables: BBOB 2010 function testbed with BBOB 2009 as reference in 5-D

The BBOBies

August 31, 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 [16, 12]. The experimental set-up is described in [15].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm in BBOB-2009 (see [7]) if an algorithm from BBOB-2009 reached the given target function value. The ERT value is given otherwise ($\mathrm{ERT}_{\mathrm{best}}$ is noted as infinite). See [15] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values.

Table 1: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_1, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

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	0.20	0.20	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	ERT_{best}/D
(1,2)-CMA-ES	**1**	3.1	7.4	15	27	37	47	54	63	80	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	3.2	10	15	21	28	35	40	53	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	**2.1**	7.2	13	18	24	30	35	45	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	4.5	12	22	29	38	48	55	71	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	**2.5**	6.9	11	16	21	25	30	40	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	**2.2**	6.2	10	15	19	23	27	37	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.0**	**5.0**	**8.3**	**12**	**15**	**18**	**22**	**30**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.9**	**2.5**	6.5	10	15	18	22	26	34	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.1**	**2.1**	5.6	10	13	17	21	24	32	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	**1.5**	**4.9**	**8.0**	**12**	**15**	**18**	**21**	**28**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	12	32	62	89	122	156	191	255	Artif Bee Colony [9]
avg NEWUOA	**1**	3.3	**1.5**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**2.3**	27	7.2	16	24	34	43	55	67	87	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.3**	5.9	37	67	104	132	166	203	266	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.3**	8.6	42	80	117	155	194	236	313	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1.3**	3.2	8.9	15	22	27	33	39	51	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1.1**	**2.5**	8.0	14	20	27	32	39	51	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.1**	6.5	33	66	90	121	142	169	217	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.3**	5.6	26	42	53	65	74	85	108	NBC-CMA [22]
POEMS	**1**	263	102	136	329	766	1195	1592	2001	2796	POEMS [18]
PM-AdapSS-DE	**1**	**2.1**	4.8	39	74	111	145	182	223	292	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.2**	97	129	614	2849	5775	8274	12299	18337	pPOEMS [18, 21]
Basic RCGA	**1**	**1.1**	8.7	72	155	329	561	831	1141	1741	Basic RCGA [25]
SPSA	**1**	43	11	15	19	22	27	31	36	44	SPSA [14]

Table 2: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_2, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

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	10	15	17	17	18	18	18	18	18	19	ERT_{best}/D
(1,2)-CMA-ES	46	45	57	61	64	65	66	67	68	69	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	28	30	37	40	42	43	44	44	45	46	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	30	27	30	34	35	36	36	36	37	37	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	35	59	66	74	81	83	85	86	87	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	13	14	20	22	24	24	25	25	26	27	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	12	16	19	22	22	23	23	24	24	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	8.6	12	14	15	16	16	17	17	18	18	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	12	15	18	21	22	22	23	23	23	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**6.0**	**6.9**	11	**13**	**13**	**14**	**14**	**14**	**15**	**15**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**6.6**	**7.7**	**10**	**11**	**12**	**12**	**13**	**13**	**13**	**14**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	8.9	11	18	26	30	38	44	50	62	Artif Bee Colony [9]
avg NEWUOA	**1.2**	**2.0**	**6.4**	21	41	56	75	92	108	145	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	48	53	68	69	69	70	72	72	73	75	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	13	14	18	22	26	30	35	38	42	50	Adap DE (F-AUC) [11]
DE (Uniform)	14	16	20	24	30	35	40	45	50	58	DE (Uniform) [10]
IPOP-aCMA-ES	7.5	8.5	**10**	**12**	**14**	**14**	**15**	**16**	**16**	**18**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	9.4	10	14	16	18	18	19	20	21	22	IPOP-CMA-ES [23]
CMA+DE-MOS	16	19	23	29	35	40	46	51	55	64	CMA+DE-MOS [19]
NBC-CMA	16	18	23	27	30	31	33	34	35	37	NBC-CMA [22]
POEMS	119	145	200	295	341	371	438	494	550	636	POEMS [18]
PM-AdapSS-DE	15	16	19	24	28	33	38	42	47	55	PM-AdapSS-DE [10, 11]
pPOEMS	139	842	1208	1316	1735	2219	2549	2927	3091	3928	pPOEMS [18, 21]
Basic RCGA	34	46	78	125	169	207	252	309	347	1069	Basic RCGA [25]
SPSA	5535	43870	*46e+1/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 3: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_3, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	0.20	2.9	143	324	327	328	329	330	330	331	ERT_{best}/D
(1,2)-CMA-ES	**2.7**	24	39	*80e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.2**	**2.6**	3.5	147	454	453	452	451	451	450	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.6**	6.2	441	*30e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.2**	15	28	225	*60e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.4**	4.3	434	*20e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.5**	**1.5**	4.5	79	443	442	441	440	440	439	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.3**	**1.6**	**2.8**	98	*20e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.2**	**1.1**	5.9	*30e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.7**	**1.6**	7.2	*30e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.9**	**1.8**	3.4	91	*20e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.3**	**2.7**	**1.0**	**1.5**	**1.8**	**2.4**	**2.7**	**3.2**	**3.6**	**4.4**	Artif Bee Colony [9]
avg NEWUOA	3.3	4.8	**3.0**	130	*40e-1/6e3*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	18	7.6	40	2261	4484	4473	4463	*20e-1/1e5*	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1.2**	**2.7**	3.4	12	59	59	60	60	60	60	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.6**	3.5	12	125	125	125	125	125	126	DE (Uniform) [10]
IPOP-aCMA-ES	**1.4**	**2.4**	**1.1**	20	1359	1356	1353	1351	1350	1348	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.3**	**1.7**	**2.2**	70	3130	3121	3113	3108	3106	3099	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.2**	3.3	**1.5**	**1.6**	**2.4**	**2.9**	**3.2**	**3.4**	**3.8**	**4.4**	CMA+DE-MOS [19]
NBC-CMA	**1.5**	**2.1**	**1.9**	30	155	154	154	154	154	154	NBC-CMA [22]
POEMS	168	77	4.0	**11**	**36**	**38**	**42**	**45**	**48**	**54**	POEMS [18]
PM-AdapSS-DE	**1.5**	**2.1**	4.9	33	166	217	362	470	621	621	PM-AdapSS-DE [10, 11]
pPOEMS	**1.3**	66	4.8	30	64	92	116	140	158	203	pPOEMS [18, 21]
Basic RCGA	**1.1**	4.0	3.4	37	89	95	114	116	118	120	Basic RCGA [25]
SPSA	54	8613	*21e+0/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 4: 05-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_4, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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
$\mathrm{ERT}_{\text{best}}$/D	0.20	3.8	162	327	338	352	363	370	377	381	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	3.5	13	75	*80e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.3**	3.0	11	*40e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	3.4	8.8	445	*30e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.5	10	48	*98e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.7**	**2.0**	10	*40e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.8**	**1.9**	4.6	450	*40e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	**1.7**	**2.9**	456	*30e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	3.0	11	448	433	416	403	395	388	385	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**1.9**	22	*50e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.8**	**2.0**	7.1	444	*40e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.5**	5.7	**1.1**	**2.4**	**2.9**	**3.4**	**4.3**	**4.6**	**4.9**	**6.0**	Artif Bee Colony [9]
avg NEWUOA	5.4	10	14	*50e-1/8e3*	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	28	5.2	309	*70e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1.4**	5.8	5.7	625	*20e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	**1.6**	5.2	5.1	626	1941	1864	1803	1771	1739	1723	DE (Uniform) [10]
IPOP-aCMA-ES	**2.1**	**2.5**	**1.8**	*29e-1/2e5*	.	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.7**	**2.6**	**2.0**	*29e-1/2e5*	.	.	.	.	.	.	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.6**	3.1	**1.6**	**3.6**	**5.6**	**5.8**	**6.1**	**6.4**	**6.6**	**7.3**	CMA+DE-MOS [19]
NBC-CMA	**1.7**	4.6	**2.6**	221	1252	1202	1163	1142	1121	1111	NBC-CMA [22]
POEMS	240	60	4.9	43	118	117	**116**	**118**	**119**	**124**	POEMS [18]
PM-AdapSS-DE	3.3	6.9	4.9	4295	*30e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	**1.5**	67	6.8	**36**	**79**	**106**	120	141	158	198	pPOEMS [18, 21]
Basic RCGA	**1.9**	6.7	14	*30e-1/5e4*	.	.	.	.	.	.	Basic RCGA [25]
SPSA	67	2112	4238	*36e+0/1e5*	.	.	.	.	.	.	SPSA [14]

Table 5: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_5, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

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	0.20	0.29	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	ERT_{best}/D
(1,2)-CMA-ES	**1**	4.9	5.7	7.5	8.1	8.1	8.1	8.1	8.1	8.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.6**	3.1	4.8	4.8	4.9	4.9	4.9	4.9	4.9	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**2.0**	**2.6**	3.3	3.5	3.5	3.5	3.5	3.5	3.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	3.1	5.7	8.4	9.1	9.1	9.1	9.1	9.1	9.1	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.8**	3.2	4.3	4.5	4.5	4.5	4.5	4.5	4.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.7**	3.3	4.5	4.8	4.8	4.8	4.8	4.8	4.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.8**	**2.4**	3.5	3.6	3.6	3.6	3.6	3.6	3.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.5**	**2.9**	3.9	4.0	4.0	4.0	4.0	4.0	4.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**2.9**	**2.0**	**2.9**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.4**	**1.8**	**2.7**	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	32	49	58	59	59	59	59	59	Artif Bee Colony [9]
avg NEWUOA	**1**	4.1	**1.8**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1**	9.0	4.9	6.9	7.2	7.3	7.3	7.3	7.3	7.3	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.7**	15	23	24	24	24	24	24	24	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.4**	20	34	35	35	35	35	35	35	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	3.7	4.6	6.3	6.8	6.8	6.8	6.8	6.8	6.8	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	4.5	4.6	6.0	6.3	6.3	6.3	6.3	6.3	6.3	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.8**	20	42	50	50	51	51	51	51	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.8**	33	39	43	43	43	43	43	43	NBC-CMA [22]
POEMS	**1**	430	161	203	222	229	230	231	231	231	POEMS [18]
PM-AdapSS-DE	**1**	**1.5**	24	33	36	36	36	36	36	36	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.3**	153	203	215	217	218	218	218	218	pPOEMS [18, 21]
Basic RCGA	**1**	**2.0**	327	747	1146	1577	2004	2429	2866	3740	Basic RCGA [25]
SPSA	**1**	12	9.3	13	14	14	14	14	14	14	SPSA [14]

Table 6: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_6, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

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	2.3	3.2	23	43	56	81	116	149	208	266	ERT_{best}/D
(1,2)-CMA-ES	**2.6**	13	5.9	5.1	5.0	4.8	4.3	4.2	3.9	4.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.5**	6.4	**2.7**	**2.4**	**2.5**	**2.1**	**1.8**	**1.7**	**1.4**	**1.4**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	4.2	**2.2**	**2.0**	**2.1**	**1.9**	**1.6**	**1.4**	**1.1**	**1.1**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.8	11	6.5	6.6	7.7	7.3	6.8	6.5	5.8	5.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.2**	**2.4**	**1.6**	**1.8**	**1.8**	**1.7**	**1.5**	**1.4**	**1.3**	**1.2**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.2**	4.7	**1.8**	**1.6**	**1.7**	**1.5**	**1.3**	**1.2**	**1.00**	**0.96**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.9**	**2.8**	**1.1**	**1.1**	**1.2**	**1.1**	**0.91**	**0.83**	**0.70**	**0.69**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.0**	5.0	**1.8**	**1.9**	**1.9**	**1.8**	**1.5**	**1.4**	**1.1**	**1.1**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.8**	3.5	**1.8**	**1.5**	**1.9**	**1.7**	**1.4**	**1.3**	**1.1**	**1.4**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.2**	**2.3**	**1.1**	**1.2**	**1.6**	**1.4**	**1.4**	**1.6**	**1.6**	**2.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.7	8.3	4.9	15	365	408	619	522	498	507	Artif Bee Colony [9]
avg NEWUOA	**1.2**	**2.6**	**1.3**	**1.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.4**	**2.5**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	5.0	54	241	657	518	518	372	300	220	230	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	4.8	7.1	6.5	7.6	8.5	8.1	7.0	6.5	5.3	5.4	Adap DE (F-AUC) [11]
DE (Uniform)	4.7	7.2	9.0	9.2	10	9.2	7.8	7.3	6.1	6.1	DE (Uniform) [10]
IPOP-aCMA-ES	**2.6**	5.3	**2.5**	**2.1**	**2.2**	**2.0**	**1.6**	**1.5**	**1.2**	**1.2**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1.9**	3.2	**2.5**	**2.1**	**2.2**	**2.0**	**1.7**	**1.5**	**1.3**	**1.2**	IPOP-CMA-ES [23]
CMA+DE-MOS	11	11	8.0	8.6	8.8	7.7	6.3	5.7	4.8	4.6	CMA+DE-MOS [19]
NBC-CMA	9.2	8.5	8.2	19	16	11	8.4	6.8	5.1	4.3	NBC-CMA [22]
POEMS	102	81	26	46	54	51	45	43	36	37	POEMS [18]
PM-AdapSS-DE	6.0	7.4	8.1	8.1	9.0	8.3	7.3	6.7	5.7	5.7	PM-AdapSS-DE [10, 11]
pPOEMS	91	76	31	202	313	323	306	300	266	282	pPOEMS [18, 21]
Basic RCGA	29	28	26	72	255	434	598	*47e-4/5e4*	.	.	Basic RCGA [25]
SPSA	521	13582	28485	32769	25181	*44e+0/1e5*	.	.	.	.	SPSA [14]

Table 7: 05-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_7, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

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	0.20	1.2	4.7	65	234	290	314	314	314	319	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	3.5	8.5	19	28	188	*17e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.5**	4.0	7.2	5.3	11	50	225	225	225	221	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.4**	**2.8**	5.8	5.0	17	40	81	81	81	104	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.3**	8.6	37	39	187	*28e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.6**	**2.3**	7.1	3.1	5.8	25	41	41	41	97	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.4**	**2.9**	5.5	3.7	7.1	16	35	35	35	80	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**1.7**	**4.1**	**1.9**	3.9	17	25	25	25	60	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**2.8**	8.4	4.2	11	23	100	100	100	139	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**2.1**	4.1	**2.8**	3.2	**3.0**	3.6	3.6	3.6	3.5	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**2.0**	**1.8**	**3.7**	**2.6**	**1.4**	**1.7**	**1.9**	**1.9**	**1.9**	**1.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	3.6	20	16	62	464	957	957	957	1359	Artif Bee Colony [9]
avg NEWUOA	**1.1**	**2.5**	4.4	5.9	13	131	*17e-3/8e3*	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	19	17	274	1509	6253	*94e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1.3**	**1.8**	13	**2.4**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	Adap DE (F-AUC) [11]
DE (Uniform)	**1.5**	5.0	14	**2.7**	**1.2**	**1.5**	**1.4**	**1.4**	**1.4**	**1.6**	DE (Uniform) [10]
IPOP-aCMA-ES	**1.7**	3.1	**4.0**	**0.87**	**0.70**	**0.68**	**0.69**	**0.69**	**0.69**	**0.70**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.8**	**2.8**	4.4	**1.7**	**1.2**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.5**	3.0	13	5.1	**2.5**	**2.4**	**2.3**	**2.3**	**2.3**	**2.3**	CMA+DE-MOS [19]
NBC-CMA	**1.3**	**2.4**	7.0	7.2	6.1	5.0	4.7	4.7	4.7	4.7	NBC-CMA [22]
POEMS	200	187	83	17	9.0	11	11	11	11	12	POEMS [18]
PM-AdapSS-DE	**1.8**	**1.9**	12	**2.5**	**1.2**	**1.4**	**1.3**	**1.3**	**1.3**	**1.5**	PM-AdapSS-DE [10, 11]
pPOEMS	**1.4**	114	89	26	43	59	76	76	76	79	pPOEMS [18, 21]
Basic RCGA	**1.7**	3.1	25	73	147	336	690	690	690	1072	Basic RCGA [25]
SPSA	122	259	32256	*11e+0/1e5*	.	.	.	.	.	.	SPSA [14]

Table 8: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_8, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

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	3.6	8.8	15	55	67	74	78	80	82	84	ERT_{best}/D
(1,2)-CMA-ES	6.5	12	10	10	14	14	15	15	15	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.1	5.7	5.6	5.7	7.2	7.8	8.1	8.3	8.4	8.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.2	4.5	4.2	5.8	6.8	7.3	7.5	7.6	7.6	7.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.8	15	12	14	19	19	20	20	21	21	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.6**	**2.9**	**2.6**	4.9	5.7	5.8	5.9	6.1	6.2	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.0**	3.2	**2.9**	3.6	4.3	4.7	4.8	5.0	5.0	5.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**2.6**	**2.3**	**2.9**	**3.5**	**3.6**	**3.7**	**3.8**	**3.8**	**4.0**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.5**	**2.3**	**2.4**	4.1	5.0	5.2	5.4	5.4	5.5	5.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.5**	**2.5**	**2.3**	3.5	3.8	3.8	3.8	3.9	4.0	4.1	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.7**	**2.0**	**1.9**	3.0	**3.2**	**3.2**	**3.3**	**3.4**	**3.4**	**3.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.4	5.0	6.0	12	52	449	2509	*10e-4/1e5*	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.3**	**1.6**	**1.2**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	11	9.0	8.2	7.6	8.2	8.5	8.8	9.3	10	11	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	6.5	11	13	8.9	11	11	11	12	13	14	Adap DE (F-AUC) [11]
DE (Uniform)	7.2	12	15	10	14	16	17	17	18	20	DE (Uniform) [10]
IPOP-aCMA-ES	**2.1**	**2.4**	**2.8**	**3.0**	3.6	3.8	4.0	4.1	4.2	4.5	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.6**	3.8	3.5	4.8	5.3	5.5	5.6	5.7	5.8	6.1	IPOP-CMA-ES [23]
CMA+DE-MOS	6.3	6.8	11	11	12	13	13	14	14	15	CMA+DE-MOS [19]
NBC-CMA	4.4	7.5	7.1	7.0	8.1	8.4	8.6	8.8	8.9	9.3	NBC-CMA [22]
POEMS	66	40	58	52	117	380	689	1132	1485	2230	POEMS [18]
PM-AdapSS-DE	5.5	11	13	9.4	15	18	19	19	20	21	PM-AdapSS-DE [10, 11]
pPOEMS	56	36	84	262	365	482	583	689	795	1052	pPOEMS [18, 21]
Basic RCGA	5.7	12	32	558	1450	2992	2983	9295	*54e-2/5e4*	.	Basic RCGA [25]
SPSA	360	1473	3764	12308	*50e-1/1e5*	.	.	.	.	.	SPSA [14]

Table 9: 05-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_9, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

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	0.20	0.20	6.9	25	43	53	60	65	67	74	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	131	285	12	27	24	23	21	21	20	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	62	164	7.4	14	12	12	11	11	11	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	57	273	14	12	11	10	10	9.3	9.2	8.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	98	382	16	51	40	37	34	33	33	31	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	31	218	9.0	14	11	10	9.4	9.1	9.0	8.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	30	111	5.2	9.5	8.2	7.6	7.2	7.0	7.0	6.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	26	117	5.4	10	7.7	6.8	6.3	6.1	6.0	5.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	28	128	5.7	11	9.2	8.3	7.7	7.4	7.3	6.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**22**	**65**	**3.3**	13	9.0	7.8	7.2	6.8	6.8	6.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**25**	102	**4.6**	**6.2**	**5.0**	**4.4**	**4.2**	**4.0**	**4.0**	**3.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	86	259	14	69	699	3988	*13e-3/1e5*	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**20**	**56**	**2.4**	**3.1**	**2.1**	**1.8**	**1.7**	**1.6**	**1.6**	**1.5**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	276	692	48	79	56	50	45	46	46	45	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	97	393	24	18	16	16	16	16	16	17	Adap DE (F-AUC) [11]
DE (Uniform)	143	444	30	23	21	22	21	21	22	22	DE (Uniform) [10]
IPOP-aCMA-ES	28	97	5.4	**6.2**	**5.7**	**5.3**	**5.0**	**4.9**	**5.0**	**4.9**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	29	**92**	6.0	11	8.7	7.9	7.5	7.3	7.3	7.2	IPOP-CMA-ES [23]
CMA+DE-MOS	98	367	13	10	17	18	17	17	17	17	CMA+DE-MOS [19]
NBC-CMA	84	281	15	11	11	10	10	9.5	10	9.5	NBC-CMA [22]
POEMS	1148	1606	109	116	176	616	1039	1473	1856	2809	POEMS [18]
PM-AdapSS-DE	90	374	25	22	21	22	21	21	21	22	PM-AdapSS-DE [10, 11]
pPOEMS	1126	1981	287	563	596	630	722	850	994	1200	pPOEMS [18, 21]
Basic RCGA	118	318	40	8950	*17e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	8379	1.78e5	13128	56959	*54e-1/1e5*	.	.	.	.	.	SPSA [14]

Table 10: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{10}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	21	34	70	100	115	121	125	129	166	176	ERT_{best}/D
(1,2)-CMA-ES	21	23	16	12	11	10	10	10	8.2	8.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	13	9.4	7.6	6.8	6.6	6.5	6.5	5.1	5.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	12	11	7.3	5.8	5.4	5.2	5.2	5.1	4.1	4.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	21	25	19	14	13	13	13	12	10	10	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.3	6.4	5.0	4.1	3.9	3.9	3.9	3.8	3.1	3.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	7.2	7.3	4.5	3.6	3.3	3.3	3.4	3.4	**2.7**	**2.7**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	4.7	3.8	3.1	**2.6**	**2.6**	**2.5**	**2.5**	**2.5**	**2.0**	**2.0**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.3	5.5	3.7	3.2	3.1	3.1	3.1	3.1	**2.5**	**2.5**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.7**	**3.4**	**2.6**	**2.1**	**2.1**	**2.0**	**2.0**	**2.1**	**1.7**	**1.7**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**2.4**	**2.9**	**2.2**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.4**	**1.4**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	195	2201	21228	*55e+0/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.2**	**2.2**	3.1	4.6	6.6	8.1	10	12	11	14	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	22	23	16	12	11	11	10	10	8.2	8.1	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	7.1	6.5	4.5	3.9	4.0	4.5	4.9	5.4	4.7	5.3	Adap DE (F-AUC) [11]
DE (Uniform)	7.7	6.9	4.5	4.2	4.6	5.1	5.5	6.1	5.4	6.2	DE (Uniform) [10]
IPOP-aCMA-ES	3.8	3.7	**2.5**	**2.2**	**2.1**	**2.1**	**2.2**	**2.2**	**1.8**	**1.9**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	4.6	4.3	3.6	**2.9**	**2.7**	**2.7**	**2.8**	**2.8**	**2.3**	**2.3**	IPOP-CMA-ES [23]
CMA+DE-MOS	13	13	10	8.1	7.6	7.6	7.7	7.9	6.4	6.5	CMA+DE-MOS [19]
NBC-CMA	6.2	6.7	4.6	4.5	4.4	4.4	4.5	4.6	3.8	3.8	NBC-CMA [22]
POEMS	54	408	1411	4129	17335	*24e-1/3e5*	.	.	.	.	POEMS [18]
PM-AdapSS-DE	6.6	6.5	4.6	4.0	4.3	4.8	5.3	5.9	5.2	5.9	PM-AdapSS-DE [10, 11]
pPOEMS	59	343	552	639	738	844	1002	1180	1040	1238	pPOEMS [18, 21]
Basic RCGA	460	1563	3242	*72e+0/5e4*	.	.	.	.	.	.	Basic RCGA [25]
SPSA	5248	*73e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [14]

Table 11: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{11}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	2.5	4.9	29	40	153	195	235	270	293	335	ERT_{best}/D
(1,2)-CMA-ES	31	91	28	25	7.3	6.0	5.1	4.5	4.3	3.9	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	25	91	24	20	5.6	4.6	3.9	3.5	3.3	**3.0**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	37	59	19	16	4.8	3.9	3.3	**3.0**	**2.8**	**2.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.8	88	31	29	9.1	7.3	6.3	5.6	5.3	4.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**3.9**	20	10	10	**2.9**	**2.3**	**2.0**	**1.8**	**1.7**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.7	39	12	10	**2.8**	**2.3**	**2.0**	**1.8**	**1.7**	**1.6**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	5.7	37	10	7.9	**2.2**	**1.8**	**1.5**	**1.4**	**1.3**	**1.2**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	17	31	10	8.1	**2.3**	**1.9**	**1.7**	**1.5**	**1.4**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.0	12	5.8	6.9	**2.1**	**1.8**	**1.5**	**1.3**	**1.3**	**1.2**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**4.0**	**7.7**	**4.9**	**5.2**	**1.7**	**1.4**	**1.2**	**1.1**	**1.1**	**0.98**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	6.1	**8.5**	160	6088	9336	*15e-1/1e5*	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**2.6**	11	**5.4**	7.2	**2.7**	**2.6**	**2.8**	**2.9**	3.1	3.4	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	10	180	61	51	14	11	9.0	8.0	7.4	6.7	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	12	12	6.2	6.6	**2.2**	**2.1**	**2.0**	**2.1**	**2.2**	**2.4**	Adap DE (F-AUC) [11]
DE (Uniform)	10	14	6.2	6.6	**2.4**	**2.3**	**2.4**	**2.4**	**2.6**	**2.8**	DE (Uniform) [10]
IPOP-aCMA-ES	7.1	12	**5.6**	**4.7**	**1.4**	**1.2**	**1.0**	**0.97**	**0.95**	**0.92**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	5.9	17	8.6	7.3	**2.1**	**1.8**	**1.6**	**1.4**	**1.4**	**1.3**	IPOP-CMA-ES [23]
CMA+DE-MOS	8.0	13	18	17	4.9	4.2	3.7	3.4	3.3	3.2	CMA+DE-MOS [19]
NBC-CMA	8.4	13	13	14	4.1	3.4	**3.0**	**2.7**	**2.6**	**2.4**	NBC-CMA [22]
POEMS	78	44	558	918	466	496	571	571	680	739	POEMS [18]
PM-AdapSS-DE	11	15	6.3	**6.5**	**2.3**	**2.2**	**2.3**	**2.3**	**2.4**	**2.7**	PM-AdapSS-DE [10, 11]
pPOEMS	80	50	95	393	204	232	251	261	291	341	pPOEMS [18, 21]
Basic RCGA	10	**11**	473	5466	*26e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	21	8415	49100	*63e+0/1e5*	.	.	.	.	.	.	SPSA [14]

Table 12: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{12}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

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	13	16	22	54	74	83	92	233	261	299	ERT_{best}/D
(1,2)-CMA-ES	6.4	19	33	26	24	25	24	11	10	10	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.7	10	25	16	14	14	14	6.2	6.0	5.9	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.3	11	20	15	14	14	13	5.6	5.4	5.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.4	30	44	38	45	46	45	25	23	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.7	7.5	14	9.0	8.9	8.9	8.6	3.8	3.6	3.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	5.7	14	10	10	10	10	4.4	4.2	4.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.8**	4.6	15	10	8.9	8.9	8.6	3.7	3.5	3.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**3.0**	5.5	10	8.2	8.7	9.0	9.0	4.0	3.9	3.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.9**	**3.3**	**7.8**	6.8	6.9	7.2	6.9	3.0	3.1	3.0	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**2.7**	**3.4**	**6.0**	**4.2**	**4.0**	**4.2**	**4.2**	**1.8**	**1.8**	**1.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	16	35	99	547	5852	*29e-2/1e5*	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.1**	**1.8**	**3.5**	**2.8**	**2.8**	**2.9**	**3.0**	**1.3**	**1.3**	**1.4**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	11	30	52	35	32	32	31	13	40	36	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	23	24	22	13	13	13	14	6.4	6.4	6.6	Adap DE (F-AUC) [11]
DE (Uniform)	27	29	28	21	21	22	22	10	10	11	DE (Uniform) [10]
IPOP-aCMA-ES	4.6	5.0	8.8	**5.9**	**5.7**	**6.0**	**6.0**	**2.6**	**2.6**	**2.6**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	5.2	5.2	9.4	6.1	6.2	6.4	6.3	**2.8**	**2.8**	**2.8**	IPOP-CMA-ES [23]
CMA+DE-MOS	21	21	25	16	16	16	16	7.1	6.9	6.8	CMA+DE-MOS [19]
NBC-CMA	18	17	17	10	12	12	12	5.5	5.5	5.5	NBC-CMA [22]
POEMS	183	222	9450	6512	56748	50936	45608	18045	*16e-1/3e5*	.	POEMS [18]
PM-AdapSS-DE	22	25	24	16	24	27	27	12	12	13	PM-AdapSS-DE [10, 11]
pPOEMS	934	1481	2087	1366	1384	1554	1879	917	1009	1369	pPOEMS [18, 21]
Basic RCGA	76	91	423	665	1672	8906	7980	*29e-2/5e4*	.	.	Basic RCGA [25]
SPSA	2659	4809	18513	*75e+0/1e5*	.	.	.	.	.	.	SPSA [14]

Table 13: 05-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{13}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

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	0.56	8.9	26	39	50	64	262	305	350	451	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	7.1	15	25	27	37	65	22	22	28	98	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.0**	4.2	9.4	30	34	34	14	16	27	37	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.9	3.1	4.6	17	21	24	14	16	18	36	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.7	7.6	16	32	44	60	23	24	46	153	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.6**	3.6	7.0	10	11	10	3.0	3.1	4.2	5.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.8	3.3	6.4	11	10	9.1	**2.8**	3.1	3.2	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.5**	4.3	**2.9**	**4.9**	7.7	6.7	**2.5**	3.5	3.1	3.1	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	3.1	5.0	10	10	8.8	3.3	3.1	3.1	5.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.4**	**2.2**	3.7	7.1	8.3	7.9	**2.4**	**2.2**	**2.2**	3.1	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.9**	**2.1**	**3.1**	7.9	**7.1**	**6.1**	**1.9**	**2.0**	**2.0**	**2.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.9**	11	18	187	6618	*15e-2/1e5*	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	4.0	**1.0**	4.5	8.1	42	67	68	450	391	*15e-4/9e3*	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	28	30	506	1310	8016	10188	5347	*38e-2/1e5*	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**2.9**	14	10	11	11	11	3.2	3.3	3.2	3.1	Adap DE (F-AUC) [11]
DE (Uniform)	**2.3**	15	11	12	13	13	3.7	3.8	3.8	3.7	DE (Uniform) [10]
IPOP-aCMA-ES	**2.6**	3.3	**3.0**	**4.1**	**4.2**	**4.0**	**1.2**	**1.2**	**1.2**	**1.1**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.8	4.0	3.1	**5.0**	**5.3**	**5.1**	**1.4**	**1.6**	**1.6**	**1.6**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.7**	15	11	12	14	13	3.5	3.4	3.4	3.2	CMA+DE-MOS [19]
NBC-CMA	**1.8**	9.5	6.2	7.5	9.3	9.3	**2.6**	**2.6**	**2.7**	**2.6**	NBC-CMA [22]
POEMS	286	52	904	2912	9139	18912	16068	13841	*12e-2/3e5*	.	POEMS [18]
PM-AdapSS-DE	**2.1**	13	10	11	12	12	3.4	3.5	3.5	3.4	PM-AdapSS-DE [10, 11]
pPOEMS	26	57	446	793	1067	1220	390	472	1316	9956	pPOEMS [18, 21]
Basic RCGA	**2.4**	34	282	1074	6915	11505	*50e-2/5e4*	.	.	.	Basic RCGA [25]
SPSA	22	55	2055	*43e-1/1e5*	.	.	.	.	.	.	SPSA [14]

Table 14: 05-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_{14}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.20	0.20	2.0	8.2	12	18	28	42	50	95	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.8**	**2.3**	5.0	5.9	6.3	8.3	11	13	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	4.3	3.5	3.9	4.3	5.8	8.2	11	9.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.8**	3.1	3.2	3.3	3.6	4.8	6.9	9.2	8.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.2**	3.5	6.4	6.4	6.3	11	14	17	16	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.6**	**1.7**	**1.9**	3.1	3.2	4.2	5.0	6.8	5.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.6**	**2.3**	**2.1**	**2.9**	3.3	3.9	4.6	6.0	5.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.5**	**1.7**	**1.8**	**2.3**	**2.3**	**2.9**	3.6	4.5	4.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**2.5**	**2.0**	**2.0**	**2.5**	3.0	3.8	4.2	5.2	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.6**	**1.2**	**1.8**	**2.3**	**2.5**	**2.7**	**3.1**	**4.1**	**3.3**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.6**	**0.82**	**1.4**	**1.7**	**2.0**	**2.7**	**2.9**	**3.2**	**2.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.9**	3.5	11	19	29	679	33788	*27e-5/1e5*	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1.7**	**2.1**	**1.0**	**1.0**	**1.0**	**1.2**	**1.8**	5.0	1029	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	4.1	25	14	7.3	7.5	8.8	17	21	27	203	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.3**	**2.2**	9.4	15	15	13	11	11	8.2	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.2**	**2.3**	10	16	18	15	13	13	9.3	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**2.3**	**1.5**	**2.2**	3.2	3.6	3.6	3.4	**3.8**	**2.9**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1.3**	**2.2**	**2.9**	3.8	4.3	4.7	4.7	5.4	4.4	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.2**	**2.9**	13	14	15	14	13	14	11	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.3**	**1.4**	7.0	8.7	8.1	7.4	6.6	7.7	6.4	NBC-CMA [22]
POEMS	**1**	280	111	43	79	124	136	130	501	*46e-8/3e5*	POEMS [18]
PM-AdapSS-DE	**1**	**1.5**	**1**	9.4	17	17	15	12	12	8.9	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	69	61	47	140	597	798	868	1057	2134	pPOEMS [18, 21]
Basic RCGA	**1**	**1.1**	**1.5**	23	40	59	273	1453	14895	*90e-6/5e4*	Basic RCGA [25]
SPSA	24	120	167	106	86	69	99	601	2141	*60e-7/1e5*	SPSA [14]

Table 15: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{15}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	0.20	2.6	102	1862	3874	3949	4015	4084	4154	4272	ERT_{best}/D
(1,2)-CMA-ES	**1.5**	5.7	27	76	*50e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.2**	8.1	26	*30e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.8**	11	25	*30e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.1**	6.5	129	*99e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.5**	**2.9**	8.2	38	*20e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.3**	**2.5**	3.7	18	*20e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.1**	**1.5**	**2.8**	13	38	37	36	36	35	34	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	7.3	8.5	40	*30e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.5**	**2.3**	6.1	*20e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.2**	4.6	38	*20e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**2.8**	15	243	*11e-1/1e5*	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.3**	**2.0**	5.8	46	*30e-1/6e3*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	15	7.1	8.6	95	185	366	361	354	*20e-1/1e5*	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1.1**	3.8	5.4	**2.0**	7.5	7.4	7.3	7.2	7.1	6.9	Adap DE (F-AUC) [11]
DE (Uniform)	**1.2**	4.5	4.8	**2.2**	3.0	**3.0**	**3.0**	**2.9**	**2.9**	**2.9**	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**2.3**	**1.5**	**0.89**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1.3**	**1.3**	**2.3**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.1**	**2.5**	4.3	**1.4**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	CMA+DE-MOS [19]
NBC-CMA	**1.1**	**2.7**	**2.3**	4.3	16	16	15	15	15	14	NBC-CMA [22]
POEMS	154	92	18	232	335	329	324	319	314	305	POEMS [18]
PM-AdapSS-DE	**1.4**	**2.4**	5.4	6.3	3.2	3.2	3.2	3.3	7.6	7.4	PM-AdapSS-DE [10, 11]
pPOEMS	**1.3**	73	57	29	60	61	62	63	64	66	pPOEMS [18, 21]
Basic RCGA	**1.1**	3.1	25	9.4	12	12	12	12	15	20	Basic RCGA [25]
SPSA	35780	5960	2251	*13e+0/1e5*	.	.	.	.	.	.	SPSA [14]

Table 16: 05-D, running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_{16}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.20	0.24	24	122	532	2033	2090	2283	2329	2419	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.4**	42	259	*14e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	16	29	45	70	69	63	62	*18e-2/1e4*	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.2**	15	43	38	36	*17e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	58	589	*28e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	7.2	27	31	34	*22e-2/1e4*	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	**2.9**	5.8	12	6.1	11	29	*98e-4/1e4*	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.5**	5.6	16	19	15	33	*39e-3/1e4*	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.8**	8.1	20	33	72	*14e-2/1e4*	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.2**	**2.0**	21	19	33	*71e-3/1e4*	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.2**	**1.7**	7.7	16	*62e-3/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.7**	**2.3**	10	95	*48e-3/1e5*	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1.2**	**2.6**	12	47	*35e-2/8e3*	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1.3**	20	7.8	179	409	324	671	*15e-2/1e5*	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.2**	6.4	39	31	8.2	12	11	11	10	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.2**	4.3	44	20	13	17	16	16	15	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1.1**	3.9	**2.4**	**1.7**	**0.56**	**0.82**	**0.84**	**0.84**	**0.85**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1.3**	**2.5**	**2.3**	**1.7**	**0.55**	**0.96**	**0.94**	**0.94**	**0.95**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.6**	**1.6**	**2.9**	**2.6**	**1.2**	**1.2**	**1.2**	7.7	7.7	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.3**	3.0	4.0	**1.3**	**0.81**	**0.86**	**0.84**	**0.83**	**0.83**	NBC-CMA [22]
POEMS	**1**	57	11	14	92	56	74	68	68	66	POEMS [18]
PM-AdapSS-DE	**1**	**1.3**	3.9	124	55	16	20	18	28	27	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.5**	10	52	40	53	116	110	113	116	pPOEMS [18, 21]
Basic RCGA	**1**	**1.4**	**2.4**	60	49	80	351	322	*16e-3/5e4*	.	Basic RCGA [25]
SPSA	4.3	280	548	1367	594	349	695	*12e-1/1e5*	.	.	SPSA [14]

Table 17: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{17}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

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	0.20	0.20	1.0	43	180	572	734	959	1270	1587	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.1**	52	54	404	*14e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	6.7	5.3	6.2	13	64	*51e-4/1e4*	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	5.3	5.0	13	22	*87e-4/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	52	87	397	*36e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	116	20	18	31	*27e-3/1e4*	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	20	**2.3**	4.1	7.2	90	*34e-4/1e4*	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	5.1	**0.71**	4.5	28	*12e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	4.2	3.6	18	54	*23e-3/1e4*	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	15	25	94	*14e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.2**	15	17	24	*38e-3/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	6.5	15	64	1259	*31e-3/1e5*	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1.2**	**3.1**	42	405	*24e-2/1e4*	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	17	37	17	3.3	**2.5**	40	62	120	1104	*36e-5/1e5*	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.2**	5.7	3.9	**2.3**	**1.2**	**1.3**	**1.3**	**1.3**	**1.4**	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	3.8	4.3	**2.7**	**1.4**	**1.6**	**1.6**	**1.5**	**1.6**	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1.3**	4.3	**0.89**	**0.53**	**0.59**	**0.77**	**0.74**	**1.00**	**1.1**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1.1**	4.8	**1.1**	**0.97**	**0.61**	**0.77**	**0.80**	**0.81**	**1.0**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.1**	**2.8**	5.8	5.2	3.9	5.4	4.7	3.9	4.0	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.2**	5.6	**2.2**	**1.9**	**0.74**	**0.68**	**0.68**	**1.6**	3.3	NBC-CMA [22]
POEMS	**1**	78	221	17	15	8.2	14	61	98	139	POEMS [18]
PM-AdapSS-DE	**1**	**1.3**	4.2	4.0	**2.3**	**1.2**	**1.4**	**1.4**	**1.3**	**1.4**	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.3**	169	22	88	57	71	75	73	82	pPOEMS [18, 21]
Basic RCGA	**1**	**1.1**	**2.9**	57	48	35	56	124	173	*30e-5/5e4*	Basic RCGA [25]
SPSA	35977	77306	48618	2098	2228	2447	*85e-2/1e5*	.	.	.	SPSA [14]

Table 18: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{18}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

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	0.20	0.24	21	76	794	1690	1856	2076	2181	2494	ERT_{best}/D
(1,2)-CMA-ES	**1.1**	**2.4**	36	201	*11e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	4.7	3.7	28	23	*16e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	5.4	8.2	27	21	83	*13e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	7.6	29	601	*19e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	3.5	**3.0**	31	21	84	*14e-2/1e4*	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.1**	**1.9**	5.9	9.2	19	*67e-3/1e4*	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**2.7**	3.1	18	6.4	84	*39e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	5.4	8.8	35	20	*13e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	4.1	8.6	52	87	*42e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.1**	3.6	15	48	33	85	*14e-2/1e4*	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**1.6**	5.0	27	300	*14e-2/1e5*	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	5.4	10	272	*57e-2/3e4*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	28	53	**2.2**	7.2	25	122	*22e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**2.4**	4.3	3.8	**0.75**	**0.55**	**0.69**	**0.75**	**0.88**	**0.98**	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**2.7**	4.0	4.3	**0.81**	**0.58**	**0.73**	**0.80**	**0.95**	**1.1**	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	5.8	3.5	**1.6**	**0.70**	**0.69**	**0.77**	**0.73**	**0.80**	**0.84**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1.6**	7.5	**1.2**	**2.7**	**0.87**	**1.1**	**1.0**	**0.98**	**1.0**	**0.99**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.1**	**1.7**	4.9	6.7	**2.9**	**1.7**	**1.7**	**1.6**	**1.6**	**2.0**	CMA+DE-MOS [19]
NBC-CMA	**1**	**2.3**	3.1	**3.0**	**0.41**	**0.48**	**1.2**	3.4	6.2	15	NBC-CMA [22]
POEMS	**2.5**	260	19	23	33	207	449	2029	*15e-3/3e5*	.	POEMS [18]
PM-AdapSS-DE	**1.1**	4.4	4.3	4.1	**0.76**	**0.54**	**0.67**	**0.74**	**0.89**	**1.0**	PM-AdapSS-DE [10, 11]
pPOEMS	**1.1**	77	18	95	34	30	39	46	55	69	pPOEMS [18, 21]
Basic RCGA	**1**	3.5	7.9	88	23	35	187	347	*53e-4/5e4*	.	Basic RCGA [25]
SPSA	3.33e5	6.26e5	19476	18540	*31e+1/1e5*	.	.	.	.	.	SPSA [14]

Table 19: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{19}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	0.20	0.20	0.20	0.20	48	20972	24088	24169	24229	24404	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	31	16363	*56e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	62	4556	945	*27e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.4**	22	8527	1393	*39e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	55	25341	*59e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	21	6463	*39e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	20	8960	659	*19e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**17**	3093	478	7.0	6.1	6.1	6.0	6.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	25	10110	*34e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**13**	5123	1482	*20e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	**17**	6018	233	*98e-3/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.2**	34	2898	3823	69	*12e-2/1e5*	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	24	15619	995	*55e-3/1e5*	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	17	37	97	5695	2016	33	*73e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.1**	29	2586	1726	10	11	11	11	10	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.2**	35	3449	1630	15	13	13	13	13	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	**14**	**1207**	**123**	**0.84**	**0.95**	**0.95**	**0.96**	**0.96**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	21	1720	**125**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.2**	27	**658**	**108**	**3.9**	**4.8**	**4.8**	**4.8**	**4.8**	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.1**	39	2946	2141	40	35	35	35	35	NBC-CMA [22]
POEMS	**1**	202	1047	30587	10531	98	87	86	86	86	POEMS [18]
PM-AdapSS-DE	**1**	**1.7**	37	2000	2054	22	19	19	19	29	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.1**	982	18467	1645	12	27	27	27	27	pPOEMS [18, 21]
Basic RCGA	**1**	**1.1**	33	**1019**	463	*63e-3/5e4*	.	.	.	.	Basic RCGA [25]
SPSA	36	97	422	2.10e5	29091	*59e-2/1e5*	.	.	.	.	SPSA [14]

Table 20: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{20}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	2.7	3.0	3.2	170	7622	10272	10894	10921	10972	11063	ERT_{best}/D
(1,2)-CMA-ES	3.4	4.1	4.7	19	*67e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.9**	4.0	4.5	11	*67e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.4	4.5	4.7	9.3	18	14	13	13	13	13	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	8.2	8.9	14	*67e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.3**	3.3	3.3	10	9.4	7.0	6.6	6.6	6.6	6.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.6**	**2.5**	**2.8**	6.9	*47e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.8**	**2.5**	**2.6**	7.6	*47e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**2.6**	**2.8**	6.8	*47e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.2**	**2.7**	**2.8**	10	19	14	13	13	13	13	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.7**	**2.2**	**2.6**	5.4	19	14	13	13	13	13	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.5	6.3	7.2	**1.5**	**0.55**	**0.48**	**0.58**	**1.1**	**1.5**	**2.6**	Artif Bee Colony [9]
avg NEWUOA	**1.2**	**1.1**	**1**	8.4	12	8.6	8.2	8.1	8.1	8.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	7.1	8.7	9.2	869	*12e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**3.0**	5.5	6.8	7.6	6.9	5.1	4.9	4.9	4.8	4.8	Adap DE (F-AUC) [11]
DE (Uniform)	5.9	8.6	11	10	9.2	6.8	6.4	6.4	6.4	6.4	DE (Uniform) [10]
IPOP-aCMA-ES	**2.1**	3.0	3.9	10	**1.4**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.4**	3.7	3.9	11	**1.4**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [23]
CMA+DE-MOS	5.0	10	10	**2.7**	**0.43**	**0.49**	**0.55**	**0.70**	**1.0**	**1.1**	CMA+DE-MOS [19]
NBC-CMA	3.1	6.5	7.9	**5.0**	25	19	18	18	18	17	NBC-CMA [22]
POEMS	82	86	84	8.4	30	22	21	21	21	21	POEMS [18]
PM-AdapSS-DE	4.9	11	11	14	9.4	7.0	6.6	6.6	6.6	6.6	PM-AdapSS-DE [10, 11]
pPOEMS	81	78	81	17	17	13	13	14	14	15	pPOEMS [18, 21]
Basic RCGA	4.0	8.1	8.7	439	95	*97e-2/5e4*	.	.	.	.	Basic RCGA [25]
SPSA	13	19	25	*18e-1/1e5*	.	.	.	.	.	.	SPSA [14]

Table 21: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{21}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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
ERT_{best}/D	0.20	0.20	8.2	231	335	338	341	344	346	351	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	6.9	8.6	13	13	13	13	13	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	5.7	5.8	9.0	9.0	8.9	8.9	8.9	8.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**2.4**	5.0	10	9.4	9.4	9.4	9.3	9.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	24	14	23	23	23	23	23	22	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	5.7	**2.9**	6.9	6.8	6.8	6.8	6.8	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.5	3.4	6.1	6.1	6.1	6.0	6.0	6.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**1.2**	**1.7**	**3.1**	**3.1**	**3.1**	**3.1**	**3.1**	**3.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	5.1	4.3	**5.3**	**5.3**	**5.3**	**5.2**	**5.2**	**5.2**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.7**	3.4	5.6	5.5	5.5	5.5	5.5	5.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	7.6	3.8	7.5	7.4	7.4	7.3	7.3	7.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	3.2	**1.8**	6.7	10	13	24	84	265	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	**1.7**	**2.5**	**3.6**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1**	21	3.4	114	217	267	287	327	374	458	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1**	5.2	**1.7**	110	109	109	108	107	106	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	4.5	33	76	76	75	75	74	74	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	3.5	7.3	32	33	33	33	33	33	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	6.3	5.6	30	30	31	31	31	31	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1**	4.6	69	280	478	485	485	483	527	CMA+DE-MOS [19]
NBC-CMA	**1**	**1**	**2.5**	96	119	118	117	116	115	114	NBC-CMA [22]
POEMS	**1**	**1**	25	744	1429	1415	1405	1397	1389	1371	POEMS [18]
PM-AdapSS-DE	**1**	**1**	4.0	33	201	199	198	196	195	192	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1**	28	11	214	238	243	254	263	283	pPOEMS [18, 21]
Basic RCGA	**1**	**1**	**2.5**	84	105	129	129	134	135	140	Basic RCGA [25]
SPSA	**1**	34	34	299	1985	1967	1958	1997	4056	3995	SPSA [14]

Table 22: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{22}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

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	0.20	0.20	14	77	188	196	202	205	208	214	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	18	31	31	30	30	29	29	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	10	11	20	19	19	19	18	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	15	21	51	49	48	47	47	46	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	23	32	49	47	46	46	45	44	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	6.9	13	16	16	15	15	15	15	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	12	10	12	12	12	12	12	11	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	10	12	15	15	14	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	16	18	12	11	11	11	11	11	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	3.7	8.0	**8.5**	**8.2**	**8.0**	**8.0**	**7.9**	**7.8**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	**3.1**	**6.5**	**4.9**	**4.7**	**4.6**	**4.6**	**4.6**	**4.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	5.1	7.6	35	237	374	1160	3311	6900	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	**3.4**	**2.6**	**2.3**	**2.3**	**2.3**	**2.3**	**2.4**	**2.4**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1**	27	58	336	1483	1421	1384	1364	1933	1885	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1**	4.8	203	803	768	747	734	724	706	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	6.6	203	469	450	437	430	424	414	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	8.8	21	65	276	270	265	262	257	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	12	48	166	165	161	159	158	155	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1**	3.7	24	299	483	557	551	549	541	CMA+DE-MOS [19]
NBC-CMA	**1**	**1**	**3.0**	264	289	360	350	343	339	331	NBC-CMA [22]
POEMS	**1**	**1**	1137	2347	2593	2485	2417	2377	2348	2292	POEMS [18]
PM-AdapSS-DE	**1**	**1**	4.1	**4.6**	469	449	437	430	424	414	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1**	29	24	268	276	284	305	326	362	pPOEMS [18, 21]
Basic RCGA	**1**	**1**	6.2	154	365	857	1697	1716	1706	3410	Basic RCGA [25]
SPSA	**1**	42	676	1318	7823	*69e-2/1e5*	.	.	.	.	SPSA [14]

Table 23: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{23}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	0.20	0.20	0.60	104	2850	5578	6331	6479	6606	6851	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	**2.8**	101	*97e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	15	37	16	13	23	23	22	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	6.4	23	9.5	26	*18e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	3.1	105	*98e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	5.7	28	7.0	12	11	22	22	21	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.8	12	4.2	*87e-3/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.2**	8.9	24	25	*20e-2/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**3.0**	23	51	*23e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	5.0	**5.4**	5.5	12	*10e-2/1e4*	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	4.7	**1.3**	9.3	*12e-2/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.2**	19	*37e-2/1e5*	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	6.0	**2.5**	14	*15e-2/9e3*	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1**	8.1	15	33	*55e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1**	**2.4**	9.3	**2.3**	**2.5**	**3.4**	**4.4**	**5.3**	**6.9**	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	**2.0**	11	**2.5**	**2.7**	**3.6**	**4.6**	**5.5**	**7.2**	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	**1.6**	20	76	39	34	33	33	32	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	**2.2**	26	33	17	15	15	14	14	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1**	**2.2**	16	**4.1**	**3.5**	**3.8**	**3.7**	**4.0**	**3.9**	CMA+DE-MOS [19]
NBC-CMA	**1**	**1**	**1.4**	42	299	153	135	132	129	124	NBC-CMA [22]
POEMS	**1**	**1**	12	21	41	63	57	56	55	54	POEMS [18]
PM-AdapSS-DE	**1**	**1**	**1.8**	8.9	12	15	14	15	21	27	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1**	3.4	71	29	43	42	44	47	53	pPOEMS [18, 21]
Basic RCGA	**1**	**1**	**2.2**	37	119	*53e-2/5e4*	.	.	.	.	Basic RCGA [25]
SPSA	**1**	105	309	1779	*11e-1/1e5*	.	.	.	.	.	SPSA [14]

Table 24: 05-D, running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{24}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

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_{best}/D	0.20	0.20	324	43284	1.27e6	1.92e6	1.92e6	1.92e6	2.57e6	2.57e6	ERT_{best}/D
(1,2)-CMA-ES	**1**	11	40	*87e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	7.9	8.3	*50e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	7.5	6.0	*54e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	15	49	*10e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**4.9**	5.3	*41e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	10	4.4	*33e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	6.3	6.0	**3.3**	*31e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**3.9**	7.0	*58e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	9.3	6.2	*42e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	5.6	4.7	3.3	*50e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	6.1	13	*42e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	14	**2.0**	**2.2**	*30e-1/7e3*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	31	57	30	*23e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	5.7	4.1	3.7	**0.13**	**0.15**	**0.15**	**0.15**	**0.11**	**0.11**	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**3.9**	4.3	3.7	**0.17**	**0.15**	**0.15**	**0.15**	**0.11**	**0.11**	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	6.5	**2.6**	41	*50e-1/3e5*	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	6.3	**2.9**	18	**1.4**	**0.94**	**0.94**	**0.94**	**0.70**	**0.70**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	5.7	**2.2**	**2.8**	**0.52**	**1.2**	**1.2**	**1.2**	**0.87**	**0.87**	CMA+DE-MOS [19]
NBC-CMA	**1**	5.5	15	9.4	*56e-1/6e4*	.	.	.	.	.	NBC-CMA [22]
POEMS	**1**	505	72	*62e-1/3e5*	.	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	6.8	5.9	6.8	**0.24**	**0.36**	**0.36**	**0.36**	**0.27**	**0.27**	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	157	39	7.2	*85e-2/3e5*	.	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	**1**	8.1	3.5	8.2	*55e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	76	3.02e5	4351	*74e+0/1e5*	.	.	.	.	.	.	SPSA [14]

References

[1] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Benchmarking the (1, 4)-CMA-ES with mirrored sampling and sequential selection on the noiseless BBOB-2010 testbed. In Pelikan and Branke [20], pages 1617–1624.

[2] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Comparing the (1+1)-CMA-ES with a mirrored (1+2)-CMA-ES with sequential selection on the noiseless BBOB-2010 testbed. In Pelikan and Branke [20], pages 1543–1550.

[3] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Investigating the impact of sequential selection in the (1, 2)-CMA-ES on the noiseless BBOB-2010 testbed. In Pelikan and Branke [20], pages 1591–1596.

[4] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Investigating the impact of sequential selection in the (1, 4)-CMA-ES on the noiseless BBOB-2010 testbed. In Pelikan and Branke [20], pages 1597–1604.

[5] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Mirrored variants of the (1, 2)-CMA-ES compared on the noiseless BBOB-2010 testbed. In Pelikan and Branke [20], pages 1551–1558.

[6] Anne Auger, Dimo Brockhoff, and Nikolaus Hansen. Mirrored variants of the (1, 4)-CMA-ES compared on the noiseless BBOB-2010 testbed. In Pelikan and Branke [20], pages 1559–1566.

[7] Anne Auger, Steffen Finck, Nikolaus Hansen, and Raymond Ros. BBOB 2009: Comparison tables of all algorithms on all noiseless functions. Technical Report RT-0383, INRIA, April 2010.

[8] Anne Auger and Nikolaus Hansen. Benchmarking the (1+1)-CMA-ES on the BBOB-2009 function testbed. In Franz Rothlauf, editor, *GECCO (Companion)*, pages 2459–2466. ACM, 2009.

[9] Mohammed El-Abd. Black-box optimization benchmarking for noiseless function testbed using artificial bee colony algorithm. In Pelikan and Branke [20], pages 1719–1724.

[10] Álvaro Fialho, Wenyin Gong, and Zhihua Cai. Probability matching-based adaptive strategy selection vs. uniform strategy selection within differential evolution: an empirical comparison on the BBOB-2010 noiseless testbed. In Pelikan and Branke [20], pages 1527–1534.

[11] Álvaro Fialho, Marc Schoenauer, and Michèle Sebag. Fitness-AUC bandit adaptive strategy selection vs. the probability matching one within differential evolution: an empirical comparison on the BBOB-2010 noiseless testbed. In Pelikan and Branke [20], pages 1535–1542.

[12] S. Finck, N. Hansen, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Presentation of the noiseless functions. Technical Report 2009/20, Research Center PPE, 2009. Updated February 2010.

[13] Steffen Finck and Hans-Georg Beyer. Benchmarking CMA-EGS on the BBOB 2010 noiseless function testbed. In Pelikan and Branke [20], pages 1633–1640.

[14] Steffen Finck and Hans-Georg Beyer. Benchmarking SPSA on BBOB-2010 noiseless function testbed. In Pelikan and Branke [20], pages 1657–1664.

[15] N. Hansen, A. Auger, S. Finck, and R. Ros. Real-parameter black-box optimization benchmarking 2010: Experimental setup. Technical Report RR-7215, INRIA, 2010.

[16] N. Hansen, S. Finck, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Noiseless functions definitions. Technical Report RR-6829, INRIA, 2009. Updated February 2010.

[17] Nikolaus Hansen and Raymond Ros. Benchmarking a weighted negative covariance matrix update on the BBOB-2010 noiseless testbed. In Pelikan and Branke [20], pages 1673–1680.

[18] Jirí Kubalík. Black-box optimization benchmarking of two variants of the POEMS algorithm on the noiseless testbed. In Pelikan and Branke [20], pages 1567–1574.

[19] Antonio LaTorre, Santiago Muelas, and José María Peña. Benchmarking a MOS-based algorithm on the BBOB-2010 noiseless function testbed. In Pelikan and Branke [20], pages 1649–1656.

[20] Martin Pelikan and Jürgen Branke, editors. *Genetic and Evolutionary Computation Conference, GECCO 2010, Proceedings, Portland, Oregon, USA, July 7-11, 2010, Companion Material*. ACM, 2010.

[21] Petr Posík and Jirí Kubalík. Comparison of Cauchy EDA and pPOEMS algorithms on the BBOB noiseless testbed. In Pelikan and Branke [20], pages 1703–1710.

[22] Mike Preuss. Niching the CMA-ES via nearest-better clustering. In Pelikan and Branke [20], pages 1711–1718.

[23] Raymond Ros. Black-box optimization benchmarking the IPOP-CMA-ES on the noiseless testbed: comparison to the BIPOP-CMA-ES. In Pelikan and Branke [20], pages 1503–1510.

[24] Raymond Ros. Comparison of NEWUOA with different numbers of interpolation points on the BBOB noiseless testbed. In Pelikan and Branke [20], pages 1487–1494.

[25] Thanh-Do Tran and Gang-Gyoo Jin. Real-coded genetic algorithm benchmarked on noiseless black-box optimization testbed. In Pelikan and Branke [20], pages 1731–1738.