Comparison tables: BBOB 2010 noisy 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 [7, 3]. The experimental set-up is described in [6].

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 [6] 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$_{\text{best}}$ on f_{101}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

101 Sphere moderate Gauss

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	8.8	18	26	32	39	47	54	61	76	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	736	11	10	8.7	7.5	6.7	6.0	5.6	5.3	4.8	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1.3**	**1.4**	**1.5**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1.1**	**1.3**	**1.4**	**1.5**	**1.5**	**1.5**	**1.6**	**1.6**	**1.6**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	4.5	5.8	4.7	4.2	4.2	5.1	4.9	4.6	4.7	CMA+DE-MOS [9]
Basic RCGA	**1**	3.0	8.5	86	261	306	310	306	297	270	Basic RCGA [12]
SPSA	536	35	*52e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 2: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{102}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

102 Sphere moderate unif

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	8.8	21	30	38	48	58	68	82	111	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	686	11	8.4	7.4	6.4	5.5	5.0	4.6	4.1	3.5	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1.2**	**1.1**	**1.2**	**1.3**	**1.3**	**1.3**	**1.3**	**1.2**	**1.2**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1.0**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	5.8	5.0	4.1	3.6	3.4	4.2	3.8	3.4	3.4	CMA+DE-MOS [9]
Basic RCGA	**1**	**2.8**	7.2	74	226	251	252	243	221	184	Basic RCGA [12]
SPSA	488	882	*78e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 3: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{103}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

103 Sphere moderate Cauchy

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	9.0	19	26	34	41	49	56	64	80	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.4**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	739	10	9.4	9.0	7.7	6.7	6.1	5.8	5.8	5.9	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1.0**	**1.1**	**1.4**	**1.4**	**1.5**	**1.6**	**1.7**	**1.7**	**1.8**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1.2**	**1.4**	**1.4**	**1.5**	**1.6**	**1.7**	**1.7**	**1.7**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	4.2	5.4	4.6	4.1	4.4	5.2	4.9	5.2	5.3	CMA+DE-MOS [9]
Basic RCGA	**1**	**2.8**	7.5	97	534	500	466	432	398	343	Basic RCGA [12]
SPSA	864	24	23	28	31	82	322	*52e-5/1e5*	.	.	SPSA [5]

Table 4: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{104}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

104 Rosenbrock moderate Gauss

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	101	25643	27893	28622	29029	29287	29518	29735	30167	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.2**	*32e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	5.9	**1.9**	*25e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.3**	**1.0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.3**	**1**	**2.9**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	IPOP-CMA-ES [11]
CMA+DE-MOS	5.3	72	*38e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	8.7	51	*38e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	22	*27e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [5]

Table 5: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{105}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

105 Rosenbrock moderate unif

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	21	84	69232	74593	76229	77140	77843	78534	79214	80631	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	3.7	*40e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	5.9	**2.7**	*34e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.3**	**1.9**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	IPOP-CMA-ES [11]
CMA+DE-MOS	5.0	**1.6**	*38e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	8.5	69	*38e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	26	*27e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [5]

Table 6: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{106}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

106 Rosenbrock moderate Cauchy

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	48	938	1484	1569	1603	1634	1654	1672	1705	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	5.6	4.0	22	37	36	35	42	75	125	167	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.3**	**1.4**	**1.5**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.2**	**1**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.1**	**2.1**	**2.0**	IPOP-CMA-ES [11]
CMA+DE-MOS	5.3	3.1	7.3	6.9	7.2	7.4	7.5	7.6	7.6	7.7	CMA+DE-MOS [9]
Basic RCGA	9.4	112	*37e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	72	5868	*25e+1/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 7: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{107}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

107 Sphere Gauss

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	254	1095	1387	1723	2048	2323	2653	2957	3632	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	*24e+1/1e4*	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	738	**1**	**1.3**	**2.0**	**2.5**	**2.9**	**3.3**	**3.3**	**3.7**	**4.3**	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**2.0**	**1.1**	**1.3**	**1.3**	**1.7**	**2.2**	**2.2**	**2.9**	**2.6**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	214	1354	1070	*57e+0/1e5*	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**2.0**	14	13	14	16	15	14	18	18	Basic RCGA [12]
SPSA	476	2597	*14e+1/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 8: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{108}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

108 Sphere unif

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	1667	4706	10659	17859	24926	34943	45832	58275	92191	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	*25e+1/1e4*	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	29020	**2.8**	**3.2**	**3.2**	**3.8**	**4.7**	**21**	*78e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1.3**	**1.3**	**1.7**	**1.6**	**1.7**	**2.1**	**2.3**	**2.2**	**1.9**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	402	*15e+1/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	22	*92e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	27994	**2.8**	*20e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 9: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{109}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

109 Sphere Cauchy

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	8.3	20	31	42	56	69	82	94	121	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.4**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	689	11	9.0	7.4	6.4	*38e-3/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1.1**	**1.2**	**1.3**	**1.6**	**1.8**	**1.9**	**2.0**	**2.1**	**2.2**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1.1**	**1.3**	**1.6**	**1.8**	**1.9**	**2.0**	**2.1**	**2.1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	4.8	5.3	4.1	5.7	5.2	5.9	6.2	6.1	6.4	CMA+DE-MOS [9]
Basic RCGA	**1**	3.2	8.7	297	346	319	288	265	242	204	Basic RCGA [12]
SPSA	683	28	396	1849	33291	*82e-2/1e5*	.	.	.	.	SPSA [5]

Table 10: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{110}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

110 Rosenbrock Gauss

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	337	2177	∞	∞	∞	∞	∞	∞	∞	∞	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	*32e+4/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	344	186	*12e+2/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.5**	**1**	*37e+0/1e6*	.	.	.	.	.	.	.	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.7**	**1.0**	*37e+0/9e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [11]
CMA+DE-MOS	174	340	*47e+1/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**5.0**	*51e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	830	*17e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [5]

Table 11: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{111}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

111 Rosenbrock unif

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	2264	10316	∞	∞	∞	∞	∞	∞	∞	∞	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	*29e+4/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	*97e+3/1e5*	.	.	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1.2**	*38e+0/1e6*	.	.	.	.	.	.	.	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.0**	**1**	*38e+0/1e6*	.	.	.	.	.	.	.	IPOP-CMA-ES [11]
CMA+DE-MOS	*39e+3/1e5*	.	.	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**10**	*63e+1/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	31	*77e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [5]

Table 12: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{112}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

112 Rosenbrock Cauchy

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	22	43	1815	3253	3424	3514	3566	3610	3652	3728	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	5.8	4.5	*38e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.1**	**1.4**	**2.3**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.1**	**1**	**2.4**	**2.1**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	IPOP-CMA-ES [11]
CMA+DE-MOS	4.8	3.4	5.6	4.1	4.2	4.1	4.1	4.1	4.1	4.0	CMA+DE-MOS [9]
Basic RCGA	8.2	136	*37e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	51	3186	*10e+1/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 13: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{113}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

113 Step-ellipsoid Gauss

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	53	1014	5897	15017	17513	19075	19075	19075	19075	19155	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	*17e+2/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	**2.2**	**1.2**	8.1	*52e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**2.1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**2.5**	**1**	**1.4**	**2.6**	**2.8**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	IPOP-CMA-ES [11]
CMA+DE-MOS	7.6	238	*11e+1/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**2.2**	**5.8**	*70e-1/5e4*	.	.	.	.	.	.	Basic RCGA [12]
SPSA	3.0	*21e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [5]

Table 14: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{114}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

114 Step-ellipsoid unif

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	191	5188	21852	67746	87251	1.31e5	1.31e5	1.31e5	1.31e5	1.32e5	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	*16e+2/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	23	**4.3**	**66**	*25e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**3.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**3.7**	**1.0**	**1.1**	**1.8**	**1.9**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	IPOP-CMA-ES [11]
CMA+DE-MOS	145	*74e+1/1e5*	.	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	*32e+1/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	22	*28e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [5]

Table 15: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{115}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

115 Step-ellipsoid Cauchy

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	4.7	26	213	4094	5334	5887	5887	5887	5887	5932	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1.6**	**1.8**	*24e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	11	4.2	**1**	*30e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.3**	**1.2**	**2.0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**3.7**	**4.4**	**4.4**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	IPOP-CMA-ES [11]
CMA+DE-MOS	4.6	4.1	117	*58e-1/1e5*	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**2.6**	6.6	52	*45e-1/5e4*	.	.	.	.	.	.	Basic RCGA [12]
SPSA	5.5	7.5	*21e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 16: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{116}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

116 Ellipsoid Gauss

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	5083	15799	23313	27069	28619	30108	32081	34946	36455	39385	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	*13e+4/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	*12e+4/1e5*	.	.	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**2.5**	**2.6**	**3.5**	**3.5**	**3.6**	**4.0**	**4.1**	**3.8**	**3.8**	**3.7**	IPOP-CMA-ES [11]
CMA+DE-MOS	*47e+2/1e5*	.	.	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**5.2**	*70e+1/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	*40e+3/1e5*	.	.	.	.	.	.	.	.	.	SPSA [5]

Table 17: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{117}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

117 Ellipsoid unif

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	11888	43288	66394	91504	1.28e5	1.40e5	1.52e5	1.66e5	1.84e5	2.72e5	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	*12e+4/1e4*	.	.	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	*31e+3/1e5*	.	.	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.9**	**1.7**	**2.1**	**2.4**	**1.9**	**2.1**	**2.2**	**2.1**	**2.1**	**1.6**	IPOP-CMA-ES [11]
CMA+DE-MOS	*47e+3/1e5*	.	.	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	*95e+2/5e4*	.	.	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	*42e+3/1e5*	.	.	.	.	.	.	.	.	.	SPSA [5]

Table 18: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{118}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

118 Ellipsoid Cauchy

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	70	181	365	608	829	1081	1362	1550	1699	1866	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	4.7	3.8	3.1	1074	*20e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1.5**	**1.4**	**1.4**	**1.3**	**1.3**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.9**	**2.4**	**2.8**	**2.8**	**2.7**	**2.6**	**2.4**	**2.4**	**2.4**	**2.5**	IPOP-CMA-ES [11]
CMA+DE-MOS	3.5	3.5	3.7	3.5	3.4	3.1	**2.8**	**2.7**	**2.6**	**2.7**	CMA+DE-MOS [9]
Basic RCGA	150	*30e+1/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	15	7903	*18e+1/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 19: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{119}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

119 Sum of diff powers Gauss

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	2.4	687	2003	2589	6878	27847	41084	48350	68515	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	136	*50e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	1209	18	**2.0**	**7.1**	**6.3**	**5.0**	*27e-4/1e5*	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	4.3	**2.0**	**1.2**	**1.1**	**1.4**	**1.3**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1.3**	**3.4**	**1**	**1**	**1**	**1**	**1.6**	**2.5**	**4.5**	**4.2**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1.1**	5.2	175	741	573	*88e-1/1e5*	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	6.2	28	29	104	*25e-2/5e4*	.	.	.	Basic RCGA [12]
SPSA	437	7.5	*34e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 20: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{120}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

120 Sum of diff powers unif

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	3.0	3323	12814	31056	69445	1.81e5	2.83e5	3.23e5	1.33e6	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	1513	*81e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	17083	516	**8.3**	**18**	**12**	*24e-1/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	41	**1**	**1.4**	**1.8**	**1.4**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**35**	**1.0**	**1**	**1**	**1**	**1.3**	**1.6**	**2.7**	**11**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1.1**	**6.4**	*28e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	*19e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	34780	556	*23e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 21: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{121}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

121 Sum of diff powers Cauchy

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	2.2	21	38	56	101	219	459	864	2518	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	3.7	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	673	13	8.5	11	914	*89e-3/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1.2**	**1**	**1.2**	**1.7**	**1.9**	**2.2**	**1.9**	**1.7**	**1.2**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1.1**	**1.0**	**1.2**	**1.7**	**2.1**	**3.1**	**3.9**	**4.5**	**4.0**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1.1**	**1.5**	4.5	3.4	4.7	5.8	6.8	6.7	6.3	4.2	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	5.1	25	167	166	*38e-4/5e4*	.	.	.	Basic RCGA [12]
SPSA	517	42	31062	*18e+0/1e5*	.	.	.	.	.	.	SPSA [5]

Table 22: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{122}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

122 Schaffer F7 Gauss

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	4579	12383	24252	37209	71118	1.37e5	5.80e5	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	13	1067	*12e+0/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
IPOP-aCMA-ES	**1**	**1**	**3.3**	**1**	**1.1**	**1.3**	**1.5**	**1.0**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	6.4	**2.9**	**1.2**	**1**	**1**	**1**	**1**	**1.1**	**1.2**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1.3**	13	*64e-1/1e5*	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1.5**	**1**	**73**	*30e-1/5e4*	.	.	.	.	.	Basic RCGA [12]
SPSA	6.00e6	6.01e6	10675	*68e+3/1e5*	.	.	.	.	.	.	SPSA [5]

Table 23: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{123}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

123 Schaffer F7 unif

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	881	52295	1.85e5	3.75e5	5.15e5	1.23e6	∞	∞	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	*17e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
IPOP-aCMA-ES	**1**	**1**	**1.3**	**1**	**1**	**1.2**	**3.3**	**6.0**	*12e-4/1e6*	.	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	14	**1.1**	**1.0**	**1.2**	**1**	**1**	**1**	*25e-6/1e6*	.	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1.3**	93	*97e-1/1e5*	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1.2**	**1**	*75e-1/5e4*	.	.	.	.	.	.	Basic RCGA [12]
SPSA	1.60e7	1.60e7	*10e+4/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 24: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{124}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

124 Schaffer F7 Cauchy

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	14	628	2840	4719	7403	10258	17969	35937	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	14	31	*58e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
IPOP-aCMA-ES	**1**	**2.4**	**1.1**	5.2	**3.3**	**2.5**	**1.9**	**1.9**	**1.4**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**2.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1.1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	6.4	**2.4**	**1.3**	**1.3**	**1.4**	**1.7**	**1.4**	**1.3**	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	**1.6**	**1.8**	4.5	4.5	6.1	22	*21e-5/5e4*	.	Basic RCGA [12]
SPSA	1.60e7	1.26e7	*94e+3/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 25: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{125}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

125 Griewank-Rosenbrock Gauss

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	11	2.20e5	1.08e6	5.44e6	∞	∞	∞	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	**1**	*16e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	717	916	1032	**3.7**	*45e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1**	30	**2.5**	**1**	**1**	*95e-4/1e6*	.	.	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1**	33	**6.6**	**1.9**	*48e-2/3e5*	.	.	.	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	**1.1**	**6.7**	*51e-2/1e5*	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	**1.1**	**1**	**1**	*52e-2/5e4*	.	.	.	.	Basic RCGA [12]
SPSA	*11e+4/1e5*	.	.	.	.	.	.	.	.	.	SPSA [5]

Table 26: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{126}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

126 Griewank-Rosenbrock unif

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	13	3.41e5	∞	∞	∞	∞	∞	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	**1**	*17e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	3014	3562	3755	**22**	*52e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1**	66	*51e-2/2e5*	.	.	.	.	.	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1**	57	*50e-2/2e5*	.	.	.	.	.	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	**1.1**	**6.0**	*54e-2/1e5*	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	**1.1**	**1**	**1**	*55e-2/5e4*	.	.	.	.	Basic RCGA [12]
SPSA	2.60e7	2.60e7	2.60e7	51513	*93e+3/1e5*	.	.	.	.	.	SPSA [5]

Table 27: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{127}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

127 Griewank-Rosenbrock Cauchy

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	10	47116	1.02e5	2.77e5	3.69e5	4.89e5	5.41e5	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	**1**	18	*78e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	711	818	968	4.1	*47e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1**	**1.8**	**1**	**1**	**1.2**	**1.6**	**1.3**	**1.2**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1**	**2.0**	3.4	**2.4**	**1**	**1**	**1**	**1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	**1.1**	7.6	**2.5**	*10e-2/1e5*	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	**1**	**1**	**3.0**	*16e-2/5e4*	.	.	.	.	Basic RCGA [12]
SPSA	431	527	4104	11818	30	*19e-1/1e5*	.	.	.	.	SPSA [5]

Table 28: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{128}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

128 Gallagher Gauss

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	16799	4.33e5	4.36e5	4.38e5	4.40e5	4.42e5	4.45e5	4.50e5	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	*81e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	673	930	**6.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1**	**1.4**	**3.8**	**3.8**	**3.8**	**3.7**	**3.7**	**3.7**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**4.6**	**2.9**	**5.3**	**5.3**	**5.3**	**5.2**	**5.2**	**5.1**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	*77e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	*69e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	560	629	*80e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 29: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{129}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

129 Gallagher unif

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	3.27e5	7.72e5	1.26e6	1.27e6	1.28e6	1.29e6	1.30e6	1.32e6	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	*82e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	1358	1503	*69e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**1.6**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**1**	**1**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	*76e+0/1e5*	.	.	.	.	.	.	.	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	*69e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [12]
SPSA	3993	8599	*78e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

Table 30: 40-D, running time excess ERT/ERT$_{\text{best}}$ on f_{130}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

130 Gallagher Cauchy

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	165	2864	8052	8064	8074	8088	8100	8125	ERT$_{\text{best}}$/D
(1,4ms)-CMA-ES	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	(1,4ms)-CMA-ES [1, 2]
CMA-EGS (IPOP,r1)	658	840	48	96	**34**	**35**	*20e-1/1e5*	.	.	.	CMA-EGS (IPOP,r1) [4]
IPOP-aCMA-ES	**1**	**1**	**2.1**	114	119	119	119	119	119	118	IPOP-aCMA-ES [8]
IPOP-CMA-ES	**1**	**1**	**3.5**	200	298	298	298	297	297	296	IPOP-CMA-ES [11]
CMA+DE-MOS	**1**	**1**	94	**96**	50	50	**50**	**50**	**50**	**49**	CMA+DE-MOS [9]
Basic RCGA	**1**	**1**	55	**23**	**14**	**15**	**15**	**16**	**16**	**16**	Basic RCGA [12]
SPSA	606	755	*84e+0/1e5*	.	.	.	.	.	.	.	SPSA [5]

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