Comparison tables: BBOB 2010 function testbed with BBOB 2009 as reference in 20-D

The BBOBies

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Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2010, see `http://coco.gforge.inria.fr/doku.php?id=bbob-2010`. More than 30 algorithms have been tested on 24 benchmark functions in dimensions between 2 and 40. A description of the used objective functions can be found in [16, 12]. The experimental set-up is described in [15].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm in BBOB-2009 (see [7]) if an algorithm from BBOB-2009 reached the given target function value. The ERT value is given otherwise ($\mathrm{ERT}_{\mathrm{best}}$ 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: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_1, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	0.28	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	63	15	25	34	44	53	63	72	93	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	26	8.9	15	20	25	30	35	41	52	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	25	8.1	13	18	22	27	32	36	47	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	63	17	26	35	44	53	62	72	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	18	7.7	13	18	23	27	33	38	49	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	15	6.2	11	15	19	24	28	32	42	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	14	**4.7**	**8.1**	**11**	**14**	**18**	**21**	**24**	**31**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	17	6.3	11	15	19	23	26	31	40	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	11	5.5	10	14	18	21	25	29	37	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**10**	**4.9**	**8.5**	**12**	**15**	**19**	**23**	**26**	**33**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	50	36	66	94	136	177	244	292	374	Artif Bee Colony [9]
avg NEWUOA	**1**	18	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	47	41	13	19	26	33	40	47	54	68	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	79	93	180	265	350	431	515	597	763	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	89	146	298	442	588	734	882	1027	1319	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**9.4**	7.9	14	20	27	33	39	45	58	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**10**	8.0	14	20	26	33	39	46	58	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	34	34	58	68	91	123	134	148	200	CMA+DE-MOS [19]
NBC-CMA	**1**	17	13	21	30	38	46	54	62	79	NBC-CMA [22]
POEMS	**1**	804	183	411	853	1372	1783	2331	2828	3744	POEMS [18]
PM-AdapSS-DE	**1**	69	101	196	291	377	465	555	646	827	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	847	196	468	1052	1852	2567	3510	4501	7123	pPOEMS [18, 21]
Basic RCGA	**1**	36	55	133	868	2715	3825	4686	5435	6380	Basic RCGA [25]
SPSA	158	59	12	16	20	25	29	34	38	46	SPSA [14]

Table 2: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_2, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	19	19	19	19	19	19	19	20	20	20	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	94	133	155	168	172	175	177	179	181	184	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	39	58	71	80	82	83	84	84	85	86	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	33	50	61	67	69	69	70	70	71	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	95	147	165	183	188	194	196	198	200	205	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	24	41	54	62	65	67	68	68	69	70	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	21	34	45	51	54	56	56	57	57	58	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	17	26	34	39	41	41	42	**42**	**43**	**43**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	20	33	43	51	53	54	55	56	57	58	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	12	23	32	38	41	42	43	43	44	45	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	11	21	29	**33**	**35**	**35**	**36**	**36**	**37**	**37**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**6.3**	**8.1**	**12**	**16**	**24**	**30**	**40**	47	56	70	Artif Bee Colony [9]
avg NEWUOA	**3.5**	**10**	**21**	43	63	89	116	141	161	199	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	48	66	73	79	82	83	84	84	85	86	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	27	37	48	58	68	77	86	95	105	123	Adap DE (F-AUC) [11]
DE (Uniform)	45	61	77	92	108	124	140	157	172	203	DE (Uniform) [10]
IPOP-aCMA-ES	**10**	**17**	**22**	**27**	**29**	**30**	**31**	**32**	**33**	**34**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	16	25	35	41	43	44	45	46	47	48	IPOP-CMA-ES [23]
CMA+DE-MOS	25	35	44	50	57	61	67	70	74	82	CMA+DE-MOS [19]
NBC-CMA	23	39	58	73	83	87	90	93	95	98	NBC-CMA [22]
POEMS	145	191	247	295	345	407	450	507	561	663	POEMS [18]
PM-AdapSS-DE	32	42	52	63	73	83	93	103	112	132	PM-AdapSS-DE [10, 11]
pPOEMS	151	216	305	423	513	661	744				

Table 3: 20-D, running time excess ERT/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$_{\text{best}}$/D	0.05	13	253	381	382	382	382	382	382	383	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	262	11707	*14e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	121	122	*63e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	89	133	*67e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	301	*16e+1/1e4*	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	75	122	*64e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	38	41	*54e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	42	55	*61e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	51	189	*73e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	30	472	*95e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	29	378	*84e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	32	7.7	**1.5**	**2.7**	**3.0**	**3.2**	**3.6**	**3.9**	**4.1**	**4.9**	Artif Bee Colony [9]
avg NEWUOA	88	1036	*97e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	176	**7.0**	1214	*18e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**20**	342	*59e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	26	362	*66e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	25	**6.3**	**10**	*60e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	26	**6.3**	13	*50e-1/1e5*	.	.	.	.	.	.	IPOP-CMA-ES [23]
CMA+DE-MOS	**19**	13	**4.7**	**7.4**	**8.9**	**9.4**	**10**	**10**	**11**	**12**	CMA+DE-MOS [19]
NBC-CMA	23	18	839	*18e+0/2e4*	.	.	.	.	.	.	NBC-CMA [22]
POEMS	3775	42	10	64	135	136	140	143	145	151	POEMS [18]
PM-AdapSS-DE	26	137	*56e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	3229	42	13	**57**	**105**	**107**	**109**	**113**	**119**	**132**	pPOEMS [18, 21]
Basic RCGA	**22**	36	27	1867	*41e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	1.33e6	*82e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [14]

Table 4: 20-D, running time excess ERT/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
ERT$_{\text{best}}$/D	0.05	37	236	381	383	384	385	386	388	7053	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	467	*17e+1/1e4*	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	219	119	*79e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	200	151	*79e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	447	*15e+1/1e4*	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	151	171	*88e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	100	53	*66e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	109	66	*69e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	149	453	*10e+1/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**51**	3814	*14e+1/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	61	3765	*13e+1/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	220	**2.9**	**2.0**	**4.2**	**5.6**	**6.0**	**6.3**	**6.9**	**7.3**	**0.45**	Artif Bee Colony [9]
avg NEWUOA	112	1442	*12e+1/2e4*	.	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	298	**2.5**	*26e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	93	237	*19e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	109	250	*21e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	**54**	**2.4**	*14e+0/1e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	59	**2.3**	*13e+0/1e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [23]
CMA+DE-MOS	88	4.7	**10**	**12**	**14**	**14**	**15**	**15**	**16**	**0.93**	CMA+DE-MOS [19]
NBC-CMA	**50**	4.5	*25e+0/1e4*	.	.	.	.	.	.	.	NBC-CMA [22]
POEMS	4010	18	**14**	**109**	**307**	**308**	**310**	**311**	**313**	**18**	POEMS [18]
PM-AdapSS-DE	137	128	*20e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	4614	21	31	254	1043	1054	1056	1056	1054	59	pPOEMS [18, 21]
Basic RCGA	86	67	*22e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [25]
SPSA	1638	*24e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [14]

Table 5: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_5, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**2.6**	6.1	7.0	7.2	7.2	7.2	7.2	7.2	7.2	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.6**	3.5	4.4	4.4	4.4	4.4	4.4	4.4	4.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.5**	3.3	3.9	4.1	4.1	4.1	4.1	4.1	4.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	3.1	6.5	7.7	7.9	8.3	8.3	8.3	8.3	8.3	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**2.2**	5.1	6.1	6.4	6.5	6.5	6.5	6.5	6.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.9**	3.7	4.4	4.5	4.6	4.6	4.6	4.6	4.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**2.7**	**3.2**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.7**	4.1	5.0	5.4	5.4	5.4	5.4	5.4	5.4	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.6**	3.1	3.6	3.8	3.8	3.8	3.8	3.8	3.8	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.1**	**2.5**	**3.1**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	37	69	90	93	93	93	93	93	93	Artif Bee Colony [9]
avg NEWUOA	**1**	**2.7**	**2.7**	**3.2**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1**	3.6	5.3	5.8	6.0	6.0	6.0	6.0	6.0	6.0	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	15	42	52	53	54	54	54	54	54	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	27	69	83	85	86	86	86	86	86	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**2.7**	5.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	3.2	5.8	6.5	6.7	6.7	6.7	6.7	6.7	6.7	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	23	51	53	53	53	53	53	53	53	CMA+DE-MOS [19]
NBC-CMA	**1**	12	6573	13412	13412	13412	13412	13412	13412	13412	NBC-CMA [22]
POEMS	**1**	180	255	310	330	343	348	350	352	352	POEMS [18]
PM-AdapSS-DE	**1**	35	82	92	96	96	96	96	96	96	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	175	253	308	338	349	355	360	360	360	pPOEMS [18, 21]
Basic RCGA	**1**	138	557	3186	5233	6485	7260	7764	9890	*64e-7/5e4*	Basic RCGA [25]
SPSA	**1**	3.1	6.4	7.9	8.1	8.2	8.2	8.2	8.2	8.2	SPSA [14]

Table 6: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	4.0	26	65	117	171	213	261	298	336	420	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	21	11	8.9	12	26	78	567	*11e-3/1e4*	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	7.1	3.1	**2.2**	**1.8**	**1.8**	**2.1**	**2.5**	**3.0**	3.5	6.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.9	**2.7**	**1.9**	**1.6**	**1.5**	**1.5**	**1.7**	**1.8**	**2.1**	3.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	19	11	15	41	133	670	*15e-2/1e4*	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.8	**2.6**	**2.1**	**1.9**	**2.0**	**2.2**	**2.5**	3.1	3.6	7.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.6	**2.7**	**2.0**	**1.6**	**1.6**	**1.6**	**1.5**	**1.7**	**1.8**	**2.2**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.2	**1.6**	**1.3**	**1.1**	**1.0**	**1.1**	**1.2**	**1.5**	**1.7**	**2.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.3	**2.3**	**2.0**	**2.0**	**2.4**	3.1	4.8	10	22	342	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.1**	**1.7**	13	92	831	*69e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.7**	**1.8**	12	107	846	*74e-2/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	8.3	46	453	2587	*54e-2/1e5*	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**2.3**	**1.1**	**1.00**	**0.74**	**0.72**	**0.71**	**0.70**	**0.74**	**0.74**	**0.73**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	13	5.3	3.7	3.2	3.7	7.5	45	177	874	1036	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	22	25	19	15	14	14	14	14	14	14	Adap DE (F-AUC) [11]
DE (Uniform)	27	40	29	23	20	20	20	20	20	20	DE (Uniform) [10]
IPOP-aCMA-ES	3.6	**2.3**	**1.6**	**1.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.0	**2.3**	**1.7**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [23]
CMA+DE-MOS	20	8.9	5.5	3.9	3.4	3.2	3.0	**3.0**	**3.0**	**2.8**	CMA+DE-MOS [19]
NBC-CMA	53	108	50	28	19	16	13	12	10	8.6	NBC-CMA [22]
POEMS	91	30	32	28	26	26	26	27	27	27	POEMS [18]
PM-AdapSS-DE	22	28	20	16	15	14	14	14	14	14	PM-AdapSS-DE [10, 11]
pPOEMS	94	32	36	32	32	34	34	35	35	38	pPOEMS [18, 21]
Basic RCGA	41	15	52	60	56	54	51	196	2128	*63e-6/5e4*	Basic RCGA [25]
SPSA	2263	*40e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [14]

Table 7: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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
ERT_{best}/D	0.53	7.6	68	214	475	826	826	826	826	848	ERT_{best}/D
(1,2)-CMA-ES	39	42	*23e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	14	4.4	71	*67e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	11	4.8	71	*72e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	25	27	*29e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.1	3.7	118	*78e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.1	3.2	23	*48e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.0	4.6	37	*62e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.8	4.5	275	*12e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.0**	11	24	41	37	177	177	177	177	172	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.8**	**1.9**	24	54	96	181	181	181	181	176	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.5	19	251	*60e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	7.1	**1.4**	101	*51e-1/2e4*	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	21	5.3	21	*53e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	3.0	18	5.2	**3.1**	**1.9**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	Adap DE (F-AUC) [11]
DE (Uniform)	3.3	30	8.4	5.2	3.3	**2.6**	**2.7**	**2.7**	**2.7**	**2.7**	DE (Uniform) [10]
IPOP-aCMA-ES	**2.7**	**2.5**	**1.6**	**2.7**	**1.6**	**0.99**	**0.99**	**0.99**	**0.99**	**1.0**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.1	**3.0**	**1.9**	4.8	**2.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.6**	IPOP-CMA-ES [23]
CMA+DE-MOS	**2.7**	12	**2.7**	6.0	3.9	**2.4**	**2.4**	**2.4**	**2.4**	**2.3**	CMA+DE-MOS [19]
NBC-CMA	3.2	3.6	**1.3**	31	225	*55e-2/1e4*	.	.	.	.	NBC-CMA [22]
POEMS	429	57	23	1968	*11e-1/3e5*	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	3.0	21	5.9	**3.4**	**2.1**	**1.6**	**1.6**	**1.6**	**1.6**	**1.7**	PM-AdapSS-DE [10, 11]
pPOEMS	307	55	22	280	1778	2412	2412	2412	2412	2349	pPOEMS [18, 21]
Basic RCGA	4.7	12	13	1111	*13e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	104	995	*58e+0/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 8: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_8, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	5.5	21	102	194	202	207	211	215	219	224	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	11	4.9	10	19	20	20	20	20	20	20	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.4	7.2	5.3	7.8	8.2	8.3	8.3	8.3	8.2	8.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.5	**2.2**	3.6	4.5	4.8	5.0	5.0	5.0	5.0	5.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	11	13	12	17	18	18	19	19	19	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.1	**2.3**	4.9	7.7	8.0	8.0	8.1	8.0	8.0	8.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.8	**2.6**	3.6	5.8	6.0	6.1	6.1	6.1	6.1	6.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.8**	**2.0**	3.3	5.8	5.9	5.9	5.9	5.9	5.8	5.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.8	3.2	3.8	5.9	6.2	6.2	6.2	6.2	6.2	6.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.6**	**1.5**	**3.2**	4.8	5.1	5.2	5.3	5.3	5.3	5.3	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**2.4**	**1.7**	**3.0**	5.4	5.6	5.6	5.7	5.7	5.7	5.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	14	6.4	3.9	5.9	10	37	353	1171	*24e-5/1e5*	.	Artif Bee Colony [9]
avg NEWUOA	**2.0**	**1.6**	**0.96**	**0.97**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.99**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	6.3	3.2	5.3	6.5	6.9	7.1	7.2	7.2	7.3	7.4	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	43	21	23	21	23	24	24	25	25	26	Adap DE (F-AUC) [11]
DE (Uniform)	73	37	34	31	33	34	35	36	37	39	DE (Uniform) [10]
IPOP-aCMA-ES	4.1	**2.6**	3.5	**3.5**	**3.7**	**3.8**	**3.9**	**3.9**	**3.9**	**4.0**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.9	3.2	3.7	**3.9**	**4.2**	**4.3**	**4.4**	**4.4**	**4.4**	**4.5**	IPOP-CMA-ES [23]
CMA+DE-MOS	19	6.7	11	12	13	13	13	13	13	13	CMA+DE-MOS [19]
NBC-CMA	5.7	3.5	6.3	6.8	7.7	8.3	8.6	8.7	8.7	8.8	NBC-CMA [22]
POEMS	96	79	500	902	1629	21544	*15e-3/3e5*	.	.	.	POEMS [18]
PM-AdapSS-DE	48	24	35	35	38	39	39	40	40	41	PM-AdapSS-DE [10, 11]
pPOEMS	96	75	103	97	109	117	121	135	147	188	pPOEMS [18, 21]
Basic RCGA	24	25	*17e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [25]
SPSA	256	3988	*98e+0/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 9: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_9, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	18	86	155	164	169	173	176	180	186	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	1227	10	12	24	25	25	25	24	24	24	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	875	6.6	5.8	8.1	8.5	8.6	8.6	8.5	8.5	8.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	491	3.1	4.5	6.5	6.8	6.9	6.9	6.9	6.9	6.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1085	11	16	22	23	23	23	23	23	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	534	3.7	5.1	6.0	6.5	6.6	6.6	6.6	6.6	6.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	421	**2.3**	4.6	5.7	6.1	6.2	6.2	6.2	6.2	6.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	284	**2.0**	**3.3**	**5.2**	**5.4**	**5.4**	**5.4**	**5.4**	**5.4**	**5.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	418	**2.7**	5.0	7.2	7.5	7.5	7.5	7.4	7.4	7.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**261**	**1.4**	3.6	6.2	6.4	6.5	6.5	6.5	6.5	6.5	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**238**	**1.7**	**3.4**	6.9	7.1	7.1	7.1	7.1	7.1	7.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1427	10	699	*92e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**228**	**1.5**	**1.0**	**1.2**	**1.2**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	728	5.4	6.6	10	10	10	10	11	11	11	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	3720	21	26	25	27	28	29	30	30	31	Adap DE (F-AUC) [11]
DE (Uniform)	7549	41	41	39	41	42	43	44	45	46	DE (Uniform) [10]
IPOP-aCMA-ES	370	**2.1**	4.1	**4.6**	**4.9**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	378	**2.2**	4.6	5.7	6.0	6.1	6.1	6.1	6.1	6.1	IPOP-CMA-ES [23]
CMA+DE-MOS	1526	5.2	10	12	15	15	15	15	15	15	CMA+DE-MOS [19]
NBC-CMA	610	**2.9**	7.1	9.1	10	11	11	11	11	11	NBC-CMA [22]
POEMS	10487	164	1097	*22e-1/3e5*	.	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	4649	25	37	41	43	45	45	46	46	47	PM-AdapSS-DE [10, 11]
pPOEMS	9902	86	214	328	443	680	972	1281	2537	24109	pPOEMS [18, 21]
Basic RCGA	678	17	*17e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [25]
SPSA	59214	16242	*14e+1/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 10: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{10}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	116	263	371	433	537	682	746	810	854	874	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	13	9.1	7.9	7.4	6.4	5.2	4.9	4.5	4.4	4.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.8	4.2	3.5	3.5	**2.9**	**2.4**	**2.2**	**2.1**	**2.0**	**2.0**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.5	3.8	3.2	**3.0**	**2.5**	**2.0**	**1.8**	**1.7**	**1.6**	**1.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	16	11	9.0	8.2	6.9	5.5	5.1	4.8	4.6	4.6	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.2	3.1	**2.8**	**2.8**	**2.4**	**1.9**	**1.8**	**1.6**	**1.6**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	**2.6**	**2.3**	**2.2**	**1.9**	**1.6**	**1.5**	**1.4**	**1.3**	**1.3**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.0**	**2.0**	**1.8**	**1.7**	**1.5**	**1.2**	**1.1**	**1.0**	**0.98**	**0.98**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.4	**2.6**	**2.4**	**2.3**	**2.0**	**1.6**	**1.5**	**1.4**	**1.3**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**1.8**	**1.7**	**1.7**	**1.4**	**1.2**	**1.1**	**1.0**	**0.99**	**0.99**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.6**	**1.3**	**1.3**	**1.3**	**1.2**	**0.98**	**0.91**	**0.85**	**0.82**	**0.82**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	*50e+2/1e5*	.	.	.	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**0.81**	**1.0**	**1.5**	**2.6**	3.1	3.1	3.6	3.9	4.2	5.0	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	7.8	4.6	3.9	3.5	**2.9**	**2.3**	**2.2**	**2.0**	**1.9**	**1.9**	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	4.3	**2.7**	**2.5**	**2.6**	**2.4**	**2.2**	**2.2**	**2.3**	**2.4**	**2.8**	Adap DE (F-AUC) [11]
DE (Uniform)	7.1	4.3	3.9	4.1	3.9	3.5	3.6	3.8	3.9	4.6	DE (Uniform) [10]
IPOP-aCMA-ES	**1.7**	**1.2**	**1.2**	**1.2**	**1.0**	**0.85**	**0.80**	**0.75**	**0.73**	**0.75**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.3**	**1.7**	**1.8**	**1.8**	**1.5**	**1.3**	**1.2**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [23]
CMA+DE-MOS	4.9	3.4	3.4	3.4	**3.0**	**2.5**	**2.3**	**2.2**	**2.1**	**2.2**	CMA+DE-MOS [19]
NBC-CMA	4.1	**2.9**	3.1	3.3	3.0	**2.6**	**2.5**	**2.4**	**2.3**	**2.3**	NBC-CMA [22]
POEMS	1036	*35e+1/3e5*	.	.	.	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	5.1	3.0	**2.7**	**2.8**	**2.6**	**2.4**	**2.4**	**2.5**	**2.6**	**3.0**	PM-AdapSS-DE [10, 11]
pPOEMS	183	1311	*97e+0/3e5*	.	.	.	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	*48e+2/5e4*	.	.	.	.	.	.	.	.	.	Basic RCGA [25]
SPSA	*30e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [14]

Table 11: 20-D, running time excess ERT/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$_{\text{best}}$/D	1.4	24	50	111	314	429	488	554	614	742	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	481	44	24	12	4.8	3.8	3.6	3.4	3.2	**2.9**	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	359	33	18	8.6	3.3	**2.5**	**2.3**	**2.1**	**2.0**	**1.7**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	347	29	16	7.7	**2.9**	**2.2**	**2.0**	**1.8**	**1.7**	**1.5**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	514	40	22	12	4.5	3.7	3.5	3.3	3.2	**2.9**	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	233	29	16	8.0	3.1	**2.4**	**2.2**	**2.0**	**1.9**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	139	29	16	7.8	**2.9**	**2.3**	**2.1**	**1.9**	**1.8**	**1.5**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	197	23	13	6.1	**2.3**	**1.8**	**1.6**	**1.5**	**1.4**	**1.2**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	126	22	13	6.3	**2.4**	**1.9**	**1.8**	**1.6**	**1.5**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.1**	**6.9**	7.7	5.9	**2.7**	**2.6**	**2.6**	**2.5**	**2.4**	**2.1**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	6.9	**4.8**	**5.8**	**4.3**	**2.1**	**1.9**	**2.0**	**2.0**	**1.9**	**1.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.0**	2180	*92e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	6.0	11	15	11	5.7	5.1	5.6	5.5	5.8	6.1	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	912	135	119	94	58	60	54	48	45	50	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	7.7	**7.7**	**7.3**	**5.1**	**2.4**	**2.2**	**2.3**	**2.3**	**2.4**	**2.5**	Adap DE (F-AUC) [11]
DE (Uniform)	5.0	11	11	8.1	3.8	3.5	3.8	3.9	4.0	4.2	DE (Uniform) [10]
IPOP-aCMA-ES	13	7.9	**4.5**	**2.3**	**0.87**	**0.68**	**0.64**	**0.59**	**0.56**	**0.50**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.5**	19	11	5.4	**2.1**	**1.6**	**1.4**	**1.3**	**1.2**	**1.1**	IPOP-CMA-ES [23]
CMA+DE-MOS	4.0	15	21	10	4.0	3.1	**2.9**	**2.6**	**2.5**	**2.2**	CMA+DE-MOS [19]
NBC-CMA	4.3	203	*85e+0/1e4*	.	.	.	.	.	.	.	NBC-CMA [22]
POEMS	126	51	483	400	218	207	220	230	240	258	POEMS [18]
PM-AdapSS-DE	8.6	10	8.7	5.7	**2.6**	**2.4**	**2.5**	**2.6**	**2.6**	**2.7**	PM-AdapSS-DE [10, 11]
pPOEMS	132	52	111	106	84	142	358	1006	7059	*18e-5/3e5*	pPOEMS [18, 21]
Basic RCGA	4.8	40	*51e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [25]
SPSA	74845	*97e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [14]

Table 12: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{12}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	25	30	52	97	137	158	207	321	620	691	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	5.9	19	24	21	19	19	16	11	6.4	6.7	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**3.0**	8.8	15	13	12	11	9.3	6.5	3.6	3.6	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.4**	3.7	7.4	8.0	7.6	7.5	6.4	4.6	**2.6**	**2.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	10	23	23	21	21	18	13	7.0	7.5	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.7**	5.3	8.8	8.8	8.5	8.5	7.2	5.1	**2.9**	**2.9**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.3**	3.6	6.1	6.7	6.5	6.7	5.7	4.1	**2.3**	**2.3**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.7**	3.1	**4.8**	**5.1**	**5.0**	**5.1**	**4.4**	**3.1**	**1.8**	**1.8**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.2**	3.7	7.1	6.9	6.7	6.7	5.7	4.1	**2.3**	**2.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.9**	**2.5**	6.6	10	10	11	9.1	6.4	3.6	3.7	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1.7**	**2.3**	6.3	8.3	8.2	8.3	6.9	4.9	**2.9**	3.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	13	21	26	67	429	2185	7243	*18e-3/1e5*	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.4**	**1.3**	11	15	18	24	24	20	12	21	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	4.3	16	30	37	39	39	33	23	13	14	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	37	38	27	20	19	21	20	16	9.4	10	Adap DE (F-AUC) [11]
DE (Uniform)	63	65	44	27	25	27	26	21	12	13	DE (Uniform) [10]
IPOP-aCMA-ES	**2.9**	**3.0**	**2.6**	**3.0**	**3.2**	**3.4**	**3.1**	**2.3**	**1.3**	**1.4**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**2.9**	3.1	**4.8**	**5.3**	**5.5**	**5.9**	**5.1**	**3.8**	**2.1**	**2.2**	IPOP-CMA-ES [23]
CMA+DE-MOS	10	10	7.1	8.9	14	14	12	8.5	4.7	4.7	CMA+DE-MOS [19]
NBC-CMA	4.0	4.0	6.2	13	14	15	13	9.1	5.2	5.2	NBC-CMA [22]
POEMS	155	171	1557	4721	*12e-1/3e5*	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	43	43	29	18	20	24	24	20	12	13	PM-AdapSS-DE [10, 11]
pPOEMS	5132	4450	3375	3894	9258	*17e-1/3e5*	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	329	343	222	241	519	1359	*12e-2/5e4*	.	.	.	Basic RCGA [25]
SPSA	8176	9420	*20e+5/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 13: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{13}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

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	3.2	8.5	33	101	138	175	937	1086	1223	1510	ERT_{best}/D
(1,2)-CMA-ES	11	10	20	25	41	87	47	63	*13e-3/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.8	5.2	13	12	24	36	33	62	55	93	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.5	4.7	4.6	6.9	23	37	49	130	116	94	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	10	9.5	13	29	41	115	36	*27e-3/1e4*	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.2	5.0	8.3	15	25	42	21	65	121	*46e-4/1e4*	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.4	4.0	6.4	10	16	28	8.0	18	36	*32e-5/1e4*	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.6**	**3.2**	**4.5**	6.6	11	26	21	30	56	*18e-4/1e4*	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.5	4.0	7.6	4.9	14	23	17	30	57	*10e-4/1e4*	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.5**	3.3	6.5	**4.8**	10	16	4.1	5.4	7.6	13	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**2.3**	**3.0**	4.9	6.0	**7.7**	13	3.3	3.6	5.2	18	(1+2ms)-CMA-ES [2]
Artif Bee Colony	25	41	25	73	627	3931	1555	*60e-3/1e5*	.	.	Artif Bee Colony [9]
avg NEWUOA	**2.1**	**1.8**	**1.5**	5.3	14	30	14	57	172	*67e-5/2e4*	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	6.4	6.5	6.8	7.6	37	125	108	256	556	*90e-5/1e5*	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	35	55	25	12	11	**11**	**2.4**	**2.4**	**2.5**	**2.5**	Adap DE (F-AUC) [11]
DE (Uniform)	57	90	43	20	19	19	4.1	4.1	4.2	4.2	DE (Uniform) [10]
IPOP-aCMA-ES	3.9	5.3	**3.6**	**3.4**	**3.7**	**3.4**	**0.80**	**0.98**	**1.3**	**1.3**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	3.5	5.3	6.5	**4.8**	**6.2**	**5.1**	**1.4**	**1.6**	**1.7**	**2.3**	IPOP-CMA-ES [23]
CMA+DE-MOS	16	18	10	9.1	12	12	**2.8**	**2.9**	3.2	3.0	CMA+DE-MOS [19]
NBC-CMA	6.0	7.6	4.7	15	29	24	5.7	7.4	9.3	45	NBC-CMA [22]
POEMS	98	201	6277	41616	*90e-1/3e5*	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	41	63	28	13	12	12	**2.6**	**2.6**	**2.6**	**2.6**	PM-AdapSS-DE [10, 11]
pPOEMS	104	223	938	2244	6207	24363	4562	*57e-2/3e5*	.	.	pPOEMS [18, 21]
Basic RCGA	19	112	232	296	825	1228	*28e-2/5e4*	.	.	.	Basic RCGA [25]
SPSA	76	2892	*29e+0/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 14: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}\ 2009}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	3.8	12	15	23	47	67	82	783	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	156	16	8.2	8.2	8.2	7.8	10	14	4.8	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	62	7.7	3.8	4.1	4.2	4.2	5.6	8.1	**2.0**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	41	6.0	3.1	3.3	3.5	3.6	4.9	6.6	**1.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	143	14	6.9	7.4	7.4	6.9	9.3	13	5.7	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	16	5.7	3.1	3.6	4.0	3.9	5.2	7.3	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	19	5.0	**2.8**	3.1	3.3	3.2	4.5	6.4	**1.4**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	16	3.8	**2.1**	**2.3**	**2.6**	**2.6**	3.5	**5.0**	**1.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	17	4.7	**2.6**	**2.9**	3.4	3.2	4.2	5.4	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	12	**2.9**	**1.9**	**2.3**	**2.5**	**2.2**	**3.3**	5.4	**1.2**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	13	**2.3**	**1.6**	**1.9**	**2.1**	**1.9**	**2.7**	**4.5**	**0.97**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**4.0**	18	18	28	53	3378	*10e-4/1e5*	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	38	**2.7**	**1.5**	**1.6**	**1.6**	**1.3**	**2.7**	9.3	26	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	26	159	10	4.6	5.2	5.7	6.2	11	22	4.8	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**4.5**	33	30	38	36	23	20	19	**2.8**	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	5.5	53	50	64	60	38	32	31	4.2	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	10	3.6	**2.7**	3.5	4.0	3.2	3.4	**3.9**	**0.67**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	13	3.7	**2.8**	3.6	4.2	3.9	4.7	6.0	**1.2**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	5.1	20	10	11	13	12	13	14	**2.3**	CMA+DE-MOS [19]
NBC-CMA	**1.1**	**3.5**	5.5	3.7	4.6	5.3	5.1	6.9	9.0	**1.7**	NBC-CMA [22]
POEMS	**1**	3152	98	65	123	165	131	1158	*27e-6/3e5*	.	POEMS [18]
PM-AdapSS-DE	**1**	5.1	43	34	43	40	25	21	20	**2.8**	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	743	102	72	143	423	353	443	4529	*78e-7/3e5*	pPOEMS [18, 21]
Basic RCGA	**1**	4.9	16	26	57	298	1502	*11e-4/5e4*	.	.	Basic RCGA [25]
SPSA	59	853	98	51	45	39	56	234	1207	*85e-7/1e5*	SPSA [14]

Table 15: 20-D, running time excess ERT/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$_{\text{best}}$/D	0.06	84	1519	7327	15577	15779	15996	16135	22471	22954	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	227	536	*15e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	114	13	*55e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	78	13	*54e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	258	1748	*15e+1/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	43	24	*65e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	28	8.5	*50e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	30	6.2	*53e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	58	27	*76e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	24	75	*83e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	20	52	*81e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	70	582	*84e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	56	116	*95e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	188	**1.3**	280	*14e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	18	43	474	*30e+0/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	**12**	55	979	*38e+0/1e5*	.	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	20	**1.3**	**0.82**	**1.1**	**0.71**	**0.72**	**0.72**	**0.73**	**0.53**	**0.54**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	25	**1.3**	**1.1**	**1.1**	**0.69**	**0.70**	**0.70**	**0.71**	**0.52**	**0.53**	IPOP-CMA-ES [23]
CMA+DE-MOS	35	**2.9**	**1.5**	**1.6**	**0.98**	**0.98**	**0.99**	**1.00**	**0.73**	**0.73**	CMA+DE-MOS [19]
NBC-CMA	21	17	*20e+0/1e4*	.	.	.	.	.	.	.	NBC-CMA [22]
POEMS	2565	21	*33e+0/3e5*	.	.	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**16**	19	*59e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	1958	69	*20e+0/3e5*	.	.	.	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	**13**	14	6.3	97	*50e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	8.91e5	16866	*16e+1/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 16: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ 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
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	69	1363	3851	6963	9397	9762	9889	11005	$\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1**	**1.1**	*31e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	153	*94e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.5**	191	*97e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	*33e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	141	*88e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	34	*61e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.4**	49	*55e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	124	*86e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.2**	31	*57e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.3**	15	*51e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	13	*39e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1.5**	3.6	*31e-1/2e4*	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1**	88	4.6	41	179	*55e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.2**	*15e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.1**	21496	*15e+0/1e5*	.	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1.5**	**2.8**	**1.1**	**0.88**	**0.76**	**0.80**	**0.81**	**0.82**	**0.76**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1.2**	**1.7**	**0.81**	**0.92**	**0.85**	**0.84**	**0.94**	**1.1**	**1.0**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.1**	**1.8**	**0.27**	**0.50**	**2.9**	**5.5**	**5.6**	**5.6**	**6.3**	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.1**	19	**1.8**	7.1	*15e-2/1e4*	.	.	.	.	NBC-CMA [22]
POEMS	**1**	69	14	**2.6**	508	*33e-2/3e5*	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	**1.3**	21677	*14e+0/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.3**	26	24	1098	*29e-2/3e5*	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	**1**	**1.1**	8.1	4.6	18	102	*12e-2/5e4*	.	.	.	Basic RCGA [25]
SPSA	**1**	8885	4463	*13e+0/1e5*	.	.	.	.	.	.	SPSA [14]

Table 17: 20-D, running time excess ERT/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$_{\text{best}}$/D	0.05	0.05	3.1	52	200	612	1534	2231	2814	4024	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	403	*53e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	13	8.6	2765	*19e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	10	6.7	2880	*20e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	15	462	*64e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	73	2771	*26e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	5.1	641	*22e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	7.1	6.1	1374	*16e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	3.3	59	*30e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.3**	53	*48e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1.2**	42	*46e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	34	*40e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**2.1**	**2.4**	*29e-1/4e4*	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	72	141	7.2	**1.2**	**1.1**	**1.2**	**1.1**	**2.1**	3.8	12	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.4**	23	13	6.6	3.4	**1.9**	**1.7**	**1.9**	5.5	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.3**	38	19	10	5.4	3.0	**2.8**	3.2	**2.8**	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1.3**	**2.3**	**0.89**	**0.50**	**1.3**	**0.82**	**0.71**	**0.83**	**0.87**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	**2.1**	**0.94**	**1.2**	**1.0**	**0.76**	**0.91**	**0.99**	**1.0**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.1**	11	8.2	**2.8**	**1.5**	**1.1**	**1.0**	**1.2**	**1.0**	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.1**	3.4	**1.2**	**1.1**	**1.3**	15	*10e-4/2e4*	.	.	NBC-CMA [22]
POEMS	**1**	691	98	27	126	188	299	1887	*21e-4/3e5*	.	POEMS [18]
PM-AdapSS-DE	**1**	**1.4**	23	13	6.6	3.4	**1.9**	**1.7**	**1.8**	18	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.3**	98	31	54	115	313	1911	*11e-4/3e5*	.	pPOEMS [18, 21]
Basic RCGA	**1.1**	**1.5**	6.1	13	31	23	17	32	*12e-5/5e4*	.	Basic RCGA [25]
SPSA	3.00e6	3.00e6	87351	*23e+2/1e5*	.	.	.	.	.	.	SPSA [14]

Table 18: 20-D, running time excess ERT/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$_{\text{best}}$/D	0.05	0.14	31	199	978	1428	3378	4977	6530	7326	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.1**	103	*18e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	45	143	*64e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	31	131	*73e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.4	115	*19e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	16	257	*82e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	10	67	*40e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	11	34	*54e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	20	302	*91e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	10	*15e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**3.7**	4700	*14e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	21	45792	*13e+0/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.3**	19	3217	*10e+0/6e4*	.	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	74	64	**1.4**	**0.97**	**1.1**	**2.0**	**2.2**	10	31	201	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1.1**	5.7	11	4.6	**1.7**	**1.8**	3.2	6.0	11	28	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	6.4	18	7.8	**2.8**	**2.9**	**1.7**	**1.5**	**1.5**	**1.6**	DE (Uniform) [10]
IPOP-aCMA-ES	**1.3**	7.5	**1.2**	**1.5**	**0.75**	**1.1**	**0.91**	**0.86**	**0.78**	**0.83**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	7.2	**1.1**	**1.8**	**1.1**	**1.5**	**0.97**	**1.2**	**1.0**	**1.1**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1.1**	4.9	4.0	**1.6**	**1.1**	**1.8**	**1.3**	**1.3**	**1.3**	**1.2**	CMA+DE-MOS [19]
NBC-CMA	**1.1**	**3.1**	**1.5**	**0.76**	**1.1**	35	*16e-3/2e4*	.	.	.	NBC-CMA [22]
POEMS	**2.4**	915	21	125	275	2948	*92e-3/3e5*	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	**4.4**	13	5.4	**1.9**	**1.9**	8.4	5.9	6.5	7.8	PM-AdapSS-DE [10, 11]
pPOEMS	**1.1**	487	21	51	106	1394	*33e-3/3e5*	.	.	.	pPOEMS [18, 21]
Basic RCGA	**1**	6.7	7.5	20	23	62	*16e-3/5e4*	.	.	.	Basic RCGA [25]
SPSA	5.50e6	2.86e6	*46e+2/1e5*	.	.	.	.	.	.	.	SPSA [14]

Table 19: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{19}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	0.05	0.05	0.05	17160	2.34e5	3.11e5	3.33e5	3.34e5	3.37e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	2312	*62e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	657	*27e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	409	*31e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	3531	*66e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	440	*24e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	256	1.42e6	*19e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	226	2.84e6	*16e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	334	2.82e6	*36e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	289	2.94e6	*18e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	851	*16e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	2292	*37e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**2.9**	**210**	8.03e6	*20e-1/1e5*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	37	118	412	44147	*33e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1.2**	1315	9.54e6	*31e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1.1**	2846	9.50e6	*29e-1/1e5*	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	**166**	**29179**	**0.63**	**0.46**	**0.43**	**0.43**	**0.44**	**0.44**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	**161**	**27333**	**0.71**	**0.45**	**0.38**	**0.41**	**0.41**	**0.41**	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1.1**	1233	**20554**	**2.9**	**3.2**	*47e-3/1e5*	.	.	.	CMA+DE-MOS [19]
NBC-CMA	**1**	**1.1**	255	*41e-1/2e4*	.	.	.	.	.	.	NBC-CMA [22]
POEMS	**1**	701	6058	6.15e6	*98e-2/3e5*	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	**1.1**	1839	*26e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1.2**	6256	1.44e6	*45e-2/3e5*	.	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	**1**	**1.2**	311	4.06e5	6.9	*23e-2/5e4*	.	.	.	.	Basic RCGA [25]
SPSA	116	413	5211	*39e-1/1e5*	.	.	.	.	.	.	SPSA [14]

Table 20: 20-D, running time excess ERT/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$_{\text{best}}$/D	2.8	3.5	4.1	2307	1.55e5	2.76e5	2.77e5	2.78e5	2.80e5	2.82e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	15	13	13	30	*12e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	7.5	6.9	6.5	30	*11e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.0	5.6	5.3	*11e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	14	12	11	15	*12e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.9	5.6	5.1	61	*12e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.0	4.6	4.6	31	*11e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.8	3.6	3.5	11	*11e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.7	4.4	4.4	7.3	*10e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.5**	**3.5**	**3.3**	20	*12e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**3.2**	**3.1**	**2.9**	18	*11e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	20	18	16	**0.12**	*23e-2/1e5*	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1.8**	**1.4**	**1.3**	107	*12e-1/2e4*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	10	8.7	7.9	*20e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	43	42	40	643	*15e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	76	77	76	*17e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	4.5	4.7	4.7	3.2	**0.83**	**0.58**	**0.58**	**0.59**	**0.59**	**0.60**	IPOP-aCMA-ES [17]
IPOP-CMA-ES	4.9	4.8	4.6	6.4	**0.65**	**0.57**	**0.57**	**0.58**	**0.58**	**0.58**	IPOP-CMA-ES [23]
CMA+DE-MOS	23	23	21	**0.97**	**0.08**	**0.05**	**0.06**	**0.06**	**0.06**	**0.07**	CMA+DE-MOS [19]
NBC-CMA	8.2	8.0	7.3	91	*12e-1/1e4*	.	.	.	.	.	NBC-CMA [22]
POEMS	129	124	118	**2.4**	8.6	*30e-2/3e5*	.	.	.	.	POEMS [18]
PM-AdapSS-DE	51	51	46	*22e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	128	128	134	**1.8**	*24e-2/3e5*	.	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	10	10	10	*22e-1/5e4*	.	.	.	.	.	.	Basic RCGA [25]
SPSA	14	15	16	*22e-1/1e5*	.	.	.	.	.	.	SPSA [14]

Table 21: 20-D, running time excess ERT/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$_{\text{best}}$/D	0.05	0.05	28	327	705	716	732	754	778	879	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	13	8.3	10	10	11	11	10	9.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	5.9	**3.3**	3.6	3.5	3.4	3.4	3.3	**2.9**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	7.2	4.9	4.0	4.0	3.9	3.8	3.7	3.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	6.8	9.3	9.1	9.0	8.9	8.6	8.4	7.4	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.1**	3.6	4.7	4.6	4.5	4.4	4.3	3.8	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.9	4.7	4.8	4.7	4.7	4.5	4.4	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.4**	**1.7**	**1.8**	**1.8**	**1.7**	**1.7**	**1.6**	**1.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	3.8	**2.3**	**2.6**	**2.6**	**2.5**	**2.4**	**2.4**	**2.1**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	3.5	5.5	5.4	5.3	5.2	5.1	4.9	4.4	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	3.3	4.6	3.9	3.8	3.8	3.7	3.6	3.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	5.0	22	25	26	27	30	35	85	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	3.2	5.7	**3.5**	**3.5**	**3.4**	**3.3**	**3.3**	**2.9**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**2.7**	106	**1.9**	211	217	214	210	204	197	175	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1**	12	613	568	560	547	531	515	456	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	21	461	568	560	548	532	516	457	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	**1.9**	81	66	65	64	62	60	54	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	3.7	139	110	108	106	103	100	88	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1**	11	262	285	281	275	268	260	231	CMA+DE-MOS [19]
NBC-CMA	**1**	**1**	84	69	59	58	56	55	53	47	NBC-CMA [22]
POEMS	**1**	**1**	11053	5970	*47e-1/3e5*	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	**1**	12	351	568	560	547	531	515	456	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1**	137	1172	956	1186	1160	1127	1093	974	pPOEMS [18, 21]
Basic RCGA	**1**	**1**	119	103	85	85	86	97	96	87	Basic RCGA [25]
SPSA	3.5	251	597	1240	*18e-1/1e5*	.	.	.	.	.	SPSA [14]

Table 22: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{22}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	0.05	23	279	1175	1208	1247	1307	1342	6740	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	10	27	124	120	116	111	108	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	8.8	13	21	20	20	19	18	3.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	8.2	13	17	16	16	15	15	**3.0**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	35	22	37	36	35	34	33	6.6	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	18	6.6	**11**	**11**	**11**	**10**	**10**	**2.0**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**5.6**	7.7	16	16	15	15	14	**2.9**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	9.0	**5.0**	28	27	26	25	24	4.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**4.7**	13	27	26	25	24	24	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	17	9.4	15	14	14	13	13	**2.6**	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	10	**4.4**	**10**	**10**	**9.2**	**8.8**	**8.6**	**1.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	10	47	77	578	*44e-3/1e5*	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	**2.0**	**5.6**	**14**	**13**	**13**	**12**	**12**	**2.4**	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1.9**	104	676	546	*20e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1**	675	1436	*26e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	1580	989	*20e-1/1e5*	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	462	264	*20e-1/6e4*	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	445	287	*20e-1/6e4*	.	.	.	.	.	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1**	536	797	677	659	638	610	594	118	CMA+DE-MOS [19]
NBC-CMA	**1**	**1**	323	350	*73e-1/1e4*	.	.	.	.	.	NBC-CMA [22]
POEMS	**1**	**1**	6453	6994	*73e-1/3e5*	.	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	**1**	1572	2332	*51e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1**	2022	1439	1680	1634	1584	1513	1474	294	pPOEMS [18, 21]
Basic RCGA	**1**	**1**	1186	1200	*73e-1/5e4*	.	.	.	.	.	Basic RCGA [25]
SPSA	7.6	240	1073	1439	*26e-1/1e5*	.	.	.	.	.	SPSA [14]

Table 23: 20-D, running time excess ERT/ERT$_{\text{best 2009}}$ on f_{23}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	0.05	0.16	81	3373	18276	24442	25501	40551	41895	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	341	1833	*27e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	32	138	*97e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	50	387	*14e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	192	*34e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	45	107	*86e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	19	45	*38e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	17	122	*66e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	22	138	*81e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	18	**8.1**	*40e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [8]
(1+2ms)-CMA-ES	**1**	**1**	7.9	**6.0**	*38e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.1**	78	*64e-2/1e5*	.	.	.	.	.	Artif Bee Colony [9]
avg NEWUOA	**1**	**1**	15	**4.7**	*20e-2/2e4*	.	.	.	.	.	avg NEWUOA [24]
CMA-EGS (IPOP,r1)	**1.4**	66	55	*15e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [13]
Adap DE (F-AUC)	**1**	**1**	**1.5**	2385	440	*11e-1/1e5*	.	.	.	.	Adap DE (F-AUC) [11]
DE (Uniform)	**1**	**1**	3.0	6010	*13e-1/1e5*	.	.	.	.	.	DE (Uniform) [10]
IPOP-aCMA-ES	**1**	**1**	4.1	22809	*15e-1/1e5*	.	.	.	.	.	IPOP-aCMA-ES [17]
IPOP-CMA-ES	**1**	**1**	4.3	23082	*14e-1/1e5*	.	.	.	.	.	IPOP-CMA-ES [23]
CMA+DE-MOS	**1**	**1**	**2.1**	56	**8.9**	**14**	*29e-3/1e5*	.	.	.	CMA+DE-MOS [19]
NBC-CMA	**1**	**1**	**1.9**	*18e-1/1e4*	.	.	.	.	.	.	NBC-CMA [22]
POEMS	**1**	**1**	29	48	**47**	*90e-3/3e5*	.	.	.	.	POEMS [18]
PM-AdapSS-DE	**1**	**1**	**1.5**	8493	*13e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [10, 11]
pPOEMS	**1**	**1**	4.9	320	**36**	*60e-3/3e5*	.	.	.	.	pPOEMS [18, 21]
Basic RCGA	**1**	**1**	**2.7**	572	106	*26e-2/5e4*	.	.	.	.	Basic RCGA [25]
SPSA	4.7	868	2320	*16e-1/1e5*	.	.	.	.	.	.	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.