Comparison tables: BBOB 2010 function testbed with BBOB 2009 as reference in 40-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 [10, 6]. The experimental set-up is described in [9].

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 [2]) 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 [9] 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: 40-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	0.03	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**3.2**	**7.1**	**11**	**15**	**19**	**23**	**27**	**31**	**39**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**2.7**	**6.1**	**10**	**13**	**17**	**20**	**24**	**27**	**35**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	139	7.7	15	22	30	37	44	52	59	74	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	65	205	383	594	823	1086	1353	1573	2016	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	113	376	642	898	1164	1442	1709	1982	2502	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	3.3	10	16	21	28	34	40	46	58	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	3.3	9.4	16	21	27	33	39	45	57	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	18	50	58	65	76	106	126	134	162	CMA+DE-MOS [12]
NBC-CMA	**1**	4.7	12	19	26	32	38	45	52	66	NBC-CMA [14]
PM-AdapSS-DE	**1**	75	212	364	524	694	871	1063	1252	1643	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	12	72	1089	4155	5781	7051	8001	8768	9840	Basic RCGA [17]
SPSA	478	11	15	20	24	29	33	37	41	50	SPSA [8]

Table 2: 40-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	20	20	20	20	20	20	20	20	20	20	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	24	45	59	70	**76**	**80**	**82**	**84**	**85**	**86**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**19**	**34**	**45**	**55**	**61**	**64**	**68**	**69**	**70**	**71**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**7.5**	**23**	**36**	**62**	79	99	117	135	145	179	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	80	104	118	129	135	140	144	145	146	148	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	48	77	115	149	176	201	230	257	284	335	Adap DE (F-AUC) [5]
DE (Uniform)	87	119	152	180	209	237	265	293	321	376	DE (Uniform) [4]
IPOP-aCMA-ES	**19**	**29**	**37**	**43**	**48**	**51**	**54**	**55**	**57**	**58**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	29	46	61	70	77	82	85	87	88	90	IPOP-CMA-ES [15]
CMA+DE-MOS	42	72	95	110	120	130	138	142	147	155	CMA+DE-MOS [12]
NBC-CMA	42	83	121	146	165	182	194	202	213	226	NBC-CMA [14]
PM-AdapSS-DE	52	78	111	155	185	216	246	271	294	339	PM-AdapSS-DE [4, 5]
Basic RCGA	467	2454	*67e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	75834	*26e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [8]

Table 3: 40-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	5.6	18	388	390	390	391	391	391	391	391	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.4**	*32e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	3.9	*31e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	21	*38e+1/1e4*	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	3.1	725	*56e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	18	*22e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	30	*23e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**1.1**	**9.1**	*15e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**0.99**	**5.2**	*13e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	4.8	**27**	**46**	**54**	**56**	**58**	**59**	**61**	**63**	**66**	CMA+DE-MOS [12]
NBC-CMA	**1.5**	58	*72e+0/8e3*	.	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	22	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**2.5**	618	*14e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	72023	*10e+3/1e5*	.	.	.	.	.	.	.	.	SPSA [8]

Table 4: 40-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	11	134	388	390	391	392	393	393	393	7060	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	24	*49e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	10	*51e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	7.5	*36e+1/3e4*	.	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	**2.4**	405	*75e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	20	*23e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	39	*22e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**0.98**	**3.1**	*30e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.2**	**3.5**	*30e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	3.7	**5.6**	**116**	**118**	**152**	**154**	**155**	**156**	**157**	**8.9**	CMA+DE-MOS [12]
NBC-CMA	**1.3**	40	*90e+0/7e3*	.	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	22	243	*60e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**2.3**	78	*50e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	1411	*74e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [8]

Table 5: 40-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	0.03	2.1	2.5	2.9	3.0	3.0	3.0	3.0	3.0	3.0	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**1.6**	**2.8**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1**	3.1	**3.1**	**3.2**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	15	3.3	4.4	4.1	4.1	4.1	4.1	4.1	4.1	4.1	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	44	72	71	71	70	70	70	70	70	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	69	96	89	86	86	86	86	86	86	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	3.2	4.8	4.6	4.5	4.5	4.5	4.5	4.5	4.5	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	3.2	4.9	4.7	4.7	4.6	4.6	4.7	4.7	4.7	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	29	41	36	35	35	35	35	35	35	CMA+DE-MOS [12]
NBC-CMA	**1**	*14e+1/8e3*	.	.	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	91	135	123	119	119	119	119	119	119	PM-AdapSS-DE [4, 5]
Basic RCGA	**1.1**	265	3925	5230	6166	6845	7299	7583	32644	*11e-6/5e4*	Basic RCGA [17]
SPSA	25	**2.7**	5.2	5.1	5.0	5.0	5.0	5.0	5.0	5.0	SPSA [8]

Table 6: 40-D, running time excess ERT/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$_{\text{best}}$/D	4.9	46	88	138	179	237	288	332	375	481	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**3.6**	10	298	*17e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**2.7**	5.6	1605	*13e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	**4.7**	**1.5**	**1.3**	**1.3**	**1.2**	**1.2**	**1.1**	**1.2**	**1.1**	**1.1**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	20	4.5	4.0	3.7	3.8	3.7	4.0	4.4	5.1	12	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	82	33	32	30	32	30	30	30	30	30	Adap DE (F-AUC) [5]
DE (Uniform)	245	70	58	51	50	46	44	45	45	43	DE (Uniform) [4]
IPOP-aCMA-ES	5.2	**1.7**	**1.5**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	6.3	**1.8**	**1.7**	**1.5**	**1.5**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	21	5.3	4.4	3.7	3.4	3.1	**3.0**	**2.9**	**2.8**	**2.7**	CMA+DE-MOS [12]
NBC-CMA	63	59	32	21	16	13	11	9.4	8.8	7.5	NBC-CMA [14]
PM-AdapSS-DE	120	41	38	35	35	34	35	36	38	39	PM-AdapSS-DE [4, 5]
Basic RCGA	35	107	128	107	105	88	79	73	147	1505	Basic RCGA [17]
SPSA	9975	*42e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [8]

Table 7: 40-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$_{\text{best}}$/D	2.6	31	267	446	1026	1657	1657	1657	1657	1704	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**2.0**	99	48	*85e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1.5**	53	35	*84e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	**2.6**	5.4	*24e+0/4e4*	.	.	.	.	.	.	.	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	6.7	**1.7**	308	*97e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	25	11	3.3	279	636	406	406	406	406	395	Adap DE (F-AUC) [5]
DE (Uniform)	37	20	5.2	**5.5**	**3.3**	**2.8**	**2.8**	**2.8**	**2.8**	**2.9**	DE (Uniform) [4]
IPOP-aCMA-ES	**1.6**	**1.00**	**1.2**	**2.5**	**1.5**	**0.99**	**0.99**	**0.99**	**0.99**	**0.97**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.6**	**1.1**	**1.6**	**5.5**	**2.6**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	IPOP-CMA-ES [15]
CMA+DE-MOS	8.2	3.5	**1.9**	8.2	4.1	**2.7**	**2.7**	**2.7**	**2.7**	**2.6**	CMA+DE-MOS [12]
NBC-CMA	**2.4**	**1.2**	**1.6**	*49e-1/8e3*	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	32	12	3.0	20	67	57	57	57	57	55	PM-AdapSS-DE [4, 5]
Basic RCGA	5.1	6.2	29	*43e-1/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	18	1650	*94e+0/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 8: 40-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	13	40	177	266	275	282	286	289	293	299	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.5**	**1.9**	8.4	11	11	11	11	11	11	11	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1.2**	**1.0**	**6.9**	8.1	8.4	8.4	8.4	8.5	8.5	8.5	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.9**	**1.7**	**1.2**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	3.1	**2.8**	8.4	10	11	11	11	11	11	11	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	38	25	78	128	129	129	130	130	130	130	Adap DE (F-AUC) [5]
DE (Uniform)	75	43	107	119	122	122	123	123	124	125	DE (Uniform) [4]
IPOP-aCMA-ES	**1.9**	**1.3**	**5.2**	**4.5**	**4.6**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**2.0**	**1.8**	6.9	**6.3**	**6.5**	**6.5**	**6.5**	**6.6**	**6.6**	**6.5**	IPOP-CMA-ES [15]
CMA+DE-MOS	8.2	3.2	18	17	17	17	17	17	17	17	CMA+DE-MOS [12]
NBC-CMA	**2.3**	**1.6**	13	14	15	16	16	16	16	16	NBC-CMA [14]
PM-AdapSS-DE	39	24	156	139	144	146	148	149	150	150	PM-AdapSS-DE [4, 5]
Basic RCGA	14	133	*36e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	99	1950	*39e+0/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 9: 40-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	0.03	35	153	325	333	337	341	345	348	354	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**662**	**1.3**	9.3	6.8	7.1	7.2	7.2	7.3	7.3	7.4	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**588**	**1.1**	**7.4**	6.0	6.2	6.3	6.3	6.4	6.4	6.5	(1+2ms)-CMA-ES [1]
avg NEWUOA	**851**	**1.3**	**1.4**	**1.1**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	1663	3.3	11	9.1	9.4	9.4	9.5	9.5	10	10	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	14031	19	97	61	64	66	67	68	69	70	Adap DE (F-AUC) [5]
DE (Uniform)	34294	46	121	75	78	80	81	82	83	85	DE (Uniform) [4]
IPOP-aCMA-ES	921	**1.4**	**6.3**	**5.8**	**5.9**	**6.0**	**6.0**	**6.0**	**6.0**	**6.0**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	878	**1.4**	8.1	**5.7**	**5.9**	**5.9**	**6.0**	**6.0**	**6.0**	**6.0**	IPOP-CMA-ES [15]
CMA+DE-MOS	3026	**2.9**	20	14	14	14	14	14	14	14	CMA+DE-MOS [12]
NBC-CMA	1082	**1.9**	15	14	19	19	19	19	20	19	NBC-CMA [14]
PM-AdapSS-DE	15292	22	192	142	146	149	150	151	151	152	PM-AdapSS-DE [4, 5]
Basic RCGA	2065	202	*36e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	4.48e5	11672	*23e+1/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 10: 40-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	165	402	647	759	920	1289	1400	1516	1628	1771	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**2.8**	**2.0**	**1.7**	**1.7**	**1.6**	**1.2**	**1.2**	**1.1**	**1.0**	**0.98**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**2.1**	**1.6**	**1.4**	**1.4**	**1.3**	**0.98**	**0.95**	**0.90**	**0.85**	**0.79**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.3**	**1.6**	**1.4**	**1.9**	**1.8**	**1.7**	**1.8**	**1.9**	**1.9**	**2.1**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	8.2	4.7	3.5	3.3	**2.9**	**2.1**	**2.0**	**1.9**	**1.8**	**1.7**	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	5.8	3.9	3.6	4.0	4.0	3.3	3.4	3.4	3.5	3.8	Adap DE (F-AUC) [5]
DE (Uniform)	10	5.7	4.5	4.5	4.4	3.5	3.7	3.7	3.8	4.2	DE (Uniform) [4]
IPOP-aCMA-ES	**2.2**	**1.4**	**1.1**	**1.1**	**1.0**	**0.80**	**0.77**	**0.74**	**0.70**	**0.67**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	3.2	**2.3**	**1.9**	**1.9**	**1.7**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	IPOP-CMA-ES [15]
CMA+DE-MOS	6.2	4.7	4.0	4.0	3.6	**2.7**	**2.6**	**2.4**	**2.3**	**2.2**	CMA+DE-MOS [12]
NBC-CMA	5.7	4.3	3.7	4.0	3.7	**2.9**	**2.8**	**2.7**	**2.6**	**2.6**	NBC-CMA [14]
PM-AdapSS-DE	6.3	3.7	3.2	3.5	3.6	3.0	3.2	3.4	3.5	3.7	PM-AdapSS-DE [4, 5]
Basic RCGA	*99e+2/5e4*	.	.	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	*77e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [8]

Table 11: 40-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	1.8	23	59	121	292	633	744	858	974	1205	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	16	**9.5**	7.8	5.9	3.3	**2.0**	**2.1**	**2.2**	**2.3**	**2.4**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	20	**7.6**	**6.0**	**4.6**	**2.7**	**1.6**	**1.7**	**1.8**	**1.8**	**1.9**	(1+2ms)-CMA-ES [1]
avg NEWUOA	3.4	**5.5**	**3.9**	**2.8**	**1.5**	**0.89**	**0.91**	**0.90**	**0.91**	**0.90**	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	11999	1197	557	361	181	235	922	1658	1464	1184	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**3.1**	14	11	9.2	5.5	3.3	3.5	3.6	3.8	3.9	Adap DE (F-AUC) [5]
DE (Uniform)	3.6	26	19	14	7.6	4.4	4.5	4.5	4.6	4.6	DE (Uniform) [4]
IPOP-aCMA-ES	43	12	**5.0**	**2.7**	**1.2**	**0.58**	**0.51**	**0.46**	**0.43**	**0.37**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	71	34	15	7.7	3.4	**1.6**	**1.4**	**1.3**	**1.2**	**0.98**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.7**	60	29	16	7.2	3.5	3.1	**2.8**	**2.6**	**2.2**	CMA+DE-MOS [12]
NBC-CMA	**2.3**	*25e+1/8e3*	.	.	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	10	18	12	8.6	4.8	**2.9**	**3.0**	3.1	3.2	3.3	PM-AdapSS-DE [4, 5]
Basic RCGA	3.5	9247	12154	*14e+1/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	*25e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [8]

Table 12: 40-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	27	31	104	186	229	269	329	526	569	630	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.8**	**1.9**	**1.9**	3.2	4.4	4.8	4.9	3.6	4.1	4.4	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1.6**	**2.1**	**1.7**	**2.5**	**3.6**	**4.0**	**4.2**	**3.2**	**3.5**	**4.1**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**2.1**	8.4	21	24	31	38	42	32	39	86	avg NEWUOA [16]
CMA-EGS (IPOP,r1)	3.8	5.9	5.8	7.4	9.3	10	9.4	7.0	7.9	9.3	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	83	87	41	36	40	40	39	28	30	31	Adap DE (F-AUC) [5]
DE (Uniform)	119	122	41	29	35	38	39	30	32	34	DE (Uniform) [4]
IPOP-aCMA-ES	**2.8**	**2.9**	**1.1**	**1.3**	**1.7**	**1.9**	**1.8**	**1.3**	**1.3**	**1.3**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**2.7**	**2.8**	**2.3**	**2.5**	**2.8**	**2.9**	**2.8**	**2.0**	**2.1**	**2.2**	IPOP-CMA-ES [15]
CMA+DE-MOS	9.0	8.5	4.3	6.6	7.0	7.5	6.8	4.7	4.9	5.0	CMA+DE-MOS [12]
NBC-CMA	3.1	3.2	4.2	5.9	7.0	8.8	9.1	6.5	6.6	6.7	NBC-CMA [14]
PM-AdapSS-DE	73	75	26	30	37	43	48	40	45	51	PM-AdapSS-DE [4, 5]
Basic RCGA	555	543	194	172	328	2683	*78e-3/5e4*	.	.	.	Basic RCGA [17]
SPSA	53521	*20e+6/1e5*	.	.	.	.	.	.	.	.	SPSA [8]

Table 13: 40-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$_{\text{best}}$/D	3.7	10	51	173	218	297	1798	2098	2462	2985	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**3.2**	**3.4**	3.1	5.4	10	25	10	8.6	14	23	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**2.9**	**2.9**	**2.8**	**3.2**	**7.2**	**14**	7.0	16	29	*82e-5/1e4*	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	7.6	6.4	**2.7**	4.2	37	215	780	669	570	*67e-4/1e5*	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	78	105	37	17	18	17	3.3	3.3	3.2	3.3	Adap DE (F-AUC) [5]
DE (Uniform)	145	168	54	22	23	20	4.0	3.9	3.8	3.9	DE (Uniform) [4]
IPOP-aCMA-ES	**4.4**	**4.7**	**1.6**	**2.1**	**4.7**	**5.9**	**1.3**	**1.4**	**1.6**	**1.9**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	4.8	5.1	**2.8**	**3.5**	**6.6**	**10**	**2.3**	**2.9**	**2.7**	**2.9**	IPOP-CMA-ES [15]
CMA+DE-MOS	26	14	6.4	7.0	11	15	**3.1**	3.4	**3.2**	3.6	CMA+DE-MOS [12]
NBC-CMA	5.6	5.7	**2.5**	5.0	16	26	10	25	*63e-4/7e3*	.	NBC-CMA [14]
PM-AdapSS-DE	85	102	34	15	16	15	3.1	**3.2**	3.2	**3.3**	PM-AdapSS-DE [4, 5]
Basic RCGA	29	733	319	177	724	1169	402	*20e-2/5e4*	.	.	Basic RCGA [17]
SPSA	75	4772	14665	8631	6843	*52e+0/1e5*	.	.	.	.	SPSA [8]

Table 14: 40-D, running time excess ERT/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
ERT$_{\text{best}}$/D	0.03	0.04	7.6	15	19	28	55	91	121	1443	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**36**	**1.7**	**1.6**	**1.8**	**2.1**	**2.0**	**3.0**	**5.1**	**1.0**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	57	**1.7**	**1.5**	**1.7**	**1.9**	**1.9**	**2.7**	**4.2**	**0.85**	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	85	316	5.4	3.8	4.3	5.1	6.3	10	19	4.3	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	128	38	46	63	68	47	37	34	4.0	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	74	72	80	99	95	61	45	40	4.5	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**31**	**2.5**	**2.4**	**3.0**	**3.7**	**3.4**	**3.5**	**3.9**	**0.57**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**32**	**2.7**	**2.5**	3.0	3.9	4.3	5.2	6.7	**1.1**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	118	12	7.8	7.7	10	12	16	19	**2.7**	CMA+DE-MOS [12]
NBC-CMA	**1.1**	44	**2.9**	**2.6**	3.2	4.4	5.3	8.1	11	**1.8**	NBC-CMA [14]
PM-AdapSS-DE	**1.1**	90	44	47	59	60	41	32	30	3.7	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	51	12	28	366	484	1403	*10e-4/5e4*	.	.	Basic RCGA [17]
SPSA	195	1670	58	41	36	33	41	130	6065	*22e-6/1e5*	SPSA [8]

Table 15: 40-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	4.8	190	4699	19671	26216	26587	26959	27330	27694	28439	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.8**	*35e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	4.8	*32e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	3.4	46	*48e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	22	*23e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	39	*23e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**1.3**	**1.1**	**0.76**	**0.55**	**0.64**	**0.64**	**0.65**	**0.65**	**0.66**	**0.67**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1.3**	**1.2**	**0.80**	**0.60**	**0.70**	**0.70**	**0.71**	**0.71**	**0.72**	**0.73**	IPOP-CMA-ES [15]
CMA+DE-MOS	7.5	**1.8**	**1.9**	**1.1**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	CMA+DE-MOS [12]
NBC-CMA	**1.8**	57	*12e+1/8e3*	.	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	28	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	4.0	156	76	*13e+0/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	14116	*52e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [8]

Table 16: 40-D, running time excess ERT/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
ERT$_{\text{best}}$/D	0.03	0.03	131	1803	8037	17771	35172	49254	49707	50540	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1.1**	346	*11e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**1**	146	*10e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	**1**	202	5.9	48	*82e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	**1**	*27e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	**1**	*27e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**1.1**	**0.89**	**0.91**	**0.91**	**0.74**	**0.46**	**0.78**	**0.96**	**1.0**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.2**	**0.94**	**1.2**	**1.0**	**0.71**	**0.46**	**0.38**	**0.38**	**0.39**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.2**	**0.88**	**0.17**	**0.97**	**2.0**	**5.7**	**5.5**	**5.5**	**5.4**	CMA+DE-MOS [12]
NBC-CMA	**1**	**1.1**	413	30	*27e+0/7e3*	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	**1.1**	*24e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**1.2**	19	5.7	4.2	8.8	*37e-3/5e4*	.	.	.	Basic RCGA [17]
SPSA	**1**	24706	1031	*12e+0/1e5*	.	.	.	.	.	.	SPSA [8]

Table 17: 40-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	0.03	0.03	10	106	354	874	1299	2216	3331	6637	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	58	*68e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	5.3	234	*68e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	168	304	**2.8**	**0.68**	**1.2**	**1.5**	**2.0**	**2.1**	3.7	7.0	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	**1.2**	18	12	13	322	*15e-3/1e5*	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	**1.4**	41	20	13	8.3	8.0	17	17	34	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**2.8**	**1.0**	**0.51**	**1.1**	**1.1**	**1.2**	**1.0**	**1.00**	**0.79**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1.7**	**1.0**	**0.50**	**1.0**	**1.1**	**1.1**	**0.99**	**0.99**	**0.84**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.3**	8.0	**1.4**	**1.0**	**0.87**	**1.2**	**1.3**	**1.2**	**1.1**	CMA+DE-MOS [12]
NBC-CMA	**1**	**1.2**	**1.0**	**0.77**	**1.1**	60	*24e-3/8e3*	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	**1.4**	21	13	30	82	505	*74e-4/1e5*	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**1.2**	**2.0**	7.0	32	18	15	18	104	*40e-6/5e4*	Basic RCGA [17]
SPSA	1.60e7	1.60e7	*10e+3/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 18: 40-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	0.03	0.05	36	425	1177	3179	4685	6422	16776	23736	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	38	*26e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	60	*25e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	177	217	**1.4**	**0.49**	**1.4**	**1.1**	**1.3**	**3.0**	3.1	6.8	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	25	19	5.2	18	442	*48e-3/1e5*	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	**1.1**	22	35	7.5	4.8	**2.7**	**2.5**	6.5	13	28	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	25	**1.0**	**0.62**	**0.98**	**0.69**	**0.70**	**0.88**	**0.49**	**0.51**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	29	**0.97**	**0.66**	**1.1**	**0.85**	**0.86**	**1.0**	**0.74**	**1.4**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1.1**	17	3.5	**0.84**	**1.1**	**0.95**	**1.1**	**1.4**	**1.0**	**1.1**	CMA+DE-MOS [12]
NBC-CMA	**1**	**15**	**1.3**	**0.58**	*18e-2/7e3*	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	**8.0**	20	4.5	3.4	29	*90e-4/1e5*	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**10**	6.6	19	12	5.8	14	*95e-5/5e4*	.	.	Basic RCGA [17]
SPSA	5.60e7	2.80e7	*12e+3/1e5*	.	.	.	.	.	.	.	SPSA [8]

Table 19: 40-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	0.03	0.03	0.03	0.03	34806	4.21e5	6.38e5	1.13e6	1.13e6	1.14e6	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	5510	*41e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**1**	7249	*38e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	64	204	934	1.22e5	*45e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	**1**	5034	*50e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	**1**	13186	*51e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**1**	**458**	**49920**	**0.57**	**0.38**	**0.33**	**0.20**	**0.20**	**0.21**	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	**442**	**67521**	**0.64**	**0.38**	**0.31**	**0.21**	**0.21**	**0.22**	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1.1**	3026	**64253**	**2.6**	*66e-3/1e5*	.	.	.	.	CMA+DE-MOS [12]
NBC-CMA	**1**	**1**	624	*65e-1/8e3*	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	**1.1**	6161	*47e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**1.1**	**416**	1.87e6	*44e-2/5e4*	.	.	.	.	.	Basic RCGA [17]
SPSA	185	581	14521	*55e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 20: 40-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	3.1	4.3	5.5	3284	4.03e6	∞	∞	∞	∞	∞	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**3.5**	**3.0**	**2.6**	*13e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**3.4**	**2.9**	**2.5**	*14e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	10	8.3	7.0	*19e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	70	59	52	*30e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	154	134	116	*29e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**5.1**	**4.3**	**3.7**	**8.4**	**0.19**	*12e-2/3e5*	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	5.5	4.9	4.1	**15**	**0.33**	*14e-2/3e5*	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	25	20	16	**3.8**	**0.01**	**1.84e6**	**1.95e6**	**2.04e6**	**2.26e6**	**2.50e6**	CMA+DE-MOS [12]
NBC-CMA	6.6	6.0	5.1	*14e-1/7e3*	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	79	69	58	*30e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	8.2	8.9	8.5	*23e-1/5e4*	.	.	.	.	.	.	Basic RCGA [17]
SPSA	11	10	10	*22e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 21: 40-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	0.03	0.03	26	529	2518	2525	2533	2542	2548	2560	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	**5.0**	**1.9**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**1**	**2.4**	**2.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	20	224	14	107	62	62	62	62	62	62	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	**1**	293	758	258	258	257	256	256	255	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	**1**	36	287	557	555	553	552	550	548	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**1**	9.2	161	118	118	118	117	117	116	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	10	166	83	83	83	83	82	82	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	15	224	101	101	101	100	100	100	CMA+DE-MOS [12]
NBC-CMA	**1**	**1**	73	199	42	42	41	41	41	41	NBC-CMA [14]
PM-AdapSS-DE	**1**	**1**	295	1231	*21e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**1**	**7.7**	**89**	**31**	**33**	**33**	**34**	**34**	**35**	Basic RCGA [17]
SPSA	188	541	880	2650	*25e-1/1e5*	.	.	.	.	.	SPSA [8]

Table 22: 40-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	0.03	0.03	77	886	16210	16230	16250	16273	16297	16351	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	**9.1**	**6.2**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**1**	**1.9**	**4.9**	**9.0**	**8.9**	**8.9**	**8.9**	**8.9**	**8.9**	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	21	205	326	226	*20e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	**1**	478	312	*26e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	**1**	661	453	*73e-1/1e5*	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**1**	295	174	*20e-1/7e4*	.	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	367	133	*20e-1/8e4*	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	490	205	*20e-1/1e5*	.	.	.	.	.	CMA+DE-MOS [12]
NBC-CMA	**1**	**1**	**49**	**23**	*51e-1/7e3*	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	**1**	654	1581	*56e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**1**	335	101	*20e-1/5e4*	.	.	.	.	.	Basic RCGA [17]
SPSA	183	630	769	737	*51e-1/1e5*	.	.	.	.	.	SPSA [8]

Table 23: 40-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	0.03	0.03	0.18	298	1886	16522	31967	78995	81054	84011	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	9.0	**10**	*65e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**1**	**1**	9.0	**12**	*69e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	21	156	61	*26e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	**1**	**1**	**1.7**	*26e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	**1**	**1**	**0.75**	*28e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	**1**	**1**	8.3	*25e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	**1**	**1**	7.9	*26e-1/1e5*	.	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	**1**	**1**	**1.1**	**41**	**18**	**19**	**46**	*19e-3/1e5*	.	.	CMA+DE-MOS [12]
NBC-CMA	**1**	**1**	**1.8**	*30e-1/7e3*	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	**1**	**1**	**1.9**	*26e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**1**	**1**	**1.2**	149	**40**	**44**	*77e-3/5e4*	.	.	.	Basic RCGA [17]
SPSA	235	1095	2014	*26e-1/1e5*	.	.	.	.	.	.	SPSA [8]

Table 24: 40-D, running time excess ERT/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$_{\text{best}}$/D	0.03	967	1.46e5	2.45e6	7.50e6	7.51e6	7.51e6	7.51e6	7.51e6	7.51e6	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	230	*33e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [3]
(1+2ms)-CMA-ES	**193**	*35e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	1051	**13**	**4.6**	*51e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [7]
Adap DE (F-AUC)	3020	*24e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [5]
DE (Uniform)	5239	*26e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [4]
IPOP-aCMA-ES	209	**13**	*41e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [11]
IPOP-CMA-ES	221	26	*41e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [15]
CMA+DE-MOS	1061	**2.5**	**2.4**	*28e+0/1e5*	.	.	.	.	.	.	CMA+DE-MOS [12]
NBC-CMA	**102**	*35e+1/7e3*	.	.	.	.	.	.	.	.	NBC-CMA [14]
PM-AdapSS-DE	2988	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [4, 5]
Basic RCGA	**167**	48	*59e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [17]
SPSA	*22e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [8]

References

[1] 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 [13], pages 1543–1550.

[2] 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.

[3] 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.

[4] 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 [13], pages 1527–1534.

[5] 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 [13], pages 1535–1542.

[6] 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.

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

[8] Steffen Finck and Hans-Georg Beyer. Benchmarking SPSA on BBOB-2010 noiseless function testbed. In Pelikan and Branke [13], pages 1657–1664.

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

[10] 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.

[11] Nikolaus Hansen and Raymond Ros. Benchmarking a weighted negative covariance matrix update on the BBOB-2010 noiseless testbed. In Pelikan and Branke [13], pages 1673–1680.

[12] Antonio LaTorre, Santiago Muelas, and José María Peña. Benchmarking a MOS-based algorithm on the BBOB-2010 noiseless function testbed. In Pelikan and Branke [13], pages 1649–1656.

[13] 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.

[14] Mike Preuss. Niching the CMA-ES via nearest-better clustering. In Pelikan and Branke [13], pages 1711–1718.

[15] Raymond Ros. Black-box optimization benchmarking the IPOP-CMA-ES on the noiseless testbed: comparison to the BIPOP-CMA-ES. In Pelikan and Branke [13], pages 1503–1510.

[16] Raymond Ros. Comparison of NEWUOA with different numbers of interpolation points on the BBOB noiseless testbed. In Pelikan and Branke [13], pages 1487–1494.

[17] Thanh-Do Tran and Gang-Gyoo Jin. Real-coded genetic algorithm benchmarked on noiseless black-box optimization testbed. In Pelikan and Branke [13], pages 1731–1738.