

Comparison tables: BBOB 2010 function testbed in 3-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 [15, 11]. The experimental set-up is described in [14].

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 [14] 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: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	3.3	8.3	14	23	27	36	41	58	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	1.5	4.6	11	16	21	27	33	45	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1	3.6	7.3	12	17	21	27	37	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	2.9	5.9	11	17	25	30	37	53	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1.6	4.0	8.6	13	17	21	26	33	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	1.8	4.0	7.3	10	15	19	24	31	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	1.3	3.0	5.1	7.8	11	14	18	23	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.2	1.4	3.3	5.9	10	13	16	21	27	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.2	3.4	7.8	11	14	17	20	28	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	1.5	4.3	7.5	11	14	17	20	26	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.9	17	36	57	78	105	131	187	Artif Bee Colony [8]
avg NEWUOA	1	1.3	1.2	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1.1	23	7.1	12	21	35	61	95	124	175	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.1	1.3	13	29	47	68	86	105	145	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	1.8	12	31	50	71	93	112	154	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	1.9	5.7	10	14	20	25	30	39	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	1.9	4.3	10	16	20	27	31	42	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.1	1.3	16	43	64	89	114	135	185	CMA+DE-MOS [18]
NBC-CMA	1	1	1.2	14	40	51	59	70	80	99	NBC-CMA [21]
POEMS	1	1	91	96	170	426	854	1164	1447	2228	POEMS [17]
PM-AdapSS-DE	1	1.4	1.3	14	29	49	68	88	107	148	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	26	80	147	1351	3487	5838	8373	13687	pPOEMS [17, 20]
Basic RCGA	1	1.1	1.0	18	68	135	238	442	616	1169	Basic RCGA [24]
SPSA	1	33	10	10	12	15	18	21	24	30	SPSA [13]

Table 2: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	22	30	26	6.3	5.9	5.8	5.6	5.5	5.3	5.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	27	26	23	5.7	4.8	4.7	4.5	4.5	4.5	4.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	20	28	19	4.9	4.2	4.1	3.9	3.8	3.7	3.6	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	36	68	57	14	11	10	10	10	9.3	8.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	11	12	9.3	2.6	2.1	2.2	2.1	2.1	2.1	2.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	10	15	11	2.7	2.2	2.1	2.1	2.0	2.0	2.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	9.2	11	7.0	1.7	1.3	1.3	1.4	1.4	1.3	1.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	8.3	6.9	6.5	2.1	1.8	1.8	1.8	1.7	1.7	1.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	7.1	6.9	5.9	1.5	1.2	1.2	1.2	1.1	1.1	1.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	6.7	5.6	5.0	1.2	1	1	1	1	1	1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	15	13	11	2.5	2.7	3.3	3.8	4.4	4.4	5.0	Artif Bee Colony [8]
avg NEWUOA	1	1	1	1	1.4	1.9	2.6	3.1	3.6	4.5	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	63	92	65	14	11	15	15	14	14	13	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	13	12	8.0	2.0	1.9	2.1	2.3	2.5	2.7	3.0	Adap DE (F-AUC) [10]
DE (Uniform)	12	14	9.0	2.2	2.1	2.3	2.6	2.8	2.9	3.4	DE (Uniform) [9]
IPOP-aCMA-ES	8.1	8.6	6.8	1.6	1.3	1.4	1.4	1.4	1.4	1.4	IPOP-aCMA-ES [16]
IPOP-CMA-ES	11	10	7.3	2.0	1.7	1.7	1.7	1.7	1.7	1.7	IPOP-CMA-ES [22]
CMA+DE-MOS	19	20	13	3.2	3.2	3.5	3.9	4.3	4.8	5.2	CMA+DE-MOS [18]
NBC-CMA	18	19	12	3.7	3.8	4.1	4.6	4.6	4.5	4.4	NBC-CMA [21]
POEMS	149	203	155	39	35	43	44	48	52	56	POEMS [17]
PM-AdapSS-DE	11	13	8.5	2.1	2.0	2.3	2.5	2.7	2.9	3.2	PM-AdapSS-DE [9, 10]
pPOEMS	220	353	510	148	194	228	267	298	326	345	pPOEMS [17, 20]
Basic RCGA	27	34	42	15	16	20	28	33	61	152	Basic RCGA [24]
SPSA	2887	11651	66520	<i>95e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 3: 03-D, running time excess ERT/ERT_{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											
$\Delta\text{ftarget}$ ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ ERT_{best}/D
(1,2)-CMA-ES	1.3	3.4	16	52	139	106	89	73	67	55	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.4	2.1	1.4	14	60	46	38	32	29	24	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.2	1.8	2.8	8.9	56	53	44	37	33	28	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.1	4.7	20	68	<i>20e-1/1e4</i>	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	3.2	3.4	7.0	22	17	14	12	11	8.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	2.0	2.5	6.7	20	18	15	12	11	9.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.2	1.8	2.2	8.5	23	18	15	12	11	9.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	2.0	3.1	10	32	25	21	17	15	13	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.5	2.3	3.0	12	53	40	34	28	25	21	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.1	2.5	4.7	5.3	26	20	16	14	12	10	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	1.7	1.9	1	1	1	1	1	1	1	Artif Bee Colony [8]
avg NEWUOA	1	3.4	3.1	4.4	18	14	12	10	8.8	7.3	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.5	11	29	299	450	348	363	424	386	320	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.8	2.2	2.2	2.0	1.7	1.5	1.3	1.2	1.1	Adap DE (F-AUC) [10]
DE (Uniform)	1.1	1	2.9	2.6	75	57	48	40	36	30	DE (Uniform) [9]
IPOP-aCMA-ES	1.1	2.7	1	2.4	7.3	7.0	6.0	5.1	4.7	4.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1.1	2.8	2.5	3.0	14	14	12	10	9.4	8.0	IPOP-CMA-ES [22]
CMA+DE-MOS	1.1	1.8	3.4	1.4	1.5	1.4	1.3	1.2	1.2	1.2	CMA+DE-MOS [18]
NBC-CMA	1.1	1.6	3.0	5.1	17	13	11	9.2	8.4	7.0	NBC-CMA [21]
POEMS	33	174	9.4	6.8	13	12	11	10	10	10	POEMS [17]
PM-AdapSS-DE	1.5	1.7	2.6	2.2	16	25	21	17	16	13	PM-AdapSS-DE [9, 10]
pPOEMS	1.2	33	10	17	33	37	44	45	47	53	pPOEMS [17, 20]
Basic RCGA	1	1.7	6.8	19	20	22	23	20	18	16	Basic RCGA [24]
SPSA	97	7526	1378	<i>25e-1/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 4: 03-D, running time excess ERT/ERT_{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											
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	0.38	1.9	88	458	751	910	1095	1286	1482	1798	ERT_{best}/D
(1,2)-CMA-ES	2.2	3.7	5.2	40	<i>20e-1/1e4</i>	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.4	1.7	3.8	13	59	48	40	34	30	25	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	2.1	3.9	22	90	75	62	53	46	38	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.1	2.1	10	97	190	157	130	111	96	79	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.5	1.2	2.7	11	42	35	29	25	21	18	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.4	1.4	1.7	6.0	46	38	32	27	24	19	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.1	1	1.4	14	27	23	19	16	14	11	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.6	2.1	4.0	12	22	18	15	13	11	9.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.9	1.9	5.4	19	91	75	62	53	46	38	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.3	1.3	3.0	9.5	24	20	17	14	12	10	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.2	1.3	1	1	1	1	1	1	1	1	Artif Bee Colony [8]
avg NEWUOA	2.5	8.8	1.7	8.0	62	52	43	36	32	26	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	7.4	102	<i>42e-1/1e5</i>	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.3	1.4	1.6	148	534	441	366	312	271	223	Adap DE (F-AUC) [10]
DE (Uniform)	1.1	1.5	1.7	18	202	166	138	118	102	84	DE (Uniform) [9]
IPOP-aCMA-ES	1.6	2.2	1.2	272	<i>92e-2/2e5</i>	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1.6	2.3	1.8	259	1744	1438	1195	1018	883	728	IPOP-CMA-ES [22]
CMA+DE-MOS	1.5	1.4	1.7	1.3	2.1	2.0	1.7	1.6	1.5	1.4	CMA+DE-MOS [18]
NBC-CMA	1.2	2.3	1.8	16	40	33	27	23	20	17	NBC-CMA [21]
POEMS	93	112	6.6	10	16	14	12	12	11	10	POEMS [17]
PM-AdapSS-DE	1.8	1.4	1.9	118	368	304	253	215	191	157	PM-AdapSS-DE [9, 10]
pPOEMS	1.2	49	6.2	21	25	36	35	38	37	41	pPOEMS [17, 20]
Basic RCGA	1.3	1.2	4.7	1549	<i>11e-1/5e4</i>	.	.	.	.	.	Basic RCGA [24]
SPSA	22	8283	1811	<i>11e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 6: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	3.2	2.1	3.4	4.2	3.6	3.7	3.6	3.5	3.3	3.4	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.1	1.7	2.6	2.4	2.4	2.6	2.9	2.9	2.7	2.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.9	1.3	2.0	1.9	2.0	2.2	2.1	2.2	2.2	2.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	2.6	3.0	5.6	4.6	4.0	4.8	4.6	4.4	4.5	4.4	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.4	1.7	1.3	1.4	1.3	1.5	1.5	1.5	1.6	1.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.9	1.2	1.6	1.5	1.5	1.5	1.6	1.5	1.6	1.5	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.7	1.1	1	1	1.0	1.1	1.1	1.2	1.1	1.1	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.2	1.6	1.2	1.2	1.1	1.2	1.2	1.3	1.3	1.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.4	1.5	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.6	1	1.2	1.1	1	1	1	1	1	1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2.8	1.4	2.6	7.0	25	97	274	319	388	323	Artif Bee Colony [8]
avg NEWUOA	1	1.5	1.8	1.6	1.7	2.3	2.4	2.7	2.8	2.9	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.9	47	78	172	119	292	374	343	395	1449	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	3.9	1.8	3.6	4.9	5.1	5.4	5.5	5.9	5.7	5.8	Adap DE (F-AUC) [10]
DE (Uniform)	2.9	2.6	2.9	5.1	5.4	5.8	6.1	6.4	6.5	6.3	DE (Uniform) [9]
IPOP-aCMA-ES	3.2	2.8	2.2	1.8	1.8	2.0	2.0	1.9	1.9	1.9	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.2	1.8	1.9	1.8	1.9	2.0	2.0	2.0	2.0	1.9	IPOP-CMA-ES [22]
CMA+DE-MOS	3.4	2.2	4.0	7.7	7.6	8.9	8.6	8.6	8.7	8.4	CMA+DE-MOS [18]
NBC-CMA	4.8	2.2	3.1	7.7	6.4	5.6	5.2	5.0	4.7	4.2	NBC-CMA [21]
POEMS	121	54	23	33	48	55	62	62	63	67	POEMS [17]
PM-AdapSS-DE	4.1	2.1	2.5	4.7	5.0	5.5	5.8	6.1	6.2	6.1	PM-AdapSS-DE [9, 10]
pPOEMS	72	48	25	125	262	371	388	436	470	494	pPOEMS [17, 20]
Basic RCGA	19	9.3	8.6	88	174	488	919	2286	3118	<i>18e-4/5e4</i>	Basic RCGA [24]
SPSA	19	3020	7848	6492	8303	<i>11e+0/1e5</i>	.	.	.	.	SPSA [13]

Table 7: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1.2	2.4	12	6.5	21	92	200	200	200	241	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.4	2.2	2.8	3.9	10	23	27	27	27	48	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.2	1.6	3.2	1.9	6.4	28	44	44	44	56	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.5	5.7	10	20	119	178	178	178	365	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.2	3.3	3.2	1.2	3.8	3.7	6.7	6.7	6.7	15	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.2	1.4	1.8	1.2	2.3	3.6	3.2	3.2	3.2	3.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.3	1.3	11	2.2	1.9	2.4	3.8	3.8	3.8	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.1	1.7	2.8	1.5	3.2	3.6	5.5	5.5	5.5	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.8	1.2	2.3	1.1	1	2.5	2.5	2.5	2.5	2.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.4	1.4	1.8	1.2	1.6	1.4	1.5	1.5	1.5	1.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.1	1.1	5.0	4.6	12	25	84	84	84	118	Artif Bee Colony [8]
avg NEWUOA	1.2	2.4	1	3.9	5.8	21	40	40	40	34	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	16	112	202	447	3034	10058	8677	8677	8677	7398	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.2	1	2.0	1.9	1.4	1.4	1.4	1.4	1.4	1.4	Adap DE (F-AUC) [10]
DE (Uniform)	1.2	1.0	4.5	2.4	1.5	1.6	1.6	1.6	1.6	1.5	DE (Uniform) [9]
IPOP-aCMA-ES	1.2	1.8	2.4	1	1.1	1	1	1	1	1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1.4	1.7	2.8	4.1	2.4	1.8	1.9	1.9	1.9	1.7	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.5	2.5	2.5	2.8	2.4	2.3	2.3	2.3	2.3	CMA+DE-MOS [18]
NBC-CMA	1.1	1.5	3.4	2.8	3.0	2.4	2.2	2.2	2.2	2.0	NBC-CMA [21]
POEMS	86	164	62	16	33	28	28	28	28	26	POEMS [17]
PM-AdapSS-DE	1.4	1.2	3.5	2.0	1.5	1.5	1.6	1.6	1.6	1.5	PM-AdapSS-DE [9, 10]
pPOEMS	1.5	23	50	17	49	74	90	90	90	99	pPOEMS [17, 20]
Basic RCGA	1	1.4	4.6	24	97	179	211	211	211	195	Basic RCGA [24]
SPSA	55	132	16995	17233	<i>69e-1/1e5</i>	SPSA [13]

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Table 8: 03-D, running time excess ERT/ERT_{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												
	Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
	(1,2)-CMA-ES	2.9	6.5	6.3	11	16	17	18	18	18	18	(1,2)-CMA-ES [5, 3]
	(1,2m)-CMA-ES	1.6	1.4	5.3	7.8	9.2	11	11	11	11	11	(1,2m)-CMA-ES [5]
	(1,2ms)-CMA-ES	1.5	3.8	6.3	11	12	13	13	13	12	12	(1,2ms)-CMA-ES [5]
	(1,2s)-CMA-ES	1.0	1.4	2.0	19	23	26	29	29	28	28	(1,2s)-CMA-ES [3]
	(1,4)-CMA-ES	2.5	2.6	2.0	4.2	5.2	5.5	5.8	5.9	5.9	6.0	(1,4)-CMA-ES [6, 4]
	(1,4m)-CMA-ES	2.2	2.0	1.8	5.1	6.6	6.8	6.9	6.8	6.8	6.8	(1,4m)-CMA-ES [6]
	(1,4ms)-CMA-ES	1.4	1.6	1.8	3.6	4.2	4.4	4.6	4.6	4.6	4.6	(1,4ms)-CMA-ES [1, 6]
	(1,4s)-CMA-ES	1.5	1	1.0	3.8	4.9	5.5	5.8	5.7	5.7	5.6	(1,4s)-CMA-ES [4]
	(1+1)-CMA-ES	1.4	1.6	1.3	2.5	2.8	3.0	3.1	3.1	3.2	3.3	(1+1)-CMA-ES [7]
	(1+2ms)-CMA-ES	1	1.1	1.1	1.8	2.3	2.4	2.5	2.5	2.6	2.7	(1+2ms)-CMA-ES [2]
	Artif Bee Colony	1.2	2.4	2.0	6.6	26	239	3138	22009	<i>12e-4/1e5</i>	.	Artif Bee Colony [8]
	avg NEWUOA	1.8	1.2	1	1	1	1	1	1	1	1	avg NEWUOA [23]
	CMA-EGS (IPOP,r1)	20	11	13	19	21	23	22	22	23	25	CMA-EGS (IPOP,r1) [12]
	Adap DE (F-AUC)	2.0	2.9	4.7	5.0	7.1	8.1	8.6	9.1	10	10	Adap DE (F-AUC) [10]
	DE (Uniform)	3.0	3.2	4.3	6.3	9.3	11	12	13	13	14	DE (Uniform) [9]
	IPOP-aCMA-ES	2.1	2.5	1.8	2.8	3.7	4.1	4.3	4.4	4.4	4.6	IPOP-aCMA-ES [16]
	IPOP-CMA-ES	2.2	2.9	2.5	4.9	5.7	5.8	5.9	5.9	6.0	6.2	IPOP-CMA-ES [22]
	CMA+DE-MOS	2.0	3.7	5.6	7.2	12	13	13	14	14	15	CMA+DE-MOS [18]
	NBC-CMA	2.8	3.6	4.5	5.0	6.7	7.5	8.0	8.1	8.2	8.7	NBC-CMA [21]
	POEMS	85	34	23	34	54	75	165	283	293	370	POEMS [17]
	PM-AdapSS-DE	1.3	2.8	4.5	4.9	6.9	8.9	10	56	54	53	PM-AdapSS-DE [9, 10]
	pPOEMS	72	32	22	56	217	383	487	644	778	1038	pPOEMS [17, 20]
	Basic RCGA	1.5	4.3	6.8	24	628	1170	3518	<i>14e-3/5e4</i>	.	.	Basic RCGA [24]
	SPSA	283	170	138	3304	5722	24451	<i>12e-1/1e5</i>	.	.	.	SPSA [13]

Table 9: 03-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 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											
$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\Delta\text{ftarget}$ $\text{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	2.7	4.4	6.2	8.1	13	15	16	16	16	16	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.8	2.2	3.0	6.0	8.2	9.5	10	10	10	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1.4	2.0	9.2	10	11	12	12	12	12	12	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1.8	2.8	2.8	3.9	13	19	20	21	21	21	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.8	1.9	2.4	4.3	5.4	5.8	6.0	6.1	6.2	6.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.0	1.9	1.7	2.2	3.4	4.0	4.4	4.5	4.6	4.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.7	1.2	1.4	1.8	2.9	3.4	3.6	3.6	3.7	3.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.9	2.0	1.5	5.2	6.1	6.4	6.4	6.3	6.3	6.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.8	1.6	1.5	1.9	2.5	2.7	2.7	2.8	2.9	3.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	2.0	1.3	1.6	2.3	2.8	2.9	3.0	3.1	3.1	3.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.9	2.8	3.0	4.2	79	416	4246	23320	<i>24e-4/1e5</i>	.	Artif Bee Colony [8]
avg NEWUOA	2.0	1.0	1	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	23	8.4	15	21	24	23	24	24	24	25	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	2.5	2.2	4.4	5.7	7.9	10	17	20	20	21	Adap DE (F-AUC) [10]
DE (Uniform)	1.9	2.3	5.2	5.2	8.4	10	11	12	12	13	DE (Uniform) [9]
IPOP-aCMA-ES	1.7	1.9	2.0	3.4	4.1	4.2	4.5	4.6	4.7	4.9	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	1.7	2.8	3.7	4.2	4.4	4.5	4.7	4.9	IPOP-CMA-ES [22]
CMA+DE-MOS	1.8	2.8	6.1	2.8	5.9	8.2	9.1	10	11	12	CMA+DE-MOS [18]
NBC-CMA	1.6	2.9	5.8	5.2	7.3	8.2	8.4	8.5	8.8	9.1	NBC-CMA [21]
POEMS	109	39	31	123	116	154	220	307	398	522	POEMS [17]
PM-AdapSS-DE	1.4	1.6	4.4	4.9	7.1	8.4	8.9	9.5	10	11	PM-AdapSS-DE [9, 10]
pPOEMS	84	40	34	84	272	410	546	663	815	1101	pPOEMS [17, 20]
Basic RCGA	2.1	3.6	7.1	104	1323	6254	<i>94e-3/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	1081	636	811	5621	<i>12e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 10: 03-D, running time excess ERT/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												
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D	
(1,2)-CMA-ES	17	14	9.2	6.0	5.8	5.5	5.3	5.2	5.0	4.9	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	15	14	8.6	5.2	4.7	4.4	4.2	4.2	4.1	3.9	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	14	12	5.5	3.9	3.6	3.4	3.2	3.2	3.2	3.0	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	35	22	13	11	10	10	9.3	9.1	8.8	8.3	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	7.9	5.2	2.6	1.9	1.9	1.8	1.8	1.8	1.8	1.8	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	5.7	4.8	2.8	1.9	2.0	2.0	2.0	2.0	1.9	1.8	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	4.2	2.8	2.0	1.4	1.4	1.4	1.4	1.4	1.4	1.3	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	7.0	4.9	2.4	1.9	1.9	1.8	1.8	1.7	1.7	1.6	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	3.9	2.7	1.7	1.2	1.1	1.1	1.1	1.1	1.1	1.1	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	4.1	2.8	1.6	1	1	1	1	1	1	1	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	15	110	641	10176	9219	<i>29e-1/1e5</i>	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	1	1.3	2.1	2.4	2.8	3.2	3.4	4.1	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	44	39	22	12	11	52	49	47	45	42	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	6.2	4.9	2.5	1.6	1.8	2.0	2.2	2.3	2.5	2.8	Adap DE (F-AUC) [10]	
DE (Uniform)	5.9	5.1	2.7	1.7	1.9	2.1	2.4	2.5	2.7	3.0	DE (Uniform) [9]	
IPOP-aCMA-ES	4.1	3.3	1.7	1.3	1.2	1.2	1.2	1.2	1.2	1.3	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	4.1	2.9	2.1	1.6	1.6	1.6	1.5	1.6	1.6	1.6	IPOP-CMA-ES [22]	
CMA+DE-MOS	16	12	6.0	4.7	5.2	5.3	5.8	6.0	6.1	6.1	CMA+DE-MOS [18]	
NBC-CMA	10	7.5	4.1	3.3	3.7	4.3	4.5	4.5	4.4	4.3	NBC-CMA [21]	
POEMS	36	46	441	713	1449	2215	3517	5419	10852	19919	POEMS [17]	
PM-AdapSS-DE	5.5	5.0	2.5	1.7	1.9	2.0	2.3	2.5	2.7	2.9	PM-AdapSS-DE [9, 10]	
pPOEMS	66	132	194	173	254	288	324	371	424	471	pPOEMS [17, 20]	
Basic RCGA	292	458	302	887	4682	<i>25e-1/5e4</i>	.	.	.	.	Basic RCGA [24]
SPSA	1328	4948	9226	<i>84e+0/1e5</i>	.	.	.	.	.	.	SPSA [13]

Table 11: 03-D, running time excess ERT/ERT_{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										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	5.2	29	18	8.3	5.9	5.5	5.4	5.3	5.2	4.9	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	9.5	31	14	7.0	4.9	4.6	4.5	4.5	4.4	4.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	8.1	17	10	5.6	4.0	3.8	3.7	3.6	3.7	3.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	17	46	18	11	8.1	7.8	7.6	7.5	7.3	6.8	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.7	6.8	4.9	2.7	2.0	1.9	1.9	1.9	1.9	1.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	2.2	9.1	5.7	2.8	2.0	1.9	1.9	1.9	1.9	1.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.4	4.3	3.5	2.1	1.5	1.4	1.4	1.4	1.4	1.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.9	5.8	4.6	2.3	1.7	1.6	1.6	1.6	1.6	1.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.9	5.1	2.9	1.6	1.2	1.1	1.1	1.1	1.1	1.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	2.0	2.6	2.6	1.3	1.0	1	1	1	1	1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.6	3.1	14	79	1016	<i>14e-2/1e5</i>	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	1	1	1.0	1.2	1.5	1.7	1.9	2.2	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.1	66	39	18	12	11	11	11	10	10	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.9	7.8	2.8	1.6	1.3	1.5	1.7	1.9	2.1	2.3	Adap DE (F-AUC) [10]
DE (Uniform)	5.2	5.6	2.9	1.7	1.4	1.6	1.8	2.0	2.2	2.5	DE (Uniform) [9]
IPOP-aCMA-ES	3.1	3.5	2.6	1.3	1	1.0	1.0	1.1	1.1	1.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.1	5.1	4.5	2.3	1.7	1.6	1.6	1.7	1.6	1.6	IPOP-CMA-ES [22]
CMA+DE-MOS	6.6	9.0	8.5	5.0	3.7	3.8	3.9	4.0	4.0	4.2	CMA+DE-MOS [18]
NBC-CMA	5.8	9.4	5.5	4.7	3.8	3.9	4.1	4.1	4.0	4.0	NBC-CMA [21]
POEMS	41	31	68	215	268	396	563	728	755	1055	POEMS [17]
PM-AdapSS-DE	5.7	6.4	3.0	1.7	1.4	1.6	1.8	2.0	2.2	2.5	PM-AdapSS-DE [9, 10]
pPOEMS	36	24	42	115	130	198	239	304	353	419	pPOEMS [17, 20]
Basic RCGA	5.9	6.7	169	362	1232	3613	<i>58e-2/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	5.2	86	1751	5582	<i>58e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 12: 03-D, running time excess ERT/ERT_{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										
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	10	25	96	179	252	291	320	364	411	489	ERT_{best}/D
(1,2)-CMA-ES	22	23	12	12	12	13	12	13	12	11	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.6	6.1	5.6	5.0	4.8	4.7	4.8	4.7	4.6	4.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	9.1	7.9	5.6	5.3	4.9	4.6	4.4	4.2	3.9	3.6	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	17	27	22	28	27	25	24	28	26	36	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.4	4.8	4.2	4.0	3.6	3.4	3.3	3.1	3.0	2.8	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.2	4.7	3.8	3.8	3.5	3.4	3.3	3.1	3.0	2.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.9	1.6	2.8	3.2	3.0	3.0	2.9	2.8	2.7	2.5	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	2.9	1.8	1.5	2.2	2.5	2.6	2.5	2.5	2.4	2.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.9	2.0	2.2	1.9	1.8	1.8	1.8	1.7	1.6	1.6	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	2.9	1.9	2.3	2.5	2.3	2.3	2.2	2.1	2.0	1.9	(1+2ms)-CMA-ES [2]
Artif Bee Colony	9.2	10	12	88	738	4889	<i>12e-2/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	1	1	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	23	18	305	433	837	958	1263	1800	1597	1343	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	14	7.8	3.3	14	65	60	80	72	64	78	Adap DE (F-AUC) [10]
DE (Uniform)	15	8.5	3.1	2.5	101	127	116	140	125	106	DE (Uniform) [9]
IPOP-aCMA-ES	4.4	2.5	2.3	2.4	2.8	2.7	2.8	2.7	2.6	2.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.6	3.9	2.0	2.1	2.0	2.1	2.1	2.1	2.1	2.2	IPOP-CMA-ES [22]
CMA+DE-MOS	22	12	5.5	5.8	5.7	5.5	5.5	5.3	5.2	4.9	CMA+DE-MOS [18]
NBC-CMA	15	8.4	5.5	4.6	4.6	5.1	5.2	5.0	4.8	4.7	NBC-CMA [21]
POEMS	115	92	491	1169	1997	2513	<i>22e-2/3e5</i>	.	.	.	POEMS [17]
PM-AdapSS-DE	13	9.1	77	89	103	232	211	206	183	154	PM-AdapSS-DE [9, 10]
pPOEMS	179	229	191	188	198	248	286	310	329	351	pPOEMS [17, 20]
Basic RCGA	39	22	133	180	185	507	529	2009	<i>96e-3/5e4</i>	.	Basic RCGA [24]
SPSA	3645	2752	1612	3638	5591	<i>21e+0/1e5</i>	.	.	.	.	SPSA [13]

Table 13: 03-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 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											
$\frac{\Delta f_{\text{target}}}{\text{ERT}_{\text{best}}/D}$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	$\frac{\Delta f_{\text{target}}}{\text{ERT}_{\text{best}}/D}$
(1,2)-CMA-ES	3.0	7.0	6.2	8.1	6.8	6.8	7.8	7.0	7.2	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1.0	2.7	5.0	7.4	8.4	7.5	7.6	10	11	17	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.1	4.0	4.4	5.2	5.3	5.1	6.2	5.8	8.3	21	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	2.0	7.5	5.0	13	12	11	11	14	20	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	2.1	2.8	2.0	2.3	2.2	1.8	1.9	2.1	2.0	2.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	3.0	1.6	2.4	2.1	1.8	1.8	2.2	2.1	2.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	2.1	2.0	1.0	1.4	1.5	1.4	1.4	1.6	1.8	2.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.7	2.2	2.2	2.2	2.0	1.7	1.7	1.8	1.8	1.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1.5	2.2	1.2	2.2	1.8	1.5	1.6	1.6	1.5	1.8	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	3.4	1.5	1.4	1.3	1.1	1.0	1.1	1.1	1.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1.3	6.4	3.6	45	974	7254	<i>86e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	2.9	1	1.7	3.8	11	26	48	86	76	<i>36e-4/8e3</i>	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	19	8.1	485	737	4650	<i>61e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.8	5.6	2.2	2.1	2.2	2.0	2.1	2.2	2.2	2.1	Adap DE (F-AUC) [10]
DE (Uniform)	1.6	6.8	2.6	2.5	2.5	2.2	2.3	2.4	2.3	2.3	DE (Uniform) [9]
IPOP-aCMA-ES	2.6	2.6	1.0	1	1	1	1	1	1	1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	2.5	2.9	1	1.4	1.5	1.3	1.4	1.4	1.4	1.3	IPOP-CMA-ES [22]
CMA+DE-MOS	1.6	4.3	4.1	4.1	3.9	3.5	3.4	3.3	3.3	3.0	CMA+DE-MOS [18]
NBC-CMA	1.7	7.5	2.8	2.5	3.1	2.8	2.7	2.7	2.6	2.5	NBC-CMA [21]
POEMS	219	46	20	331	886	944	3531	<i>43e-4/3e5</i>	.	.	POEMS [17]
PM-AdapSS-DE	2.3	5.6	2.3	2.3	2.4	2.3	2.3	2.3	2.3	2.3	PM-AdapSS-DE [9, 10]
pPOEMS	1.9	49	30	166	236	286	310	359	410	489	pPOEMS [17, 20]
Basic RCGA	1.4	10	34	123	321	870	1550	1334	1155	<i>46e-3/5e4</i>	Basic RCGA [24]
SPSA	24	33	33	760	10631	<i>67e-2/1e5</i>	.	.	.	.	SPSA [13]

Table 14: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1.2	12	5.4	5.7	6.8	10	11	7.6	5.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.1	1.4	3.6	3.9	4.5	5.5	6.4	5.4	4.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	2.0	2.2	2.7	3.6	4.1	5.9	4.7	3.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.3	3.1	2.8	4.5	7.9	10	16	11	8.1	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.7	4.1	2.4	2.8	3.6	3.4	3.6	2.9	2.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	2.6	1.7	2.3	2.8	2.9	3.6	2.7	2.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.3	1.6	1.3	2.0	2.4	2.5	2.4	1.9	1.5	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.5	3.6	1.6	2.3	3.3	3.6	3.3	2.4	1.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.1	3.0	1.9	2.6	2.7	2.7	2.5	1.6	1.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	1.6	1.8	2.3	2.4	2.2	2.1	1.4	1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.2	1.3	7.7	12	24	257	1608	4666	<i>55e-6/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	1	1.2	4.1	1	1	1	1	1	1	2.1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.7	25	38	12	11	14	21	24	13	129	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.1	1.8	3.2	9.1	11	8.0	6.2	3.9	2.5	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.1	1.4	3.8	10	13	9.3	7.3	4.3	2.7	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	2.0	2.4	3.2	3.9	3.0	2.8	1.8	1.3	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1.5	2.5	3.2	3.5	4.3	3.9	3.6	2.5	1.8	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.1	1	3.5	13	15	12	11	6.5	4.3	CMA+DE-MOS [18]
NBC-CMA	1	1.3	1.9	5.0	11	11	7.7	6.1	4.0	2.7	NBC-CMA [21]
POEMS	1	39	233	46	55	105	113	101	115	4485	POEMS [17]
PM-AdapSS-DE	1	1.6	1.7	4.7	10	12	9.0	6.8	4.2	2.7	PM-AdapSS-DE [9, 10]
pPOEMS	1	1.1	35	37	80	434	599	637	451	462	pPOEMS [17, 20]
Basic RCGA	1	1.1	1.7	8.6	32	66	171	408	696	<i>51e-7/5e4</i>	Basic RCGA [24]
SPSA	10	47	464	254	179	153	349	496	837	<i>48e-7/1e5</i>	SPSA [13]

Table 15: 03-D, running time excess ERT/ERT_{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												
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D	
(1,2)-CMA-ES	2.1	5.9	7.7	23	164	137	130	124	118	108	(1,2)-CMA-ES [5, 3]	
(1,2m)-CMA-ES	1.1	2.4	2.7	6.0	29	24	23	22	21	19	(1,2m)-CMA-ES [5]	
(1,2ms)-CMA-ES	1.6	2.8	3.7	7.6	27	23	22	21	20	18	(1,2ms)-CMA-ES [5]	
(1,2s)-CMA-ES	1.4	3.5	9.1	29	81	68	64	61	59	54	(1,2s)-CMA-ES [3]	
(1,4)-CMA-ES	1.8	1.9	4.0	4.2	17	14	14	13	12	11	(1,4)-CMA-ES [6, 4]	
(1,4m)-CMA-ES	1	1.6	1.2	2.1	20	17	16	15	15	13	(1,4m)-CMA-ES [6]	
(1,4ms)-CMA-ES	1.5	2.0	2.2	1.5	6.3	5.3	5.0	4.8	4.6	4.2	(1,4ms)-CMA-ES [1, 6]	
(1,4s)-CMA-ES	1.1	2.4	4.3	2.9	55	46	44	41	40	36	(1,4s)-CMA-ES [4]	
(1+1)-CMA-ES	1.8	2.4	2.5	2.8	27	22	21	20	19	18	(1+1)-CMA-ES [7]	
(1+2ms)-CMA-ES	1.4	1.9	2.1	5.2	18	15	14	13	13	12	(1+2ms)-CMA-ES [2]	
Artif Bee Colony	1.1	1.3	3.6	25	103	236	651	1255	<i>29e-3/1e5</i>	.	Artif Bee Colony [8]	
avg NEWUOA	2.0	2.5	3.3	2.8	7.5	6.3	6.0	5.7	5.4	5.0	avg NEWUOA [23]	
CMA-EGS (IPOP,r1)	18	17	12	27	795	1398	<i>99e-2/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]	
Adap DE (F-AUC)	1.3	1.4	1.9	1	1	1	1	1	1	1	Adap DE (F-AUC) [10]	
DE (Uniform)	1	2.9	2.4	1.2	10	8.1	7.8	7.5	7.2	6.7	DE (Uniform) [9]	
IPOP-aCMA-ES	2.5	3.1	1	1.2	2.6	2.3	2.2	2.1	2.1	2.0	IPOP-aCMA-ES [16]	
IPOP-CMA-ES	1.3	2.2	2.5	1.0	2.9	2.5	2.4	2.3	2.3	2.2	IPOP-CMA-ES [22]	
CMA+DE-MOS	1.3	1.1	5.0	2.8	3.7	4.4	4.3	4.1	4.0	3.8	CMA+DE-MOS [18]	
NBC-CMA	1.2	1	3.2	2.3	7.6	6.4	6.1	5.8	5.6	5.2	NBC-CMA [21]	
POEMS	1	161	15	19	209	176	168	161	155	143	POEMS [17]	
PM-AdapSS-DE	1.4	1.9	2.3	1.1	10	8.1	7.8	7.5	7.3	6.7	PM-AdapSS-DE [9, 10]	
pPOEMS	1.1	15	17	34	57	56	61	65	68	75	pPOEMS [17, 20]	
Basic RCGA	1.3	1.5	5.4	18	23	20	25	29	42	90	Basic RCGA [24]	
SPSA	282	7237	481	2407	<i>21e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 16: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1.5	16	12	35	52	48	72	<i>25e-2/1e4</i>	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.0	3.8	7.5	13	18	22	26	45	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.7	2.1	3.5	6.8	8.3	12	18	18	68	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1.4	23	10	35	42	81	<i>17e-2/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.5	2.8	4.2	5.5	6.0	7.3	7.2	10	65	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.3	4.5	1.7	2.9	2.8	4.0	4.2	5.7	5.4	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.2	1.6	1.4	1.9	2.1	5.1	7.8	7.8	7.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.8	5.2	2.6	4.4	6.0	10	15	18	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.4	2.6	1.2	3.7	6.5	20	23	31	71	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1.2	1.6	1.1	1.7	4.1	8.7	26	46	64	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.8	1	1	7.0	46	1596	<i>45e-4/1e5</i>	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1.3	3.1	2.0	8.2	19	51	<i>19e-3/7e3</i>	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1.2	15	11	29	162	1853	<i>80e-3/1e5</i>	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.3	2.1	1.4	2.4	1.9	1.9	10	10	8.8	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.2	1.8	1.4	2.7	2.4	2.4	2.5	2.5	2.4	DE (Uniform) [9]
IPOP-aCMA-ES	1	1.2	1.3	1.0	1	1	1.1	1.1	1.1	1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1.7	1.9	1.0	1.4	1.1	1	1	1	1.1	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.2	1.3	1.7	1.6	1.2	1.4	1.4	1.5	1.5	CMA+DE-MOS [18]
NBC-CMA	1	1.5	1.3	2.4	2.6	2.8	2.7	2.7	2.7	2.6	NBC-CMA [21]
POEMS	1	20	15	9.0	191	169	158	154	150	138	POEMS [17]
PM-AdapSS-DE	1	1.4	1.4	2.0	4.0	3.4	12	12	11	11	PM-AdapSS-DE [9, 10]
pPOEMS	1	1.4	15	4.8	31	36	74	110	117	128	pPOEMS [17, 20]
Basic RCGA	1	1	1.3	5.5	16	38	88	107	132	213	Basic RCGA [24]
SPSA	2.7	107	89	99	573	<i>28e-2/1e5</i>	.	.	.	.	SPSA [13]

Table 17: 03-D, running time excess ERT/ERT_{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										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1.5	3.3	8.2	23	83	<i>14e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1.1	2.1	4.0	3.6	2.6	12	75	172	<i>26e-5/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1.3	2.0	1	4.7	4.5	23	166	170	131	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	343	59	23	46	520	<i>44e-3/1e4</i>	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1.1	10	5.8	7.7	9.4	21	39	84	<i>12e-5/1e4</i>	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.4	2.1	3.5	3.0	3.6	4.5	21	57	136	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1.5	7.0	2.8	3.5	2.3	6.9	24	80	<i>58e-6/1e4</i>	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	2.0	3.9	6.4	7.2	19	<i>54e-5/1e4</i>	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1.2	6.0	4.1	13	22	94	338	<i>26e-4/1e4</i>	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1.1	5.2	4.9	5.8	7.8	19	77	85	132	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.3	1.7	5.2	10	26	502	3255	1664	<i>11e-4/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	1	1.6	1.7	6.2	12	93	<i>32e-3/5e3</i>	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.9	17	8.5	13	11	147	791	3236	1654	<i>61e-4/1e5</i>	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.2	2.2	2.6	2.5	1.6	1.8	1.9	1.2	1.3	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.2	1.1	2.8	2.6	1.7	1.8	2.0	1.3	1.3	DE (Uniform) [9]
IPOP-aCMA-ES	1.1	2.0	2.4	5.1	2.6	1.3	1.7	1.7	1.1	1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	3.1	10	1.7	1	1.1	1.3	1.5	1	1.1	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.2	1.2	4.6	6.3	3.7	5.6	5.9	3.4	3.5	CMA+DE-MOS [18]
NBC-CMA	1	1.2	1.4	3.2	1.9	1	1	1	1.3	1.3	NBC-CMA [21]
POEMS	1	144	96	17	24	17	19	21	13	32	POEMS [17]
PM-AdapSS-DE	1	1.4	1	2.9	2.3	1.6	1.8	1.9	1.2	1.3	PM-AdapSS-DE [9, 10]
pPOEMS	1.1	1.1	8.5	14	119	112	133	151	98	111	pPOEMS [17, 20]
Basic RCGA	1	1.2	1.6	20	66	49	54	154	143	<i>63e-6/5e4</i>	Basic RCGA [24]
SPSA	57	19178	16657	3528	1201	1520	<i>11e-1/1e5</i>	.	.	.	SPSA [13]

Table 18: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1.2	3.8	6.9	23	38	248	<i>69e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	2.3	1.0	7.8	23	46	<i>42e-3/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	3.5	1.0	3.4	10	37	<i>11e-3/1e4</i>	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	3.7	11	37	170	<i>24e-2/1e4</i>	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.1	2.6	4.1	5.7	9.1	30	180	<i>12e-3/1e4</i>	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.1	31	3.5	4.0	5.1	11	27	<i>24e-4/1e4</i>	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	2.7	3.0	3.8	10	16	25	141	<i>15e-4/1e4</i>	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1.2	3.0	4.0	9.5	14	34	189	<i>15e-3/1e4</i>	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	2.3	4.5	16	18	63	<i>42e-3/1e4</i>	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	39	4.4	9.1	16	47	192	<i>24e-3/1e4</i>	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	2.0	2.5	12	115	570	<i>23e-3/1e5</i>	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1.3	3.1	8.5	24	24	160	<i>76e-3/6e3</i>	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	25	10	50	467	<i>19e-2/1e5</i>	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.1	1.7	2.2	2.9	1.4	1.0	1.0	1	1.0	1.0	Adap DE (F-AUC) [10]
DE (Uniform)	1.5	1.8	2.6	2.9	1.4	1.0	1.0	1.0	1.0	1.0	DE (Uniform) [9]
IPOP-aCMA-ES	1	4.8	1	1	1	1.6	1.4	1.1	1.2	1.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1.3	4.1	1.1	1.5	1.9	1.8	1.7	1.7	1.7	1.5	IPOP-CMA-ES [22]
CMA+DE-MOS	1.1	1.2	2.2	6.2	3.4	3.1	2.9	2.5	2.3	2.4	CMA+DE-MOS [18]
NBC-CMA	1.3	2.2	1.8	3.8	31	15	11	8.7	7.5	6.3	NBC-CMA [21]
POEMS	43	167	18	21	15	91	166	142	204	267	POEMS [17]
PM-AdapSS-DE	1.5	2.3	1.6	2.8	1.4	1	1	1.0	1	1	PM-AdapSS-DE [9, 10]
pPOEMS	1.1	34	21	65	90	77	80	89	88	99	pPOEMS [17, 20]
Basic RCGA	1	1	18	68	101	592	<i>33e-3/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	43	797	2877	2506	2541	<i>20e-1/1e5</i>	.	.	.	.	SPSA [13]

Table 19: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	1	2.7	30	13	<i>32e-3/1e4</i>	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	1.4	1.4	23	8.6	<i>39e-3/1e4</i>	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.8	3.3	15	9.1	8.1	7.9	7.7	7.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	6.4	3.2	30	14	16	16	16	15	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1.2	1.9	17	2.9	3.4	3.3	3.3	3.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1.1	2.0	2.5	10	4.4	3.5	3.4	3.4	3.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.1	1	15	2.9	7.7	7.5	7.4	7.1	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	2.3	1.5	21	28	<i>58e-3/1e4</i>	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	1.5	2.4	32	8.6	5.1	5.0	4.9	4.7	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1.1	2.5	2.1	21	6.2	7.9	7.7	7.6	7.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1.1	2.5	2.3	8.9	3.5	6.8	20	79	<i>14e-5/1e5</i>	Artif Bee Colony [8]
avg NEWUOA	1	1.5	2.7	1.9	21	17	21	21	20	20	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.2	15	10	2.0	26	21	27	73	71	148	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1.1	2.4	1.3	4.6	2.2	3.3	3.3	3.2	3.1	Adap DE (F-AUC) [10]
DE (Uniform)	1	1.1	1.5	2.0	5.5	2.4	3.5	3.5	3.4	3.3	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	1.2	1.4	7.1	1.7	1.3	1.3	1.3	1.2	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1.1	2.2	1.1	11	1.9	1.1	1.1	1.1	1.1	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1.1	2.4	1.2	1	1.6	1	1	1	1	CMA+DE-MOS [18]
NBC-CMA	1	1.2	1.8	1.4	5.1	1.4	1.2	1.2	1.2	1.1	NBC-CMA [21]
POEMS	1	42	127	10	43	35	47	46	45	44	POEMS [17]
PM-AdapSS-DE	1	1.9	1.6	1.4	4.2	1	3.4	3.4	3.3	3.6	PM-AdapSS-DE [9, 10]
pPOEMS	1	1.5	54	10	44	4.2	2.9	3.5	3.9	5.4	pPOEMS [17, 20]
Basic RCGA	1	1.1	2.2	1.6	2.8	3.8	6.7	14	38	76	Basic RCGA [24]
SPSA	18	71	54	61	512	277	<i>83e-3/1e5</i>	.	.	.	SPSA [13]

Table 20: 03-D, running time excess ERT/ERT_{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 $x*\sin(x)$										
Δf_{target}	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target}
ERT_{best}/D	1.8	3.4	3.7	137	969	1461	3037	4119	4355	5005	ERT_{best}/D
(1,2)-CMA-ES	4.7	3.2	3.7	3.8	13	8.4	4.6	3.4	3.2	2.8	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	2.5	2.1	2.4	7.6	32	21	10	7.5	7.1	6.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	2.7	2.4	2.9	7.4	72	48	23	17	16	14	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.5	5.9	5.8	10	25	18	8.5	6.3	5.9	5.2	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1.9	1.5	2.1	3.8	8.7	5.8	2.8	2.0	1.9	1.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1.4	1	1.5	7.3	14	9.3	4.5	3.3	3.1	2.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1.3	1.2	1.3	4.4	43	28	14	10	9.5	8.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1.1	1.5	5.6	16	11	5.3	3.9	3.7	3.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	2.2	1.6	1.8	2.8	8.1	5.3	2.6	1.9	1.8	1.6	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1.3	1.1	1.3	1.9	7.3	4.8	2.3	1.7	1.6	1.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	2.7	3.8	4.2	1	1	1	1	1.2	1.4	1.7	Artif Bee Colony [8]
avg NEWUOA	1.6	1	1	2.1	7.8	5.2	2.5	1.8	1.7	1.5	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	8.7	10	147	<i>45e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1.7	2.2	3.4	3.5	27	18	8.6	6.4	6.0	5.3	Adap DE (F-AUC) [10]
DE (Uniform)	3.0	2.6	3.5	2.6	27	18	8.6	6.3	6.0	5.3	DE (Uniform) [9]
IPOP-aCMA-ES	2.4	1.5	1.5	4.7	4.5	3.2	1.6	1.2	1.2	1.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	2.2	2.1	2.2	4.2	4.4	3.1	1.5	1.2	1.1	1	IPOP-CMA-ES [22]
CMA+DE-MOS	3.1	2.9	3.4	4.0	2.8	2.2	1.3	1	1	1.4	CMA+DE-MOS [18]
NBC-CMA	2.0	3.1	3.7	3.6	10	6.8	3.3	2.4	2.3	2.0	NBC-CMA [21]
POEMS	116	63	60	7.6	115	77	37	28	27	24	POEMS [17]
PM-AdapSS-DE	2.0	1.9	2.1	2.6	17	11	5.4	4.0	3.8	3.3	PM-AdapSS-DE [9, 10]
pPOEMS	66	45	48	19	13	15	10	9.0	10	12	pPOEMS [17, 20]
Basic RCGA	2.3	2.4	3.5	60	171	501	242	<i>41e-2/5e4</i>	.	.	Basic RCGA [24]
SPSA	36	29	38	4736	<i>15e-1/1e5</i>	.	.	.	.	.	SPSA [13]

Table 21: 03-D, running time excess ERT/ERT_{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										
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	6.2	6.4	15	14	14	13	13	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	1.4	4.7	4.7	5.8	5.6	5.5	5.5	5.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	1.7	4.9	7.1	6.4	8.9	8.8	8.7	8.6	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	3.8	13	24	22	21	20	20	20	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1.3	4.5	8.0	6.5	6.2	6.1	6.1	6.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1	3.3	13	13	14	14	13	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.4	3.1	4.5	3.7	3.5	3.5	3.5	3.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	2.2	4.9	7.0	5.7	5.5	5.4	5.4	5.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.3	3.2	6.1	5.0	4.8	4.7	4.6	4.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	1.5	4.5	5.5	4.5	4.3	4.2	4.2	4.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.2	1.5	2.2	3.0	5.2	13	30	73	Artif Bee Colony [8]
avg NEWUOA	1	1	3.7	1.5	1.3	1.0	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	19	9.2	21	135	157	149	292	289	282	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	1.8	1.3	1	1	1.2	1.3	1.4	1.6	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	1.2	1.2	1.1	1.2	1.3	1.4	1.5	1.7	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	1.6	4.0	6.3	5.3	5.2	5.1	5.7	5.7	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	1.4	6.6	6.2	5.5	5.5	5.5	5.5	5.6	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	1.5	8.1	14	55	248	377	376	434	CMA+DE-MOS [18]
NBC-CMA	1	1	1.2	3.1	19	28	27	26	26	25	NBC-CMA [21]
POEMS	1	1	83	606	490	398	379	373	371	364	POEMS [17]
PM-AdapSS-DE	1	1	1.0	1	32	26	25	24	24	24	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	29	7.0	6.6	12	20	29	46	73	pPOEMS [17, 20]
Basic RCGA	1	1	1.7	13	36	83	83	109	136	148	Basic RCGA [24]
SPSA	1	30	28	266	748	609	578	573	583	1470	SPSA [13]

Table 22: 03-D, running time excess ERT/ERT_{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											
Δf_{target} ERT_{best}/D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} ERT_{best}/D
(1,2)-CMA-ES	1	1	3.4	11	10	12	12	12	11	10	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	13	7.3	7.8	8.9	9.1	8.8	8.6	8.0	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	6.1	5.1	7.2	11	11	12	12	11	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	16	10	9.2	9.2	10	10	9.3	8.7	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	3.4	5.2	2.7	2.8	2.7	2.6	2.6	2.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	3.1	4.6	2.5	2.6	2.6	2.5	2.5	2.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.4	6.7	5.3	5.6	5.4	5.2	5.1	4.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	7.8	4.7	3.5	3.5	3.4	3.3	3.2	3.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	5.5	5.8	2.5	2.5	2.5	2.4	2.3	2.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	2.7	1.8	1.2	1.2	1.2	1.2	1.1	1.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	2.2	1.2	1.5	10	38	85	114	1588	Artif Bee Colony [8]
avg NEWUOA	1	1	2.4	1.3	1	1	1	1	1	1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	16	3.1	29	83	184	286	411	399	365	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	1.8	1.4	46	46	44	42	41	38	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	1.1	1	46	46	44	42	41	38	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	5.7	4.7	9.3	29	82	79	77	71	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	1	3.3	7.2	32	89	102	99	92	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	1.3	11	7.7	10	11	15	15	63	CMA+DE-MOS [18]
NBC-CMA	1	1	1.2	73	61	79	76	73	71	65	NBC-CMA [21]
POEMS	1	1	1844	416	346	342	330	316	308	283	POEMS [17]
PM-AdapSS-DE	1	1	1.1	85	75	73	71	68	66	60	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	25	7.9	74	80	84	93	103	118	pPOEMS [17, 20]
Basic RCGA	1	1	1.1	21	39	136	185	211	421	1760	Basic RCGA [24]
SPSA	1	28	27	214	2063	4287	<i>40e-2/1e5</i>	.	.	.	SPSA [13]

Table 23: 03-D, running time excess $\text{ERT}/\text{ERT}_{\text{best}}$ 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											
Δf_{target} $\text{ERT}_{\text{best}}/D$	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δf_{target} $\text{ERT}_{\text{best}}/D$
	0.33	0.33	2.2	328	1526	2661	3203	3933	4046	4294	
(1,2)-CMA-ES	1	1	2.9	15	47	27	45	37	36	<i>68e-2/1e4</i>	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	1	1	2.6	5.2	9.4	16	13	17	17	<i>22e-2/1e4</i>	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	1	1	2.1	7.6	14	12	10	12	12	11	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1	1	3.9	22	46	27	46	<i>66e-2/1e4</i>	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	1	1	1	3.0	3.9	2.4	2.3	1.9	1.8	2.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	1	1	1.2	2.6	3.8	3.2	3.2	2.7	2.6	2.4	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	1	1	2.4	3.4	5.9	4.0	3.4	2.7	2.7	2.5	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	1	1	3.8	6.8	7.9	6.2	7.8	8.3	8.1	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	1	1	2.2	1.4	2.5	2.8	3.0	2.9	3.8	5.3	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	1	1	2.0	1.5	2.0	3.1	3.8	4.7	4.6	4.3	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1	1	1.7	4.0	<i>24e-2/1e5</i>	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	1	1	4.3	1.0	4.5	13	34	<i>46e-3/7e3</i>	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1	7.1	6.3	4.6	<i>29e-2/1e5</i>	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	1	1	1.2	1.3	1	1	1.2	1.2	1.5	1.8	Adap DE (F-AUC) [10]
DE (Uniform)	1	1	1.6	1	1.0	1.1	1.3	1.3	1.6	2.0	DE (Uniform) [9]
IPOP-aCMA-ES	1	1	2.9	2.2	2.0	1.2	1	1.0	1.0	1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	1	1	2.0	2.2	16	9.1	7.6	6.2	6.0	5.7	IPOP-CMA-ES [22]
CMA+DE-MOS	1	1	1.6	3.1	2.0	1.3	1.2	1	1	1.0	CMA+DE-MOS [18]
NBC-CMA	1	1	1.1	6.3	70	40	33	27	26	25	NBC-CMA [21]
POEMS	1	1	8.0	8.6	21	22	19	16	16	16	POEMS [17]
PM-AdapSS-DE	1	1	1.6	1.1	1.1	3.9	3.6	3.3	3.5	3.8	PM-AdapSS-DE [9, 10]
pPOEMS	1	1	5.8	27	52	42	44	43	48	61	pPOEMS [17, 20]
Basic RCGA	1	1	2.2	6.8	54	127	<i>15e-2/5e4</i>	.	.	.	Basic RCGA [24]
SPSA	1	26	45	390	<i>99e-2/1e5</i>	SPSA [13]

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