Comparison tables: BBOB 2010 function testbed in 40-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 [9, 5]. The experimental set-up is described in [8].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm. Consequently, the best (smallest) value is 1 and the value 1 appears in each column at least once. See [8] 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 $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_1, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.03	5.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	**1**	**1.2**	**2.2**	**3.4**	**4.7**	**6.0**	**7.2**	**8.5**	**10**	**12**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**1.9**	**3.0**	**4.1**	**5.2**	**6.3**	**7.4**	**8.5**	**11**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	139	**2.8**	4.7	7.0	9.3	12	14	16	18	23	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	24	64	119	185	257	339	422	491	629	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	42	117	200	280	363	450	533	618	781	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1.2**	3.0	4.9	6.6	8.6	10	12	14	18	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1.2**	**2.9**	4.9	6.7	8.5	10	12	14	18	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	6.8	16	18	20	24	33	39	42	50	CMA+DE-MOS [11]
NBC-CMA	**1**	**1.7**	3.8	5.9	8.0	10	12	14	16	21	NBC-CMA [13]
PM-AdapSS-DE	**1**	28	66	114	164	216	272	332	391	513	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	4.5	22	340	1297	1804	2200	2496	2736	3070	Basic RCGA [16]
SPSA	478	3.9	4.7	6.1	7.6	8.9	10	12	13	15	SPSA [7]

Table 2: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_2, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	149	454	708	855	949	1019	1072	1103	1136	1172	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	3.2	**2.0**	**1.7**	**1.6**	**1.6**	**1.6**	**1.5**	**1.5**	**1.5**	**1.5**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**2.5**	**1.5**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.2**	**1.2**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1**	**1**	**1**	**1.4**	**1.7**	**1.9**	**2.2**	**2.4**	**2.6**	3.1	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	11	4.5	3.3	3.0	**2.8**	**2.7**	**2.7**	**2.6**	**2.6**	**2.5**	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	6.4	3.4	3.2	3.5	3.7	3.9	4.3	4.7	5.0	5.7	Adap DE (F-AUC) [4]
DE (Uniform)	12	5.2	4.3	4.2	4.4	4.6	4.9	5.3	5.7	6.4	DE (Uniform) [3]
IPOP-aCMA-ES	**2.5**	**1.3**	**1.0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	3.8	**2.0**	**1.7**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.5**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.6	3.1	**2.7**	**2.6**	**2.5**	**2.6**	**2.6**	**2.6**	**2.6**	**2.7**	CMA+DE-MOS [11]
NBC-CMA	5.5	3.6	3.4	3.4	3.5	3.6	3.6	3.7	3.8	3.9	NBC-CMA [13]
PM-AdapSS-DE	6.9	3.4	3.1	3.6	3.9	4.2	4.6	4.9	5.2	5.8	PM-AdapSS-DE [3, 4]
Basic RCGA	62	107	*67e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	10071	*26e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [7]

Table 3: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_3, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	5.5	96	17818	21192	21900	22547	23212	23890	24566	25903	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.4**	*32e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	3.9	*31e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	21	*38e+1/1e4*	.	.	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	3.1	138	*56e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	18	*22e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	30	*23e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1.2**	**1.7**	*15e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1**	*13e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [14]
CMA+DE-MOS	4.8	**5.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	CMA+DE-MOS [11]
NBC-CMA	**1.5**	11	*72e+0/8e3*	.	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	22	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**2.5**	118	*14e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	72567	*10e+3/1e5*	.	.	.	.	.	.	.	.	SPSA [7]

Table 4: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_4, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	11	414	45183	45955	59640	60194	60757	61351	61942	63108	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	25	*49e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	10	*51e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	7.7	*36e+1/3e4*	.	.	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	**2.5**	131	*75e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	20	*23e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	40	*22e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	*30e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.2**	**1.1**	*30e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [14]
CMA+DE-MOS	3.8	**1.8**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	CMA+DE-MOS [11]
NBC-CMA	**1.3**	13	*90e+0/7e3*	.	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	22	79	*60e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**2.4**	25	*50e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	1435	*74e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [7]

Table 5: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_5, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	3.5	6.7	7.6	7.7	7.7	7.7	7.7	7.7	7.7	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1.0**	**1**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**1.0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1**	**1.9**	**1.1**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	15	**2.0**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	26	26	27	28	27	27	27	27	27	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	42	35	34	34	34	34	34	34	34	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1.9**	**1.7**	**1.8**	**1.8**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1.9**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1.1**	18	15	14	14	13	13	13	13	13	CMA+DE-MOS [11]
NBC-CMA	**1**	*14e+1/8e3*	.	.	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	55	49	47	47	46	46	46	46	46	PM-AdapSS-DE [3, 4]
Basic RCGA	**1.1**	161	1428	2000	2409	2668	2845	2955	12722	*11e-6/5e4*	Basic RCGA [16]
SPSA	25	**1.6**	**1.9**	**1.9**	**2.0**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	SPSA [7]

Table 6: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_6, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	13	67	117	173	219	276	320	386	428	541	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.3**	6.6	223	*17e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	3.9	1200	*13e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.7**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	7.4	3.1	**3.0**	**2.9**	3.1	3.2	3.6	3.8	4.5	11	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	30	23	24	24	26	26	27	26	27	27	Adap DE (F-AUC) [4]
DE (Uniform)	89	48	43	40	41	39	40	38	39	38	DE (Uniform) [3]
IPOP-aCMA-ES	**1.9**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.2**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**2.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [14]
CMA+DE-MOS	7.6	3.6	3.3	**2.9**	**2.8**	**2.7**	**2.7**	**2.5**	**2.5**	**2.4**	CMA+DE-MOS [11]
NBC-CMA	23	41	24	17	13	11	10	8.1	7.7	6.6	NBC-CMA [13]
PM-AdapSS-DE	44	28	29	28	29	29	31	31	33	35	PM-AdapSS-DE [3, 4]
Basic RCGA	13	74	96	85	86	76	71	63	128	1337	Basic RCGA [16]
SPSA	3638	*42e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [7]

Table 7: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_7, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	4.0	30	311	1101	1558	1649	1649	1649	1649	1657	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.3**	100	42	*85e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	53	30	*84e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.7**	5.4	*24e+0/4e4*	.	.	.	.	.	.	.	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	4.4	**1.7**	265	*97e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	16	11	**2.8**	113	419	408	408	408	408	406	Adap DE (F-AUC) [4]
DE (Uniform)	25	21	4.5	**2.2**	**2.2**	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	DE (Uniform) [3]
IPOP-aCMA-ES	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.1**	**1.1**	**1.4**	**2.2**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.4	3.5	**1.7**	3.3	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	CMA+DE-MOS [11]
NBC-CMA	**1.6**	**1.3**	**1.4**	*49e-1/8e3*	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	21	12	**2.6**	8.1	44	57	57	57	57	57	PM-AdapSS-DE [3, 4]
Basic RCGA	3.4	6.2	25	*43e-1/5e4*	.	.	.	.	.	.	Basic RCGA [16]
SPSA	12	1658	*94e+0/1e5*	.	.	.	.	.	.	.	SPSA [7]

Table 8: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_8, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	16	42	215	436	453	464	471	474	476	480	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.2**	**1.9**	6.9	6.8	6.9	6.9	6.9	6.9	6.9	7.0	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**5.7**	5.0	5.1	5.1	5.1	5.2	5.2	5.3	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.5**	**1.7**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	**2.5**	**2.7**	6.9	6.4	6.5	6.5	6.5	6.5	6.6	6.7	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	31	24	65	78	78	78	79	79	80	81	Adap DE (F-AUC) [4]
DE (Uniform)	61	41	88	73	74	74	75	75	76	78	DE (Uniform) [3]
IPOP-aCMA-ES	**1.5**	**1.3**	**4.3**	**2.8**	**2.8**	**2.8**	**2.9**	**2.9**	**2.9**	**2.9**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.6**	**1.7**	5.7	**3.9**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	6.6	3.0	15	10	10	10	10	10	10	10	CMA+DE-MOS [11]
NBC-CMA	**1.8**	**1.6**	10	8.8	9.3	10	10	10	10	10	NBC-CMA [13]
PM-AdapSS-DE	32	23	128	85	88	89	90	91	92	93	PM-AdapSS-DE [3, 4]
Basic RCGA	12	128	*36e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	80	1881	*39e+0/1e5*	.	.	.	.	.	.	.	SPSA [7]

Table 9: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_9, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	15	38	207	363	381	391	398	401	404	408	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.1**	**1.2**	6.9	6.1	6.2	6.2	6.2	6.3	6.3	6.4	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**5.5**	5.3	5.4	5.4	5.4	5.5	5.5	5.6	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.4**	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	**2.8**	3.1	8.0	8.2	8.2	8.1	8.1	8.2	8.2	8.3	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	24	18	72	55	56	57	57	58	59	61	Adap DE (F-AUC) [4]
DE (Uniform)	58	43	89	67	68	69	69	70	71	73	DE (Uniform) [3]
IPOP-aCMA-ES	**1.6**	**1.3**	**4.7**	**5.2**	**5.2**	**5.2**	**5.2**	**5.2**	**5.2**	**5.2**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.5**	**1.3**	6.0	**5.1**	**5.1**	**5.1**	**5.1**	**5.1**	**5.2**	**5.2**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.1	**2.7**	15	13	12	12	12	12	12	12	CMA+DE-MOS [11]
NBC-CMA	**1.8**	**1.8**	11	13	16	17	17	17	17	17	NBC-CMA [13]
PM-AdapSS-DE	26	20	143	127	128	128	129	129	130	132	PM-AdapSS-DE [3, 4]
Basic RCGA	3.5	187	*36e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	762	10818	*23e+1/1e5*	.	.	.	.	.	.	.	SPSA [7]

Table 10: 40-D, running time excess ERT/$\mathrm{ERT_{best}}$ on f_{10}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT_{best}}$/D	222	555	729	853	956	1027	1084	1117	1146	1180	$\mathrm{ERT_{best}}$/D
(1+1)-CMA-ES	**2.1**	**1.4**	**1.5**	**1.6**	**1.6**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1.6**	**1.1**	**1.2**	**1.2**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1**	**1.2**	**1.2**	**1.7**	**1.8**	**2.2**	**2.4**	**2.6**	**2.8**	3.2	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	6.1	3.4	3.1	**2.9**	**2.8**	**2.7**	**2.6**	**2.6**	**2.6**	**2.5**	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	4.3	**2.8**	3.2	3.6	3.8	4.1	4.3	4.7	5.0	5.7	Adap DE (F-AUC) [4]
DE (Uniform)	7.7	4.1	4.0	4.0	4.2	4.4	4.7	5.1	5.5	6.2	DE (Uniform) [3]
IPOP-aCMA-ES	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**2.4**	**1.7**	**1.7**	**1.7**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.5**	IPOP-CMA-ES [14]
CMA+DE-MOS	4.6	3.4	3.6	3.5	3.4	3.3	3.3	3.3	3.3	3.3	CMA+DE-MOS [11]
NBC-CMA	4.3	3.1	3.3	3.5	3.5	3.6	3.6	3.7	3.7	3.8	NBC-CMA [13]
PM-AdapSS-DE	4.7	**2.7**	**2.8**	3.1	3.4	3.8	4.2	4.6	4.9	5.6	PM-AdapSS-DE [3, 4]
Basic RCGA	*99e+2/5e4*	.	.	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	*77e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [7]

Table 11: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{11}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.0	123	233	323	344	364	381	398	414	446	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	9.3	**1.7**	**2.0**	**2.2**	**2.8**	3.5	4.1	4.8	5.5	6.5	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	12	**1.4**	**1.5**	**1.7**	**2.3**	**2.9**	3.3	3.8	4.3	5.0	(1+2ms)-CMA-ES [1]
avg NEWUOA	**2.0**	**1**	**1**	**1.1**	**1.3**	**1.5**	**1.8**	**1.9**	**2.1**	**2.4**	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	7178	219	142	136	153	408	1799	3576	3443	3201	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1.8**	**2.6**	**2.9**	3.4	4.6	5.7	6.8	7.8	9.0	11	Adap DE (F-AUC) [4]
DE (Uniform)	**2.2**	4.7	4.9	5.2	6.5	7.7	8.7	10	11	12	DE (Uniform) [3]
IPOP-aCMA-ES	26	**2.1**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	42	6.2	3.7	**2.9**	**2.9**	**2.8**	**2.8**	**2.8**	**2.7**	**2.7**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	11	7.5	6.0	6.1	6.1	6.1	6.1	6.1	5.9	CMA+DE-MOS [11]
NBC-CMA	**1.3**	*25e+1/8e3*	.	.	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	5.8	3.2	3.0	3.2	4.1	5.0	5.9	6.6	7.4	8.8	PM-AdapSS-DE [3, 4]
Basic RCGA	**2.1**	1693	3092	*14e+1/5e4*	.	.	.	.	.	.	Basic RCGA [16]
SPSA	*25e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [7]

Table 12: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{12}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	43	59	112	239	400	498	590	669	733	831	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.1**	**1**	**1.8**	**2.5**	**2.5**	**2.6**	**2.7**	**2.9**	3.2	3.3	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1.1**	**1.6**	**2.0**	**2.1**	**2.2**	**2.3**	**2.5**	**2.7**	**3.1**	(1+2ms)-CMA-ES [1]
avg NEWUOA	**1.3**	4.4	20	19	18	21	23	25	30	65	avg NEWUOA [15]
CMA-EGS (IPOP,r1)	**2.3**	3.1	5.3	5.8	5.3	5.2	5.2	5.5	6.2	7.1	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	51	45	38	28	23	22	21	22	23	24	Adap DE (F-AUC) [4]
DE (Uniform)	73	63	38	23	20	21	22	24	25	26	DE (Uniform) [3]
IPOP-aCMA-ES	**1.7**	**1.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.7**	**1.5**	**2.1**	**2.0**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.5	4.4	4.0	5.1	4.0	4.0	3.8	3.7	3.8	3.8	CMA+DE-MOS [11]
NBC-CMA	**1.9**	**1.7**	3.9	4.6	4.0	4.7	5.1	5.1	5.1	5.1	NBC-CMA [13]
PM-AdapSS-DE	45	39	24	24	21	23	27	31	35	39	PM-AdapSS-DE [3, 4]
Basic RCGA	340	283	180	134	188	1447	*78e-3/5e4*	.	.	.	Basic RCGA [16]
SPSA	32734	*20e+6/1e5*	.	.	.	.	.	.	.	.	SPSA [7]

Table 13: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{13}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	11	28	80	362	1031	1742	2333	2907	3901	5599	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.1**	**1.2**	**2.0**	**2.6**	**2.2**	4.3	7.6	6.2	8.6	13	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**1.8**	**1.5**	**1.5**	**2.3**	5.4	12	18	*82e-5/1e4*	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	**2.6**	**2.2**	**1.7**	**2.0**	7.9	37	601	483	360	*67e-4/1e5*	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	27	36	24	8.1	3.8	**2.8**	**2.6**	**2.4**	**2.0**	**1.8**	Adap DE (F-AUC) [4]
DE (Uniform)	51	58	34	11	4.8	3.5	3.1	**2.8**	**2.4**	**2.1**	DE (Uniform) [3]
IPOP-aCMA-ES	**1.5**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.7**	**1.8**	**1.8**	**1.7**	**1.4**	**1.8**	**1.7**	**2.1**	**1.7**	**1.5**	IPOP-CMA-ES [14]
CMA+DE-MOS	9.0	4.9	4.0	3.3	**2.3**	**2.5**	**2.4**	**2.4**	**2.0**	**1.9**	CMA+DE-MOS [11]
NBC-CMA	**1.9**	**2.0**	**1.6**	**2.4**	3.3	4.5	8.0	18	*63e-4/7e3*	.	NBC-CMA [13]
PM-AdapSS-DE	29	35	22	7.1	3.4	**2.6**	**2.4**	**2.3**	**2.0**	**1.7**	PM-AdapSS-DE [3, 4]
Basic RCGA	10	252	202	85	153	199	310	*20e-2/5e4*	.	.	Basic RCGA [16]
SPSA	26	1638	9281	4121	1449	*52e+0/1e5*	.	.	.	.	SPSA [7]

Table 14: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{14}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	1.3	13	23	33	52	104	244	466	827	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1.2**	**1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.3**	**1.8**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1.8**	**1.0**	**1**	**1**	**1**	**1**	**1**	**1.1**	**1.5**	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	85	10	3.1	**2.6**	**2.5**	**2.7**	3.3	3.6	4.9	7.6	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	4.1	22	30	37	36	25	14	8.9	6.9	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**2.4**	42	53	58	50	32	17	10	7.8	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	**1.5**	**1.6**	**1.8**	**2.0**	**1.8**	**1.3**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1.0**	**1.6**	**1.7**	**1.8**	**2.1**	**2.3**	**1.9**	**1.7**	**2.0**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1.1**	3.7	7.2	5.2	4.5	5.5	6.2	5.9	5.0	4.7	CMA+DE-MOS [11]
NBC-CMA	**1.1**	**1.4**	**1.7**	**1.7**	**1.9**	**2.3**	**2.8**	3.0	**2.8**	3.2	NBC-CMA [13]
PM-AdapSS-DE	**1.1**	**2.9**	26	31	35	32	22	12	7.8	6.4	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1.6**	7.1	19	216	255	745	*10e-4/5e4*	.	.	Basic RCGA [16]
SPSA	195	53	34	27	21	18	22	48	1569	*22e-6/1e5*	SPSA [7]

Table 15: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{15}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	6.1	212	3554	10753	16752	17132	17512	17884	18256	18997	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.4**	*35e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	3.7	*32e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	**2.7**	41	*48e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	17	*23e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	31	*23e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	5.9	**1.7**	**2.5**	**2.0**	**2.0**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	CMA+DE-MOS [11]
NBC-CMA	**1.4**	51	*12e+1/8e3*	.	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	22	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	3.1	140	101	*13e+0/5e4*	.	.	.	.	.	.	Basic RCGA [16]
SPSA	11021	*52e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [7]

Table 16: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{16}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	0.03	116	316	7298	12683	16039	18579	18992	19718	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1.1**	391	*11e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	165	*10e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	**1**	202	6.7	275	*82e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	**1**	*27e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**1**	*27e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1.1**	**1.0**	**5.2**	**1**	**1.0**	**1.0**	**2.1**	**2.5**	**2.6**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1.2**	**1.1**	**7.1**	**1.1**	**1**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.2**	**1**	**1**	**1.1**	**2.8**	**13**	**15**	**14**	**14**	CMA+DE-MOS [11]
NBC-CMA	**1**	**1.1**	468	172	*27e+0/7e3*	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1.1**	*24e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1.2**	21	33	4.6	12	*37e-3/5e4*	.	.	.	Basic RCGA [16]
SPSA	**1**	24706	1168	*12e+0/1e5*	.	.	.	.	.	.	SPSA [7]

Table 17: 40-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_{17}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.03	0.03	10	53	356	759	1436	2185	3294	5251	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	**1**	**1**	58	*68e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	5.3	234	*68e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	168	304	**2.8**	**1.3**	**1.2**	**1.7**	**1.8**	**2.2**	3.7	8.9	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	**1.2**	18	25	13	371	*15e-3/1e5*	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**1.4**	41	40	12	10	7.2	18	17	43	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**2.8**	**1**	**1.0**	**1.1**	**1.3**	**1.1**	**1.0**	**1.0**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1.7**	**1.0**	**1**	**1**	**1.3**	**1**	**1**	**1**	**1.1**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.3**	7.9	**2.8**	**1.0**	**1**	**1.1**	**1.4**	**1.2**	**1.4**	CMA+DE-MOS [11]
NBC-CMA	**1**	**1.2**	**1.0**	**1.5**	**1.1**	69	*24e-3/8e3*	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1.4**	21	25	29	95	457	*74e-4/1e5*	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1.2**	**2.0**	14	31	21	13	18	106	*40e-6/5e4*	Basic RCGA [16]
SPSA	1.60e7	1.60e7	*10e+3/1e5*	.	.	.	.	.	.	.	SPSA [7]

Table 18: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{18}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	0.40	35	210	1156	2180	3270	5652	8266	12096	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	4.7	*26e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	7.5	*25e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	177	27	**1.5**	**1**	**1.4**	**1.6**	**1.9**	3.4	6.3	13	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	3.1	20	11	18	644	*48e-3/1e5*	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	**1.1**	**2.7**	36	15	4.9	3.9	3.5	7.4	27	56	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	3.2	**1.0**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	3.7	**1**	**1.3**	**1.1**	**1.2**	**1.2**	**1.2**	**1.5**	**2.7**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1.1**	**2.2**	3.7	**1.7**	**1.1**	**1.4**	**1.6**	**1.6**	**2.1**	**2.2**	CMA+DE-MOS [11]
NBC-CMA	**1**	**1.9**	**1.3**	**1.2**	*18e-2/7e3*	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1**	20	9.1	3.5	43	*90e-4/1e5*	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1.2**	6.8	38	13	8.5	20	*95e-5/5e4*	.	.	Basic RCGA [16]
SPSA	5.60e7	3.49e6	*12e+3/1e5*	.	.	.	.	.	.	.	SPSA [7]

Table 19: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{19}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	0.03	10	1248	19975	1.59e5	1.96e5	2.30e5	2.32e5	2.36e5	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	13	*41e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	17	*38e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	64	204	**2.2**	**2.4**	*45e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	**1**	12	*50e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**1**	32	*51e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	**1.1**	**1**	**1**	**1.0**	**1.1**	**1**	**1**	**1**	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1**	**1.1**	**1.4**	**1.1**	**1**	**1**	**1.0**	**1.0**	**1.0**	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1.1**	7.3	**1.3**	**4.5**	*66e-3/1e5*	.	.	.	.	CMA+DE-MOS [11]
NBC-CMA	**1**	**1**	**1.5**	*65e-1/8e3*	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1.1**	15	*47e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1.1**	**1**	38	*44e-2/5e4*	.	.	.	.	.	Basic RCGA [16]
SPSA	185	581	35	*55e-1/1e5*	.	.	.	.	.	.	SPSA [7]

Table 20: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{20}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	11	12	14	12340	38080	45886	48748	51019	56452	62619	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1.0**	**1.0**	**1.1**	*13e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**1**	*14e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	**2.9**	**2.9**	**2.8**	*19e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	20	20	21	*30e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	45	47	47	*29e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1.5**	**1.5**	**1.5**	**2.2**	**20**	*12e-2/3e5*	.	.	.	.	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1.6**	**1.7**	**1.7**	**3.9**	**35**	*14e-2/3e5*	.	.	.	.	IPOP-CMA-ES [14]
CMA+DE-MOS	7.4	6.8	6.4	**1**	**1**	**1**	**1**	**1**	**1**	**1**	CMA+DE-MOS [11]
NBC-CMA	**1.9**	**2.1**	**2.1**	*14e-1/7e3*	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	23	24	24	*30e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**2.4**	3.1	3.4	*23e-1/5e4*	.	.	.	.	.	.	Basic RCGA [16]
SPSA	3.2	3.5	3.9	*22e-1/1e5*	.	.	.	.	.	.	SPSA [7]

Table 21: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{21}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

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	62	985	2435	2442	2448	2455	2461	2474	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	**2.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**1**	**1.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	20	224	6.1	57	64	64	64	64	64	64	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	**1**	124	407	267	267	266	265	265	264	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**1**	15	154	575	574	573	571	570	567	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	3.9	86	122	122	122	121	121	120	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1**	4.4	89	86	86	86	85	85	85	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	6.4	120	105	104	104	104	104	103	CMA+DE-MOS [11]
NBC-CMA	**1**	**1**	31	107	43	43	43	43	43	42	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1**	124	660	*21e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1**	**3.3**	**48**	**32**	**34**	**34**	**35**	**35**	**36**	Basic RCGA [16]
SPSA	188	541	371	1422	*25e-1/1e5*	.	.	.	.	.	SPSA [7]

Table 22: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{22}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	0.03	149	4334	32572	32594	32619	32645	32665	32709	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	**4.7**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	**1**	**1**	**4.5**	**4.5**	**4.4**	**4.4**	**4.4**	**4.4**	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	21	205	170	46	*20e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	**1**	248	64	*26e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**1**	344	93	*73e-1/1e5*	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	153	36	*20e-1/7e4*	.	.	.	.	.	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1**	191	27	*20e-1/8e4*	.	.	.	.	.	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	254	42	*20e-1/1e5*	.	.	.	.	.	CMA+DE-MOS [11]
NBC-CMA	**1**	**1**	**25**	**4.8**	*51e-1/7e3*	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1**	340	323	*56e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1**	174	21	*20e-1/5e4*	.	.	.	.	.	Basic RCGA [16]
SPSA	183	630	399	151	*51e-1/1e5*	.	.	.	.	.	SPSA [7]

Table 23: 40-D, running time excess ERT/ERT_{best} on f_{23}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.03	0.13	3041	33513	3.22e5	1.46e6	∞	∞	∞	ERT_{best}/D
(1+1)-CMA-ES	**1**	**1**	12	**1**	*65e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1**	**1**	12	**1.2**	*69e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	21	156	82	*26e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	**1**	**1**	**2.2**	*26e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	**1**	**1**	**1**	*28e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**1**	**1**	11	*25e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**1**	**1**	11	*26e-1/1e5*	.	.	.	.	.	.	IPOP-CMA-ES [14]
CMA+DE-MOS	**1**	**1**	**1.5**	**4.0**	**1**	**1**	**1**	*19e-3/1e5*	.	.	CMA+DE-MOS [11]
NBC-CMA	**1**	**1**	**2.5**	*30e-1/7e3*	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	**1**	**1**	**2.5**	*26e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1**	**1**	**1.6**	15	**2.3**	**2.2**	*77e-3/5e4*	.	.	.	Basic RCGA [16]
SPSA	235	1095	2694	*26e-1/1e5*	.	.	.	.	.	.	SPSA [7]

Table 24: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{24}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	2.6	2378	3.44e5	∞	∞	∞	∞	∞	∞	∞	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**2.2**	*33e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
(1+2ms)-CMA-ES	**1.9**	*35e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [1]
CMA-EGS (IPOP,r1)	10	**5.1**	**2.0**	*51e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [6]
Adap DE (F-AUC)	30	*24e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [4]
DE (Uniform)	51	*26e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [3]
IPOP-aCMA-ES	**2.0**	**5.1**	*41e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [10]
IPOP-CMA-ES	**2.2**	11	*41e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [14]
CMA+DE-MOS	10	**1**	**1**	*28e+0/1e5*	.	.	.	.	.	.	CMA+DE-MOS [11]
NBC-CMA	**1**	*35e+1/7e3*	.	.	.	.	.	.	.	.	NBC-CMA [13]
PM-AdapSS-DE	29	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [3, 4]
Basic RCGA	**1.6**	19	*59e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [16]
SPSA	*22e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [7]

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