

Comparison tables: BBOB 2009 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 2009, see <http://coco.gforge.inria.fr/doku.php?id=bbob-2009>. 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 [14, 9]. The experimental set-up is described in [13].

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 [13] for details on how ERT is obtained. All numbers are computed with no more than two digits of precision.

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												
	ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
	ERT_{best}/D	0.333	0.333	1.2	2.67	2.67	2.67	2.67	2.67	2.67	2.67	ERT_{best}/D
ALPS	1	1	1	2.6	31	160	280	450	660	860	1200	ALPS [17]
AMaLGaM IDEA	1	1.1	1.1	3.1	7.4	16	26	37	45	54	73	AMaLGaM IDEA [4]
avg NEWUOA	1	1.3	2.4	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	avg NEWUOA [31]
BayEDAcG	1	1	2.4	9.2	9.2	96	120	160	180	280	420	BayEDAcG [10]
BFGS	1	1	2.4	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	BFGS [30]
Cauchy EDA	1	1.1	40	36	58	91	110	140	140	160	210	Cauchy EDA [24]
BIPOP-CMA-ES	1	1	2.8	5.1	11	18	23	29	29	34	47	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1	1.8	5.2	8.8	12	15	19	19	23	30	(1+1)-CMA-ES [2]
DASA	1	3.1	37	37	49	63	76	89	89	100	130	DASA [19]
DEPSO	1	1	2.9	15	36	65	96	120	120	150	200	DEPSO [12]
DIRECT	1	1	1.2	2	5.7	15	27	38	38	52	95	DIRECT [25]
EDA-PSO	1	1.1	2.8	10	28	56	120	280	280	390	690	EDA-PSO [6]
full NEWUOA	1	1.3	2.9	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	full NEWUOA [31]
G3-PCX	1	1.3	1.9	1.2	15	19	24	29	29	34	47	G3-PCX [26]
simple GA	1	1.1	3.1	26	440	1200	2100	3200	3200	4200	6800	simple GA [22]
GLOBAL	1	1.1	3.1	22	38	41	42	44	44	45	48	GLOBAL [23]
iAMaLGaM IDEA	1	1.2	2.4	5.5	12	18	24	30	30	36	49	iAMaLGaM IDEA [4]
LSfminbnd	1	2.5	5.5	4.1	5.3	5.6	5.6	5.8	5.8	5.9	5.9	LSfminbnd [28]
LSstep	1	1.2	1.30	94	100	100	100	100	100	100	100	LSstep [28]
MA-LS-Chain	1	1.1	2.5	14	36	57	70	75	75	82	96	MA-LS-Chain [21]
MCS (Neum)	1	1	1	1.6	2	2.4	2.4	2.4	2.4	2.4	2.4	MCS (Neum) [18]
NELDER (Han)	1	1.5	1.9	1.8	3.4	5.3	6.7	8.3	8.3	9.8	13	NELDER (Han) [16]
NELDER (Doe)	1	1	2	2.4	3.9	5.4	6.9	8.7	8.7	10	14	NELDER (Doe) [5]
NEWUOA	1	1	1.8	1	1	1	1	1	1	1	1	NEWUOA [31]
(1+1)-ES	1	1.3	3.4	4.1	7	11	14	18	18	22	29	(1+1)-ES [1]
POEMS	1	23	170	110	180	390	1e3	1300	1300	1700	2400	POEMS [20]
PSO	1	1.1	3.2	9.9	44	86	160	230	230	310	500	PSO [7]
PSO_Bounds	1	1	3.1	13	58	230	430	650	650	850	1500	PSO_Bounds [8]
Monte Carlo	1	1	3.8	35	1400	3.3e4	1.3e6	15e-4/1e6	.	.	.	Monte Carlo [3]
Rosenbrock	1	1.7	4.5	3.3	4.8	5.9	7.5	8.5	8.5	10	13	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1	3.5	5.3	10	14	20	26	26	31	41	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	1	2.6	1.3	24	31	37	46	46	50	62	VNS (Garcia) [11]

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											
target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
ERT_{best}/D	6.04	9.82	12.7	13.8	14.4	14.6	14.8	15.3	15.6	16	ERT_{best}/D
ALPS	43	49	66	100	130	160	190	220	250	310	ALPS [17]
AMaLgAM IDEA	5.9	5.6	6	8.1	10	12	14	16	17	20	AMaLgAM IDEA [4]
avg NEWUOA	1	1	1.7	8.2	14	21	30	36	43	57	avg NEWUOA [31]
BayEDAcG	15	15	19	26	29	46	48	55	70	93	BayEDAcG [10]
BFGS	3.4	2.3	3.1	4	4.7	4.9	5	5	5.1	5.2	BFGS [30]
Cauchy EDA	15	17	18	21	25	29	34	36	40	48	Cauchy EDA [24]
BIPOP-CMA-ES	8.9	9.5	13	17	20	21	22	22	23	24	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	6	6.4	8.4	11	12	13	13	13	14	14	(1+1)-CMA-ES [2]
DASA	15	12	11	14	15	18	19	21	23	28	DASA [19]
DEPSO	18	14	15	18	24	29	33	36	40	47	DEPSO [12]
DIRECT	5	4.6	4.5	7.3	8.9	10	12	14	33	38	DIRECT [25]
EDA-PSO	7.8	9.9	13	31	58	84	110	130	150	200	EDA-PSO [6]
full NEWUOA	1	1.1	1.7	4.2	8.2	12	16	19	22	29	full NEWUOA [31]
G3-PCX	16	11	43	87	120	130	170	180	200	230	G3-PCX [26]
simple GA	70	160	280	410	570	780	950	1200	1400	1900	simple GA [22]
GLOBAL	16	11	9	8.9	9	9.3	9.4	9.4	9.5	9.7	GLOBAL [23]
iAMaLgAM IDEA	3.2	3.7	4.4	6.1	7.6	8.9	9.9	11	12	14	iAMaLgAM IDEA [4]
LSfminbd	1.9	1.3	1	1	1	1	1	1	1	1	LSfminbd [28]
LSstep	28	17	15	14	14	14	14	13	13	13	LSstep [28]
MA-LS-Chain	12	12	14	19	22	26	30	33	38	44	MA-LS-Chain [21]
MCS (Neum)	1.9	1.1	1.8	1.9	2.2	3.7	4.4	5	5.2	6.9	MCS (Neum) [18]
NELDER (Han)	2.4	2	2.2	3.3	4.3	4.6	4.8	4.9	5.1	5.4	NELDER (Han) [16]
NELDER (Doe)	1.9	1.8	2.3	2.8	3.2	3.6	3.8	3.9	4.2	4.6	NELDER (Doe) [5]
NEWUOA	1	1.3	3.4	14	25	33	42	49	56	72	NEWUOA [31]
(1+1)-ES	60	270	5800	2e4	4.1e4	6.6e4	3.2e5	4.8e5	3.6e-4/1e6	.	(1+1)-ES [1]
POEMS	270	250	280	320	360	450	500	510	620	720	POEMS [20]
PSO	20	25	46	56	65	83	95	100	120	140	PSO [7]
PSO_Bounds	16	47	150	300	340	510	560	580	640	920	PSO_Bounds [8]
Monte Carlo	66	420	6e3	1.8e5	14e-1/1e6	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	2.9	3.2	4.9	16	20	22	24	24	24	26	Rosenbrock [27]
IPOP-SEP-CMA-ES	9	8	9.5	12	13	14	15	15	16	17	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	17	17	21	26	26	27	28	29	29	30	VNS (Garcia) [11]

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											
target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
ERT_{best}/D	0.333	0.733	12.6	274	277	278	281	282	282	284	ERT_{best}/D
ALPS	1	1	25	6.2	8.9	11	13	15	17	21	ALPS [17]
AMaLGaM IDEA	1	2	3.6	4.2	14	15	15	15	15	15	AMaLGaM IDEA [4]
avg NEWUOA	1	4.4	9.4	5	33	33	33	33	33	32	avg NEWUOA [31]
BayEDAcG	1.1	1.5	32	9.7	<i>70e-2/2e3</i>	150	150	150	150	150	BayEDAcG [10]
BFGS	1.3	29	42	25	160	2600	10e-2/5e4	150	150	150	BFGS [30]
Cauchy EDA	1.1	41	14	7.6	250	25	26	26	26	26	Cauchy EDA [24]
BIPOP-CMA-ES	1	3.5	3.2	4.7	25	38	37	37	37	37	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1.8	8.1	4	38	12	12	12	12	12	(1+1)-CMA-ES [2]
DASA	1.3	32	14	1.4	12	4.8	5.6	5.9	7.3	8.6	DASA [19]
DEPSO	1	2.4	11	2.7	4.1	17	17	17	17	17	DEPSO [12]
DIRECT	1	1	4.8	4.1	17	17	17	17	17	17	DIRECT [25]
EDA-PSO	1	1.6	5.6	13	42	44	44	45	46	49	EDA-PSO [6]
full NEWUOA	1	4.5	4.9	3.3	15	15	15	15	15	15	full NEWUOA [31]
G3-PCX	1.1	1.9	73	58	330	330	330	330	330	320	G3-PCX [26]
simple GA	1	2.2	52	15	23	31	41	56	69	100	simple GA [22]
GLOBAL	1.1	2.5	8.2	3.6	12	12	12	12	12	12	GLOBAL [23]
iAMaLGaM IDEA	1.1	1.9	12	12	39	39	39	39	39	39	iAMaLGaM IDEA [4]
LSfminbnd	1	6.9	1	38	54	54	53	53	53	52	LSfminbnd [28]
LSstep	28	150	21	1	1	1	1	1	1	1	LSstep [28]
MA-LS-Chain	1	2.3	6.7	2.3	8.3	8.4	8.4	8.4	8.4	8.5	MA-LS-Chain [21]
MCS (Neum)	1	1	6.8	1.2	10	11	11	12	12	12	MCS (Neum) [18]
NELDER (Han)	1	1.8	25	1.7	100	100	100	100	100	100	NELDER (Han) [16]
NELDER (Doe)	1	1.7	3	1.5	8.4	8.4	8.3	8.3	8.3	8.3	NELDER (Doe) [5]
NEWUOA	1	2.9	5.7	5	55	54	54	54	53	53	NEWUOA [31]
(1+1)-ES	1	4.3	14	12	69	68	68	67	67	67	(1+1)-ES [1]
POEMS	16	210	26	8.2	23	27	31	35	37	45	POEMS [20]
PSO	1	1.5	7.3	3.5	6.1	7	7.9	8.5	9.6	11	PSO [7]
PSO_Bounds	1	2.2	15	8.6	18	22	25	27	29	41	PSO_Bounds [8]
Monte Carlo	1	1.3	110	5500	5.1e4	10e-1/1e6	400	400	400	400	Monte Carlo [3]
Rosenbrock	1	42	41	27	410	410	17	17	17	17	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	2.8	3.4	3.7	14	17	17	17	17	17	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	1.7	8.4	3.8	7.4	7.4	7.6	8.6	11	17	VNS (Garcia) [11]

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

	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT _{best} /D	0.333	1.8	13.5	269	16	307	317	330	338	348	ERT _{best} /D
ALPS	1.5	1.7	37	9.6	16	18	19	21	23	27	ALPS [17]
AMaLGaM IDEA	1.3	1.2	23	110	970	950	930	900	880	870	AMaLGaM IDEA [4]
avg NEWUOA	2.9	9.2	11	14	160	150	150	140	140	130	avg NEWUOA [31]
BayEDAcG	1.3	1.3	33	47e-1/2e3							BayEDAcG [10]
BFGS	1.8	20	48	54	30e-1/3e3						BFGS [30]
Cauchy EDA	5.9	20	23	1300	13e-1/5e4						Cauchy EDA [24]
BIPOP-CMA-ES	1.1	1.4	9.5	260	3300	4e3	3900	3800	3700	3600	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	2	1.8	13	21	150	140	140	130	130	130	(1+1)-CMA-ES [2]
DASA	1.7	29	12	1.2	2	2	2	2.1	2.1	2.3	DASA [19]
DEPSO	2.5	1.5	13	6.8	18	47	46	45	44	43	DEPSO [12]
DIRECT	1	1	4.8	20	26	44	83	170	180	180	DIRECT [25]
EDA-PSO	1.5	1.2	16	24	110	110	100	100	100	100	EDA-PSO [6]
full NEWUOA	2.7	3.5	11	25	170	160	150	140	140	140	full NEWUOA [31]
G3-PCX	1.8	1.3	130	62	430	400	390	380	370	360	G3-PCX [26]
simple GA	1.3	1.4	90	19	24	34	42	54	63	110	simple GA [22]
GLOBAL	1.3	1.7	12	7.9	51	48	46	44	43	42	GLOBAL [23]
iAMaLGaM IDEA	1.3	1.6	12	130	860	820	800	770	760	740	iAMaLGaM IDEA [4]
LSfminbnd	2.1	3.4	1	20e-1/4e3							LSfminbnd [28]
LSstep	54	70	17	1	1	1	1	1	1	1	LSstep [28]
MA-LS-Chain	1.4	2.1	9.6	5.6	60	56	55	53	52	51	MA-LS-Chain [21]
MCS (Neum)	1	1.2	5.9	10	67	63	61	59	57	56	MCS (Neum) [18]
NELDER (Han)	2.3	1.4	33	72	320	300	290	280	270	270	NELDER (Han) [16]
NELDER (Doe)	1.8	1	4.5	7.8	43	40	39	37	37	36	NELDER (Doe) [5]
NEWUOA	2.3	2.2	24	21	300	280	280	260	260	250	NEWUOA [31]
(1+1)-ES	2.5	1.8	31	33	230	210	210	200	190	190	(1+1)-ES [1]
POEMS	89	100	48	13	46	47	48	51	53	57	POEMS [20]
PSO	1.3	1.3	15	6	98	93	91	89	87	87	PSO [7]
PSO_Bounds	1.5	1.1	28	21	28	36	36	38	39	51	PSO_Bounds [8]
Monte Carlo	1.3	1.7	220	1.6e4	14e-1/1e6						Monte Carlo [3]
Rosenbrock	2.2	36	43	44	140	130	130	120	120	120	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1.9	6.3	83	14e-1/1e4						IPOP-SEP-CMA-ES [29]
VNS (Garcia)	2.2	1.8	19	7.6	20	19	19	20	22	50	VNS (Garcia) [11]

Table 5: 03-D, running time excess ERT/ERT_{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												
	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
	ERT_{best}/D	0.333	0.333	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	ERT_{best}/D
ALPS	1	1.3	27	90	98	100	110	110	110	110	110	ALPS [17]
AMaLgAM IDEA	1	1.1	11	20	21	21	21	21	21	21	21	AMaLgAM IDEA [4]
avg NEWUOA	1	1.5	1.3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	avg NEWUOA [31]
BayEDAcG	1	1.3	22	360	370	370	370	370	370	370	370	BayEDAcG [10]
BFGS	1	2.6	1.6	2.4	2.5	2.6	2.6	2.6	2.6	2.6	2.6	BFGS [30]
Cauchy EDA	1	1.3	20	20	23	23	23	23	23	23	23	Cauchy EDA [24]
BIPOP-CMA-ES	1	1.5	3.6	5.4	5.7	5.8	5.8	5.8	5.8	5.8	5.8	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1.1	2.1	2.7	2.8	2.9	2.9	2.9	2.9	2.9	2.9	(1+1)-CMA-ES [2]
DASA	1	21	19	31	36	40	44	49	53	62	62	DASA [19]
DEPSO	1	1.4	15	35	39	39	39	39	39	39	39	DEPSO [12]
DIRECT	1	1	3.7	4.6	6.2	6.2	6.2	6.2	6.2	6.2	6.2	DIRECT [25]
EDA-PSO	1	1.3	8.5	16	17	17	17	17	17	17	17	EDA-PSO [6]
full NEWUOA	1	2	1.2	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	full NEWUOA [31]
G3-PCX	1	1.5	9.4	22	25	25	25	25	25	25	25	G3-PCX [26]
simple GA	1	1.2	14	1100	3e3	4800	7500	1.1e4	1.5e4	22e-8/1e5	22e-8/1e5	simple GA [22]
GLOBAL	1	1.3	31	47	47	48	48	48	48	48	48	GLOBAL [23]
iAMaLgAM IDEA	1	1.2	3.5	8.3	8.8	8.8	8.8	8.8	8.8	8.8	8.8	iAMaLgAM IDEA [4]
LSfminbd	1	1.1	7.5	11	11	11	11	11	11	11	11	LSfminbd [28]
LSstep	1	28	93	120	120	120	120	120	120	120	120	LSstep [28]
MA-LS-Chain	1	1.3	25	88	92	92	93	93	93	93	93	MA-LS-Chain [21]
MCS (Neum)	1	1	1	1	1	1	1	1	1	1	1	MCS (Neum) [18]
NELDER (Han)	1	1.3	1.6	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	NELDER (Han) [16]
NELDER (Doe)	1	1.5	1.4	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	NELDER (Doe) [5]
NEWUOA	1	1.1	1.1	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	NEWUOA [31]
(1+1)-ES	1	1.6	2.3	3	3.1	3.1	3.1	3.1	3.1	3.1	3.1	(1+1)-ES [1]
POEMS	1	59	120	150	170	180	180	180	180	180	180	POEMS [20]
PSO	1	1.1	8.2	16	18	18	18	18	18	18	18	PSO [7]
PSO_Bounds	1	1.3	6.3	14	15	15	15	15	15	15	15	PSO_Bounds [8]
Monte Carlo	1	1.2	34	1.8e4	6.5e6	32e-2/1e6	32e-2/1e6	32e-2/1e6	32e-2/1e6	32e-2/1e6	32e-2/1e6	Monte Carlo [3]
Rosenbrock	1	5	3.3	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1.3	4.1	6.7	7	7.1	7.1	7.1	7.1	7.1	7.1	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	1	18	20	20	20	20	20	20	20	20	VNS (Garcia) [11]

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												
	ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
	ERT_{best}/D											ERT_{best}/D
ALPS	4.9	1.38	2.53	9.2	18.7	30.1	38.9	49.7	61.3	71.6	88.2	ALPS [17]
AMaLGA _M IDEA	4.8	4.3	3.7	3.7	5.5	5.5	6.3	6.4	6.6	6.9	7.5	AMaLGA _M IDEA [4]
avg NEWUOA	1.2	2.3	2.6	2.6	2.9	2.9	3.8	3.9	4.1	4.3	4.7	avg NEWUOA [31]
BayEDAcG	4.2	10	130	66e-1/2e3								BayEDAcG [10]
BFGS	3.3	2.2	3.5	3.5	3.4	2.9	2.4	2	1.8	1.9	3.1	BFGS [30]
Cauchy EDA	24	33	28	31	28	27	26	26	25	24	25	Cauchy EDA [24]
BIPOP-CMA-ES	1.6	1.6	2.4	3.2	3.1	3.2	3.2	3.2	3.1	3	3.2	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1.4	1.6	1.3	1.6	1.8	1.7	1.6	1.6	1.6	1.6	1.6	(1+1)-CMA-ES [2]
DASA	33	58	30	32	30	30	36	55	56	54	66	DASA [19]
DEPSO	2.4	3.3	3.3	6	11	11	13	14	13	13	14	DEPSO [12]
DIRECT	1.4	1.1	3	3	33	440	1300	2700	23e-3/3e4			DIRECT [25]
EDA-PSO	3.9	3.4	2.7	4	13	28	42	59	62	66	76	EDA-PSO [6]
full NEWUOA	1.5	3.7	4	2.7	5.1	5.1	5.4	5.7	6	6.1	6.9	full NEWUOA [31]
G3-PCX	3	3.2	3.5	9	3.3	2.9	3.2	3.2	3.5	4.3	4.8	G3-PCX [26]
simple GA	2.4	2.7	9	100	100	270	4200	4400	3800	4400	1.6e4	simple GA [22]
GLOBAL	2.5	3.7	5.2	5.5	5.5	4	3.3	2.8	2.4	2.3	2.3	GLOBAL [23]
iAMaLGA _M IDEA	2.4	2	2.1	2.9	2.9	3.1	3.7	4.1	4.2	4.3	4.8	iAMaLGA _M IDEA [4]
LSfminbnd	14	220	490	810	510	510	400	310	260	220	190	LSfminbnd [28]
LSstep	240	690	1200	990	1e3	1e3	820	670	760	670	1700	LSstep [28]
MA-LS-Chain	3.8	4.6	4.3	10	10	9.6	9.6	9.1	8.9	8.3	8.1	MA-LS-Chain [21]
MCS (Neum)	2.1	1.5	3	160	120	140	140	140	130	150	210	MCS (Neum) [18]
NELDER (Han)	1.6	1.2	1.7	1.5	1.3	1.3	1.3	1.2	1.2	1.2	1.3	NELDER (Han) [16]
NELDER (Doe)	1	1	1	1	1	1	1	1	1	1	1	NELDER (Doe) [5]
NEWUOA	1.4	1.9	2.1	3.4	3.4	3.8	4	4.1	4	4.1	4.8	NEWUOA [31]
(1+1)-ES	2.1	3.2	1.7	2	2	1.8	1.8	2	2	2.1	3	(1+1)-ES [1]
POEMS	160	91	31	74	83	83	93	100	92	99	110	POEMS [20]
PSO	3.8	4	2.9	8	13	17	17	18	22	25	28	PSO [7]
PSO_Bounds	2.2	2.3	2.9	12	26	100	100	120	130	120	120	PSO_Bounds [8]
Monte Carlo	2.8	1.9	7.7	200	8700	1.1e5	26e-3/1e6					Monte Carlo [3]
Rosenbrock	3.9	4	2.1	1.8	1.7	1.7	1.6	1.6	1.8	1.7	1.6	Rosenbrock [27]
IPOP-SEP-CMA-ES	4.5	3.6	2.8	3.7	3.3	3.3	3.5	3.6	3.6	3.6	3.6	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	2.2	2.3	5.6	5.9	4.8	4.8	4.6	4.3	4	3.9	3.8	VNS (Garcia) [11]

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

	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT _{best} /D	0.333	0.867	3.8	21.6	114	155	161	161	161	178	ERT _{best} /D
ALPS	1.1	2	6.2	10	7	8.7	9.3	9.3	9.3	11	ALPS [17]
AMaLgAM IDEA	1.2	2.1	2.6	1.6	2.1	3.1	3	3	3	2.9	AMaLgAM IDEA [4]
avg NEWUOA	1.3	3.5	1.2	6.8	4.8	19	41	41	41	37	avg NEWUOA [31]
BayEDAcG	1.4	1	3.6	52	72	85	56e-2/2e3	.	.	.	BayEDAcG [10]
BFGS	1.8	4.1	17	86	37e-1/100	.	.	.	.	.	BFGS [30]
Cauchy EDA	7.1	16	14	6.1	1.9	1.8	1.9	1.9	1.9	2	Cauchy EDA [24]
BIPOP-CMA-ES	1	2	3.3	2.8	1.1	1	1	1	1	1	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1.4	3.5	2.7	2.1	1	1.4	1.4	1.4	1.4	1.3	(1+1)-CMA-ES [2]
DASA	24	57	85	260	120	1300	1600	1600	1600	1500	DASA [19]
DEPSO	1.2	1.7	5.2	6.1	5.9	5.1	5.1	5.1	5.1	5.3	DEPSO [12]
DIRECT	1	1.4	2.9	2.8	2.1	31	34	34	34	30	DIRECT [25]
EDA-PSO	1.3	1.9	3.3	3.7	8.8	17	20	20	20	22	EDA-PSO [6]
full NEWUOA	1.2	3.4	1	1	1.4	2.2	6.8	6.8	6.8	6.2	full NEWUOA [31]
G3-PCX	1.1	1.5	6.2	8.3	12	16	54	54	54	48	G3-PCX [26]
simple GA	1.3	2.2	3.3	24	27	130	200	200	200	250	simple GA [22]
GLOBAL	1.3	2.2	6.2	5.4	4.6	8.8	51	51	51	46	GLOBAL [23]
iAMaLgAM IDEA	1.2	3.3	2.6	15	8.1	6.1	6	6	6	5.4	iAMaLgAM IDEA [4]
LSfminbnd	8.7	19	46	68	33	100	290	290	290	260	LSfminbnd [28]
LSstep	1.6	2.10	300	320	390	930	22e-2/1e4	.	.	.	LSstep [28]
MA-LS-Chain	1.3	2.1	6.1	4.3	2.2	3.1	3.9	3.9	3.9	3.9	MA-LS-Chain [21]
MCS (Neum)	1	1.1	1	5.7	2.4	4.2	4.1	4.1	4.1	8.8	MCS (Neum) [18]
NELDER (Han)	1.7	3	8	28	20	23	30	30	30	27	NELDER (Han) [16]
NELDER (Doe)	1.1	1.9	7.5	4.2	4.3	4.2	8.8	8.8	8.8	8.8	NELDER (Doe) [5]
NEWUOA	1.3	2.6	11	12	10	14	39	39	39	35	NEWUOA [31]
(1+1)-ES	1.1	2.3	2	3.6	3.9	7.7	9.3	9.3	9.3	8.4	(1+1)-ES [1]
POEMS	1.70	270	81	29	12	18	21	21	21	20	POEMS [20]
PSO	1.1	2.2	3.5	5.3	3.1	4.4	5.1	5.1	5.1	5.1	PSO [7]
PSO_Bounds	1.3	2	4.1	7.3	4.8	9.3	12	12	12	13	PSO_Bounds [8]
Monte Carlo	1.3	2	5	30	130	3900	1.6e4	1.6e4	1.6e4	55e-4/1e6	Monte Carlo [3]
Rosenbrock	41	140	97	150	370	79e-2/3e3	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.2	3.3	2.7	2.9	1.4	1.3	1.3	1.3	1.3	1.4	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	3.2	7.5	4.2	2.6	3	4.1	4.1	4.1	3.9	VNS (Garcia) [11]

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

	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT _{best} /D	1.4	4.87	9.07	14.9	50.5	58.5	61.6	64.7	65.9	69.4	ERT _{best} /D
ALPS	2.8	8.5	23	46	33	65	93	120	150	210	ALPS [17]
AMaLgAM IDEA	5.1	2.9	3.8	9.9	5.8	6.3	7	7.5	7.8	8.3	AMaLgAM IDEA [4]
avg NEWUOA	3.1	1.9	1.9	2.6	1	1	1	1	1	1	avg NEWUOA [31]
BayEDAcG	3.7	4.7	11	110	560	73e-2/2e3	.	.	.	.	BayEDAcG [10]
BFGS	3.3	2.1	1.4	2.7	1.1	1.1	1.1	1	1	1	BFGS [30]
Cauchy EDA	24	18	21	28	14	14	15	15	16	17	Cauchy EDA [24]
BIPOP-CMA-ES	4.8	3.8	3.5	8	4.5	4.9	5.2	5.2	5.4	5.6	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1.7	1.6	1.9	6.3	2.8	2.8	3	3.1	3.2	3.4	(1+1)-CMA-ES [2]
DASA	38	22	15	470	470	750	1200	1500	2e3	2800	DASA [19]
DEPSO	6.7	8.1	7.7	14	11	24	64	62e-4/2e3	29	42	DEPSO [12]
DIRECT	1.5	1.4	2	5	3.5	9.2	15	22	29	42	DIRECT [25]
EDA-PSO	2.9	4	6.8	74	70	110	160	210	260	370	EDA-PSO [6]
full NEWUOA	3.7	1.9	1.4	2.8	1.1	1	1	1	1	1	full NEWUOA [31]
G3-PCX	2.5	4.3	4.2	16	9	9.3	9.3	9.1	9.1	9	G3-PCX [26]
simple GA	2.5	3.4	47	170	400	49e-3/1e5	.	.	.	.	simple GA [22]
GLOBAL	2.6	9.2	11	8.2	2.8	2.6	2.5	2.5	2.5	2.5	GLOBAL [23]
iAMaLgAM IDEA	2.6	2.4	2.2	8.1	4.5	5	5.1	5.3	5.6	5.9	iAMaLgAM IDEA [4]
LSminbnd	10	4.4	24	810	2800	2400	2300	2200	96e-2/1e4	.	LSminbnd [28]
LSstep	150	70	51	680	2800	2400	2300	2200	2100	73e-2/1e4	LSstep [28]
MA-LS-Chain	4.7	4.5	6.6	14	7.7	9.9	11	11	12	12	MA-LS-Chain [21]
MCS (Neum)	1	1	1	1	7.2	6.3	6.2	6	5.9	5.7	MCS (Neum) [18]
NELDER (Han)	1.6	1	1	2.1	1	1	1.1	1.1	1.1	1.2	NELDER (Han) [16]
NELDER (Doe)	2.1	2.1	1.6	4	1.5	1.4	1.4	1.4	1.5	1.5	NELDER (Doe) [5]
NEWUOA	3.1	1.5	1.4	2.8	1.2	1.2	1.2	1.2	1.2	1.2	NEWUOA [31]
(1+1)-ES	4.5	3.3	2.8	45	20	39	65	91	120	170	(1+1)-ES [1]
POEMS	140	50	37	94	48	69	170	290	330	410	POEMS [20]
PSO	2.9	4.4	9.8	46	52	93	150	210	260	380	PSO [7]
PSO_Bounds	2.5	4	17	60	160	590	740	840	920	1e3	PSO_Bounds [8]
Monte Carlo	2.7	6.9	43	1e3	1e4	1.2e5	38e-3/1e6	.	.	.	Monte Carlo [3]
Rosenbrock	4.2	1.8	1.7	6.9	3	3.1	3.1	3	3.1	3	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.8	1.9	3	8.3	6.2	6.7	7	7	7.1	7.2	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	2.5	9.9	7.7	9.4	5.1	5.4	5.7	5.7	5.9	6.1	VNS (Garcia) [11]

Table 9: 03-D, running time excess ERT/ERT_{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												
ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget	
ERT_{best}/D	0.333	0.333	6.93	21.8	42.4	49.7	53.2	54.9	56.3	59.4	ERT_{best}/D	
ALPS	7.9	130	30	30	48	83	100	130	170	220	ALPS [17]	
AMaLgAM IDEA	15	40	5.4	6.2	6	6.5	7.1	7.7	8.1	8.6	AMaLgAM IDEA [4]	
avg NEWUOA	11	20	1.7	1.7	1.2	1.1	1.1	1.1	1.2	1.2	avg NEWUOA [31]	
BayEDAcG	15	60	12	110	12e-1/2e3						BayEDAcG [10]	
BFGS	9.3	20	1.5	1.5	1.1	1.1	1.1	1.1	1.1	1	BFGS [30]	
Cauchy EDA	140	290	24	17	16	17	17	18	19	20	Cauchy EDA [24]	
BIPOP-CMA-ES	9.9	30	3.9	4.6	4.4	4.7	4.9	5.1	5.3	5.6	BIPOP-CMA-ES [15]	
(1+1)-CMA-ES	8.2	36	2.7	4.5	3.6	3.6	3.7	3.8	3.9	4.1	(1+1)-CMA-ES [2]	
DASA	200	390	24	790	720	980	1400	1900	2500	3600	DASA [19]	
DEPSO	8	77	15	19	27	55	560	46e-4/2e3			DEPSO [12]	
DIRECT	1	1	1.5	1.7	6.2	9.1	18	27	29	38	DIRECT [25]	
EDA-PSO	7	42	7.5	49	69	120	190	260	350	490	EDA-PSO [6]	
full NEWUOA	9.4	18	1.6	1.4	1	1	1	1	1	1	full NEWUOA [31]	
G3-PCX	11	53	5.4	14	12	12	12	12	12	12	G3-PCX [26]	
simple GA	8.4	130	49	100	3800	2.8e4	11e-2/1e5				simple GA [22]	
GLOBAL	10	100	14	6.2	3.5	3.2	3.1	3.1	3.1	3.1	GLOBAL [23]	
iAMaLgAM IDEA	12	28	3.3	5	4.9	5	5.4	5.8	6	6.4	iAMaLgAM IDEA [4]	
LSfminbnd	25	61	4.7	180	310	870	1300	2600	2600	71e-3/1e4	LSfminbnd [28]	
LSstep	390	3e3	180	400	3300	2800	56e-2/1e4				LSstep [28]	
MA-LS-Chain	12	73	11	9.9	8.7	9.9	11	11	12	13	MA-LS-Chain [21]	
MCS (Neum)	1	1	1	1	1	1.1	1.1	1.2	1.2	1.2	MCS (Neum) [18]	
NELDER (Ham)	5.2	12	1.2	1.2	1	1	1.1	1.1	1.2	1.3	NELDER (Ham) [16]	
NELDER (Doe)	6.9	18	1.5	1.4	1.1	1.1	1.1	1.1	1.2	1.3	NELDER (Doe) [5]	
NEWUOA	7.7	22	1.7	1.7	1.2	1.2	1.2	1.2	1.3	1.3	NEWUOA [31]	
(1+1)-ES	11	32	2.6	79	71	88	120	150	180	240	(1+1)-ES [1]	
POEMS	650	780	66	69	68	150	250	380	500	910	POEMS [20]	
PSO	9.3	75	11	17	34	66	130	200	270	440	PSO [7]	
PSO_Bounds	11	59	13	77	370	530	670	780	880	1e3	PSO_Bounds [8]	
Monte Carlo	12	71	43	670	1e4	2.9e5	43e-3/1e6				Monte Carlo [3]	
Rosenbrock	13	23	1.6	2.6	2.7	2.6	2.7	2.8	2.9	2.9	Rosenbrock [27]	
IPOP-SEP-CMA-ES	10	28	3.7	5.6	7.4	8.2	8.1	8.2	8.3	8.4	IPOP-SEP-CMA-ES [29]	
VNS (Garcia)	20	140	11	6.8	6	6.2	6.3	6.5	6.7	7	VNS (Garcia) [11]	

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

	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
	ERT_{best}/D											ERT_{best}/D
ALPS	23	38	18	50	50.7	360	700	1300	1900	2600	7100	ALPS [17]
AMaLGaM IDEA	3.2	3	3	2.3	2.3	2.7	2.9	3.2	3.4	3.6	3.8	AMaLGaM IDEA [4]
avg NEWUOA	1.1	1.3	1.9	3.4	3.4	5.8	6.9	7.9	8.8	9.5	11	avg NEWUOA [31]
BayEDAcG	88	1600	<i>37e+1/2e3</i>									BayEDAcG [10]
BFGS	1.4	1	1	1.2	1.2	1.2	1.2	1.4	1.5	5.9	76	BFGS [30]
Cauchy EDA	13	9.4	6.3	6.2	6.2	6.7	7.3	7.8	8.3	8.7	9.5	Cauchy EDA [24]
BIPOP-CMA-ES	8.1	5.6	4.1	4.1	4.1	4.6	4.9	4.9	4.9	4.9	4.8	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	4.5	3.1	2.7	2.7	2.7	2.7	3	3.1	3	3	3	(1+1)-CMA-ES [2]
DASA	130	180	1.1e4	4.4e4	4.4e4	2.5e5	24e-1/1e6					DASA [19]
DEPSO	13	35	67	110	110	55e-1/2e3						DEPSO [12]
DIRECT	4.1	8.4	7.6	49	49	120	160	490	480	1e3	2e3	DIRECT [25]
EDA-PSO	20	66	210	2400	2400	4200	7e3	1.1e4	61e-2/1e5			EDA-PSO [6]
full NEWUOA	1	1.6	1.6	2.6	2.6	3.9	4.4	4.9	5.6	6	7.1	full NEWUOA [31]
G3-PCX	8.8	7.2	14	21	21	28	30	36	39	41	42	G3-PCX [26]
simple GA	30	90	200	2e3	2e3	1.2e4	55e-2/1e5					simple GA [22]
GLOBAL	9.9	3.3	3.3	2.8	2.8	2.7	2.6	2.5	2.4	2.3	2.2	GLOBAL [23]
iAMaLGaM IDEA	3.3	2.5	1.8	2.1	2.1	2.6	2.9	3	3.1	3.2	3.3	iAMaLGaM IDEA [4]
LSfminbnd	340	480	1700	2800	2800	2500	61e+0/1e4					LSfminbnd [28]
LSstep	1100	2400	1700	53e+1/1e4	53e+1/1e4							LSstep [28]
MA-LS-Chain	16	13	9.6	11	11	12	12	13	12	12	12	MA-LS-Chain [21]
MCS (Neum)	23	14	67	170	170	820	4100	3800	29e-2/2e4			MCS (Neum) [18]
NELDER (Han)	1.8	1.3	1	1	1	1	1	1	1	1	1	NELDER (Han) [16]
NELDER (Doe)	2	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1	1.1	NELDER (Doe) [5]
NEWUOA	1.4	1.3	2.8	5.2	5.2	8.3	10	12	13	14	16	NEWUOA [31]
(1+1)-ES	28	320	2100	6200	6200	1.2e4	2.3e4	7.6e4	36e-4/1e6			(1+1)-ES [1]
POEMS	49	72	410	1600	1600	5300	1.2e4	51e-2/1e5				POEMS [20]
PSO	9.2	12	59	1100	1100	2400	3600	4800	6700	6500	1.8e4	PSO [7]
PSO_Bounds	13	31	2100	8e3	8e3	1.2e4	1.1e4	2.2e4	2.1e4	2e4	1.8e4	PSO_Bounds [8]
Monte Carlo	34	210	2100	6e4	6e4	2.5e5	11e-1/1e6					Monte Carlo [3]
Rosenbrock	2.6	3.9	8.5	7.8	7.8	7.2	6.8	6.5	6.4	6.9	6.5	Rosenbrock [27]
IPOP-SEP-CMA-ES	22	17	11	9.8	9.8	9.6	9.2	8.8	8.5	8.2	7.8	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	9.3	7.1	5.9	6	6	5.9	5.8	5.7	5.6	5.5	5.3	VNS (Garcia) [11]

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

	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
	ERT_{best}/D	3.13	3.87	22.4	35.1	75.7	87.7	92.5	96.3	101	109	ERT_{best}/D
ALPS	19	48	31	3.1	120	250	520	1100	1800	2600	5e3	ALPS [17]
AMaLGaM IDEA	5.5	7	3.1	3	3	1.7	1.9	2.1	2.3	2.5	2.8	AMaLGaM IDEA [4]
avg NEWUOA	1.9	2.6	2	3.3	3.3	2.5	2.7	3.3	3.7	4.3	5	avg NEWUOA [31]
BayEDAcG	10	23	91	810	85e-1/2e3	1	1.4	3.7	11	41	33e-7/7e3	BayEDAcG [10]
BFGS	2.1	1.9	1	1	1	1	1.4	3.7	11	41	33e-7/7e3	BFGS [30]
Cauchy EDA	19	24	7.8	6.5	4.1	4.1	4.3	5	5.2	5.6	6.4	Cauchy EDA [24]
BIPOP-CMA-ES	5.7	14	9.5	7.5	4	4	3.6	3.7	3.7	3.7	3.6	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	4.6	9.8	5.8	4.6	4.6	2.7	2.5	2.5	2.5	2.5	2.5	(1+1)-CMA-ES [2]
DASA	15	16	4600	9300	1.4e4	1.4e4	2.2e4	3.3e4	4.3e4	4.2e4	3.9e4	DASA [19]
DEPSO	9.8	62	130	270	89e-1/2e3	270	390	770	24e-4/3e4	24e-4/3e4	24e-4/3e4	DEPSO [12]
DIRECT	5.7	6.4	13	28	150	150	390	770	24e-4/3e4	24e-4/3e4	24e-4/3e4	DIRECT [25]
EDA-PSO	9.6	28	74	290	490	490	1100	5100	41e-4/1e5	41e-4/1e5	41e-4/1e5	EDA-PSO [6]
full NEWUOA	2.3	6.9	3.2	3.6	2.5	2.5	2.6	3.1	3.5	3.9	4.7	full NEWUOA [31]
G3-PCX	8.7	10	30	93	100	100	140	180	210	260	320	G3-PCX [26]
simple GA	17	66	74	2100	5600	5600	90e-2/1e5	180	210	260	320	simple GA [22]
GLOBAL	14	23	5.4	3.9	2	2	1.8	1.8	1.8	1.7	1.7	GLOBAL [23]
iAMaLGaM IDEA	4.6	6.7	3.1	3.1	3.1	1.9	1.9	2	2.1	2.2	2.4	iAMaLGaM IDEA [4]
LSfminbnd	2.1	190	1800	32e+0/1e4	32e+0/1e4	32e+0/1e4	32e+0/1e4	32e+0/1e4	32e+0/1e4	32e+0/1e4	32e+0/1e4	LSfminbnd [28]
LSstep	2.1	400	2900	36e+0/1e4	36e+0/1e4	36e+0/1e4	36e+0/1e4	36e+0/1e4	36e+0/1e4	36e+0/1e4	36e+0/1e4	LSstep [28]
MA-LS-Chain	13	24	21	22	11	11	10	10	10	9.9	9.7	MA-LS-Chain [21]
MCS (Neum)	1	1	49	82	100	100	510	24e-3/2e4	10	9.9	9.7	MCS (Neum) [18]
NELDER (Han)	3	3.4	2.2	2.2	1.3	1.3	1.2	1.2	1.2	1.2	1.1	NELDER (Han) [16]
NELDER (Doe)	3.2	3.7	2.3	2	1.1	1.1	1	1	1	1	1	NELDER (Doe) [5]
NEWUOA	1.7	8.8	3.1	3.4	3.4	2.5	2.6	3.2	3.7	4	5.1	NEWUOA [31]
(1+1)-ES	3.7	1300	8400	1.5e4	1.7e4	1.7e4	1.7e5	37e-3/1e6	3.7	4	5.1	(1+1)-ES [1]
POEMS	79	100	370	1e3	830	830	1500	1700	2100	2100	3200	POEMS [20]
PSO	12	30	60	150	160	160	270	360	450	530	990	PSO [7]
PSO.Bounds	9	25	240	740	610	610	1e3	1600	1600	1600	1700	PSO.Bounds [8]
Monte Carlo	22	52	130	2200	6.1e4	6.1e4	13e-2/1e6	1600	1600	1600	1700	Monte Carlo [3]
Rosenbrock	2.7	2.7	17	12	5.9	5.9	5.3	5.1	5	4.9	4.7	Rosenbrock [27]
IPOP-SEP-CMA-ES	5.2	20	17	15	7.4	7.4	6.6	6.6	6.5	6.4	6.1	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1.2	30	14	9.6	4.8	4.8	4.5	4.4	4.4	4.4	4.3	VNS (Garcia) [11]

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

	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
	ERT_{best}/D	1.3.2	85	94	21.6	55.9	113	134	208	232	263	ERT_{best}/D
ALPS	73	85	94	100	100	170	460	1600	3400	1.4e4	9.3e4	ALPS [17]
AMaLGaM IDEA	5.9	6.4	4.7	4.2	4.2	4.8	5.2	5.6	4.9	4.9	5.2	AMaLGaM IDEA [4]
avg NEWUOA	1.1	1.9	4.5	3.2	2.2	2.2	2.2	2.2	1.8	1.8	1.9	avg NEWUOA [31]
BayEDAacG	27	26	67	82	82	120	220	38e-1/2e3				BayEDAacG [10]
BFGS	1.9	1.5	1.7	1.4	1.4	1	1	1	2	2.3	43	BFGS [30]
Cauchy EDA	26	26	34	26	17	16	16	16	13	13	13	Cauchy EDA [24]
BIPOP-CMA-ES	5.2	4.8	7.9	5.7	4.5	4.5	4.7	4.8	3.9	4	4.1	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	3.8	4.3	8.5	6.1	6.1	4.3	4.2	4.2	3.3	3.6	3.5	(1+1)-CMA-ES [2]
DASA	17	17	3.1e4	3.6e4	3.6e4	3.6e4	81e-1/1e6					DASA [19]
DEPSO	24	25	80	160	160	260	67e-1/2e3					DEPSO [12]
DIRECT	4.6	4.6	7	6.5	5.7	5.7	10	58	53	49	240	DIRECT [25]
EDA-PSO	190	260	960	1700	5900	1.1e4	1.1e4	9500	6800	91e-2/1e5		EDA-PSO [6]
full NEWUOA	1	1.9	2.9	2.2	2.2	1.6	1.7	1.7	1.4	1.5	1.6	full NEWUOA [31]
G3-PCX	4.8	4.3	6	11	2400	8.9	9.5	9.9	8	7.9	8.1	G3-PCX [26]
simple GA	200	380	430	3.1	2400	1.3e4	1.1e4	11e-1/1e5				simple GA [22]
GLOBAL	11	8.6	5.9	3.1	8	2	2.4	2.4	2.2	2.8	4	GLOBAL [23]
iAMaLGaM IDEA	4.1	4.4	9.6	8	1200	6.1	6	5.9	4.7	4.7	4.6	iAMaLGaM IDEA [4]
LSfminbnd	6	6.2	700	790	14e+0/1e4	400	34e+0/1e4					LSfminbnd [28]
LSstep	87	73	1400	790	400	400						LSstep [28]
MA-LS-Chain	16	14	25	15	10	10	11	11	8.8	9.1	8.9	MA-LS-Chain [21]
MCS (Neum)	1.3	1.1	1	1	1.2	1.2	1.2	2.7	2.5	4.5	18	MCS (Neum) [18]
NELDER (Han)	1.5	1.4	2	1.7	1.3	1.3	1.3	1.3	1	1	1.1	NELDER (Han) [16]
NELDER (Doe)	1.5	1.4	1.8	1.6	1.6	1.3	1.2	1.3	1	1	1	NELDER (Doe) [5]
NEWUOA	1.2	1	2	1.6	1.2	1.2	1.2	1.3	1	1.1	1.2	NEWUOA [31]
(1+1)-ES	2.7	7200	2.8e4	2.7e4	3.9e4	3.9e4	1.1e5	12e-1/1e6				(1+1)-ES [1]
POEMS	100	170	1800	1600	3800	3800	5e3	69e-2/1e5				POEMS [20]
PSO	30	41	2400	2700	5800	5800	1e4	33e-1/1e5				PSO [7]
PSO.Bounds	110	280	2e3	2200	2500	2500	1.1e4	9500	24e-1/1e5			PSO.Bounds [8]
Monte Carlo	1700	1.1e4	1.6e5	26e+0/1e6								Monte Carlo [3]
Rosenbrock	1.6	1.5	38	19	10	10	9.4	8.9	6.9	7.4	11	Rosenbrock [27]
IPOP-SEP-CMA-ES	5.4	5.6	10	10	8.4	8.4	9.1	8.7	6.7	7	6.8	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	9.3	9.9	13	9.5	6	6	5.6	5.6	4.6	4.4	4.4	VNS (Garcia) [11]

Table 13: 03-D, running time excess ERT/ERT_{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												
	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
	ERT_{best}/D	5.6	16.4	28.3	36.2	45.3	71.7	84.9	122	ERT _{best} /D		
ALPS	1.5	12	48	66	100	200	410	1600	2.2e4	ALPS [17]		
AMaLGaM IDEA	1.4	4.3	3.7	3.9	4.2	4.3	3.4	3.4	3.4	AMaLGaM IDEA [4]		
avg NEWUOA	2.5	1	5.6	14	42	110	160	280	36e-4/78e3	avg NEWUOA [31]		
BayEDaCG	1.5	34	45	120	24e-1/2e3					BayEDaCG [10]		
BFGS	3.5	1.5	1.1	1	1	1	2.1	31	25e-6/9e3	BFGS [30]		
Cauchy EDA	39	22	14	12	12	12	9.4	9.2	9.6	Cauchy EDA [24]		
BIPOP-CMA-ES	1.6	2.6	3.7	3.8	5	6.1	4.5	4.4	4.8	BIPOP-CMA-ES [15]		
(1+1)-CMA-ES	1.9	2.9	4.1	4.5	5.9	6.9	5.9	5.9	6.1	(1+1)-CMA-ES [2]		
DASA	18	52	320	1100	1600	6100	2e4	4e4	1.5e5	DASA [19]		
DEPSO	1.9	9.5	14	60	100	210	11e-2/2e3			DEPSO [12]		
DIRECT	1	1.9	2.9	6.8	6.8	16	29	31	160	DIRECT [25]		
EDA-PSO	1.2	4.7	48	140	400	1400	5800	73e-4/1e5		EDA-PSO [6]		
full NEWUOA	2.2	1	3	10	38	78	120	260	51e-5/9e3	full NEWUOA [31]		
G3-PCX	1.5	4.8	20	73	97	110	160	220	210	G3-PCX [26]		
simple GA	2.2	12	150	250	3600	1.5e4	2e4	16e-2/1e5		simple GA [22]		
GLOBAL	1.3	9.4	6.6	4.5	6.3	8.4	88	35e-4/400		GLOBAL [23]		
iAMaLGaM IDEA	2.2	3.2	2.9	2.7	3.1	3	2.4	2.5	2.6	iAMaLGaM IDEA [4]		
LSminbnd	5.9	14	120	220	620	1500	39e-2/1e4			LSminbnd [28]		
LSstep	120	150	510	1500	65e-1/1e4					LSstep [28]		
MA-LS-Chain	2.2	7.9	9.7	13	17	17	13	12	12	MA-LS-Chain [21]		
MCS (Neum)	1	1.7	14	130	370	370	710	830	22e-4/2e4	MCS (Neum) [18]		
NELDER (Han)	1.9	1.2	1	1.1	1.2	1.3	1	1	1	NELDER (Han) [16]		
NELDER (Doe)	1.5	1.3	1	1.1	1.2	1.3	1.2	1.2	1.2	NELDER (Doe) [5]		
NEWUOA	2	1	4.5	9	42	62	200	1200	12e-4/7e3	NEWUOA [31]		
(1+1)-ES	1.7	2.3	16	65	120	290	1e3	1600	5.7e4	(1+1)-ES [1]		
POEMS	280	52	73	670	1700	4900	19e-3/1e5			POEMS [20]		
PSO	1.2	5.8	19	220	2200	5e3	2e4	1.7e4	71e-3/1e5	PSO [7]		
PSO_Bounds	1.5	6.6	980	1400	1200	9e3	9200	42e-3/1e5		PSO_Bounds [8]		
Monte Carlo	1.7	13	1300	1.6e5	17e-1/1e6					Monte Carlo [3]		
Rosenbrock	4.5	2.9	5	8.6	9.2	20	31	82	320	Rosenbrock [27]		
IPOP-SEP-CMA-ES	2.6	3	8.6	15	16	13	8.9	8.5	7.1	IPOP-SEP-CMA-ES [29]		
VNS (Garcia)	1	9.8	7.1	6	7.8	12	8.5	7.8	7.5	VNS (Garcia) [11]		

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														target
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target				
ERT_{best}/D	0.333	0.333	0.733	5.76	9.47	14.4	23.8	30.7	36.7	64.8	ERT_{best}/D				
ALPS	1	1.2	2.3	10	55	71	69	81	200	2500	ALPS [17]				
AMaLGaM IDEA	1	1.2	2.1	2.7	4.5	5	4.5	4.5	4.7	3.6	AMaLGaM IDEA [4]				
avg NEWUOA	1	1.2	4.7	1.2	1.1	1.1	1.2	1.6	2.7	6.9	avg NEWUOA [31]				
BayEDAcG	1	1.1	1.6		120	110	250	280	780	28e-4/2e3	BayEDAcG [10]				
BFGS	1	2.1	3.7	1.5											



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														
target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target			
ERT_{best}/D	0.333	0.778	40.5	457	2100	2760	2810	2860	2930	3010	ERT_{best}/D			
ALPS	1.3	3.3	7.6	5.3	3.9	4.2	4.4	4.6	4.8	5.1	ALPS [17]			
AMaLGaM IDEA	1.3	1.8	1.2	5	3.7	3.1	3	3	3	2.9	AMaLGaM IDEA [4]			
avg NEWUOA	2	3.4	3.2	3.7	3.1	2.3	2.3	2.2	2.2	2.1	avg NEWUOA [31]			
BayEDAcG	1.5	2.4	3.1	11	14	11e-1/2e3					BayEDAcG [10]			
BFGS	5.8	27	7.3	17	22	17	16	16	16	15	BFGS [30]			
Cauchy EDA	9.2	46	3.9	5.4	27	78e-3/5e4					Cauchy EDA [24]			
BIPOP-CMA-ES	1.9	4.4	1.9	1.3	1.7	1.3	1.3	1.3	1.3	1.3	BIPOP-CMA-ES [15]			
(1+1)-CMA-ES	1.5	3.9	1	5.8	9.5	7.2	7.1	6.9	6.8	6.6	(1+1)-CMA-ES [2]			
DASA	9.8	36	56	200	200	150	150	140	140	140	DASA [19]			
DEPSO	1.5	1	3.4	6.6	3.3	2.6	2.6	2.6	10e-1/2e3		DEPSO [12]			
DIRECT	1	1.4	1	1.5	1	1.7	1.7	1.7	1.7	1.7	DIRECT [25]			
EDA-PSO	1.2	1.6	3.8	7.4	9.5	7.4	7.3	7.4	7.4	7.5	EDA-PSO [6]			
full NEWUOA	1.3	3.3	2.2	2.8	8.8	6.7	6.5	6.4	6.3	6.1	full NEWUOA [31]			
G3-PCX	1.4	2.9	40	28	39	30	29	29	28	27	G3-PCX [26]			
simple GA	1.4	3	14	20	62	62	62	64	83	150	simple GA [22]			
GLOBAL	1.2	2.3	2.7	3.2	3.9	3	2.9	2.9	2.8	2.7	GLOBAL [23]			
iAMaLGaM IDEA	1.4	3	6.2	5.6	4.6	3.6	3.6	3.5	3.5	3.4	iAMaLGaM IDEA [4]			
LSfminbnd	1	5.5	4.8	21	20	15	15	15	15	14	LSfminbnd [28]			
LSstep	1.2	170	380	140	67	51	50	50	49	48	LSstep [28]			
MA-LS-Chain	1.5	3.1	2.6	1.6	3.3	2.5	2.5	2.5	2.4	2.4	MA-LS-Chain [21]			
MCS (Neum)	1	1.4	1.8	1	1.8	1.4	1.3	1.3	1.6	1.5	MCS (Neum) [18]			
NELDER (Han)	1.3	2.9	2.3	4.6	9.4	7.1	7	6.9	6.7	6.5	NELDER (Han) [16]			
NELDER (Doe)	2.3	2.5	1.4	1	2.5	1.9	1.9	1.9	1.8	1.8	NELDER (Doe) [5]			
NEWUOA	1.3	2.2	3.5	3.4	4.5	3.4	3.3	3.3	3.2	3.1	NEWUOA [31]			
(1+1)-ES	2.2	4.5	3.4	6.2	13	10	10	9.8	9.6	9.3	(1+1)-ES [1]			
POEMS	39	190	14	32	77	59	58	57	57	56	POEMS [20]			
PSO	1.5	2.8	2.7	4	58	44	44	43	42	41	PSO [7]			
PSO_Bounds	1.3	3.8	2.8	2.7	27	21	22	22	21	22	PSO_Bounds [8]			
Monte Carlo	1.5	2.2	29	1500	65e-2/1e6						Monte Carlo [3]			
Rosenbrock	5.9	38	11	11	19	15	14	14	14	13	Rosenbrock [27]			
IPOP-SEP-CMA-ES	1.7	4.4	2.3	2.2	1.3	1	1	1	1	1	IPOP-SEP-CMA-ES [29]			
VNS (Garcia)	1.4	2.6	3	3	3.7	2.8	2.8	2.9	2.9	4.5	VNS (Garcia) [11]			

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															
target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget				
ERT_{best}/D	0.333	0.4	13.6	106	194	263	621	720	1070	1120	ERT_{best}/D				
ALPS	1	1.1	1.1	5.9	9.1	13	9	13	10	16	ALPS [17]				
AMaLGaM IDEA	1	1.6	1.8	5.2	9.7	11	6	5.3	3.9	3.7	AMaLGaM IDEA [4]				
avg NEWUOA	1	1.3	3.7	6.1	23	59	73	19e-3/7e3	.	.	avg NEWUOA [31]				
BayEDAcG	1	1.4	1.7	25	98e-2/2e3	.	.	.	.	.	BayEDAcG [10]
BFGS	1	2.8	72	150	14e-1/7e3	.	.	.	.	.	BFGS [30]
Cauchy EDA	1	3	5.2	28	1100	14e-2/5e4	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	1	1.5	2.1	3.5	4.3	3.3	1.7	1.5	1.1	1.1	BIPOP-CMA-ES [15]				
(1+1)-CMA-ES	1	1.2	4.3	4.8	7.9	10	9.9	14	10	18	(1+1)-CMA-ES [2]				
DASA	1	8.7	37	130	300	510	1e3	2200	2900	2900	DASA [19]				
DEPSO	1	1.3	3.9	5.9	29	15e-2/2e3	.	.	.	.	DEPSO [12]
DIRECT	1	1.2	1.2	1	1	1	1	1	1.2	1.9	DIRECT [25]				
EDA-PSO	1	1.3	1.5	19	110	160	97	93	73	72	EDA-PSO [6]				
full NEWUOA	1	1.9	3.3	4.2	9	17	13	69	99	26e-5/8e3	full NEWUOA [31]				
G3-PCX	1	1	1	3.2	11	18	13	27	58	100	G3-PCX [26]				
simple GA	1	1.4	1	6	61	340	490	940	650	1300	simple GA [22]				
GLOBAL	1	1.4	1.6	1.1	1.3	1.6	1.6	1.7	1.3	3.4	GLOBAL [23]				
iAMaLGaM IDEA	1	1.1	1.9	1.9	10	9.2	6	5.2	3.5	3.6	iAMaLGaM IDEA [4]				
LSminbnd	1	1.2	1.6	3.5	19	50	100	12e-3/9e3	.	.	LSminbnd [28]				
LSstep	1	1.3	4	8.7	94	170	240	210	140	130	LSstep [28]				
MA-LS-Chain	1	1.2	1.6	1.6	4.8	5.6	5.7	6.4	6	6.2	MA-LS-Chain [21]				
MCS (Neum)	1	1.3	4.1	2.1	11	33	130	18e-4/2e4	.	.	MCS (Neum) [18]				
NELDER (Han)	1	1.3	3.7	7	21	29	13	17	14	14	NELDER (Han) [16]				
NELDER (Doe)	1	1.1	1.2	2.8	6.7	3.9	3.2	3.5	2.6	6.3	NELDER (Doe) [5]				
NEWUOA	1	2.9	4.5	6.7	12	58	150	130	13e-3/6e3	4e3	NEWUOA [31]				
(1+1)-ES	1	1.8	8.6	18	40	57	120	200	230	57	(1+1)-ES [1]				
POEMS	1	1.6	1.5	3	41	77	96	84	57	57	POEMS [20]				
PSO	1	1.6	1.8	3	41	77	73	66	45	59	PSO [7]				
PSO_Bounds	1	1.4	1.8	6.4	58	170	120	120	95	93	PSO_Bounds [8]				
Monte Carlo	1	1.3	1.8	7.9	180	4400	2.3e4	80e-4/1e6	.	.	Monte Carlo [3]				
Rosenbrock	1	3	22	31	93	270	230	23e-2/1e4	.	.	Rosenbrock [27]				
IPOP-SEP-CMA-ES	1	1.4	2.1	3.5	4	3.5	1.6	1.4	1	1	IPOP-SEP-CMA-ES [29]				
VNS (Garcia)	1	1.8	2.3	6.7	5.9	9.5	4.4	4	3	8.4	VNS (Garcia) [11]				

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

	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
	ERT_{best}/D	0.333	1.2	2.4	11	93.9	164	378	602	782	1160	ERT_{best}/D
ALPS	1	1.2	2.4	2.4	11	13	15	9.2	8.3	8.5	8.8	ALPS [17]
AMaLGaM IDEA	1	1.3	3.3	3.3	1.5	1	1	2.6	3.1	3.9	3	AMaLGaM IDEA [4]
avg NEWUOA	1	1.9	2.3	3.3	8	13	150	32e-3/5e3	.	.	.	avg NEWUOA [31]
BayEDAcG	1	1.7	2.3	6.7	6.7	7.6	17	9.7	16	32e-4/2e3	.	BayEDAcG [10]
BFGS	1	2.1	48	44	44	44e-2/2e3	.	.	.	.	.	BFGS [30]
Cauchy EDA	1	4.9	24	7.3	4.1	4.1	3.6	2.2	1.8	1.8	1.6	Cauchy EDA [24]
BIPOP-CMA-ES	1	1.2	5.3	4	4	2.4	2.3	1.5	1.2	1.4	1.1	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1.1	32	7.6	7.6	7.9	32	37	75	58	76e-5/1e4	(1+1)-CMA-ES [2]
DASA	1	15	65	49	110	110	480	900	990	3900	1.2e4	DASA [19]
DEPSO	1	1.3	5.1	4	4	3.5	3.5	2.3	2.2	2.3	5	DEPSO [12]
DIRECT	1	1	1.2	1	1	1.2	1.5	1	1	1	1.2	DIRECT [25]
EDA-PSO	1.1	1.3	2.3	4	4	17	29	20	17	17	16	EDA-PSO [6]
full NEWUOA	1	1.7	3.9	5.5	5.5	7.3	31	53	35e-4/6e3	.	.	full NEWUOA [31]
G3-PCX	1	1.3	2.6	33	33	39	48	47	110	290	640	G3-PCX [26]
simple GA	1	1.1	1.4	30	30	57	72	72	65	120	58e-8/1e5	simple GA [22]
GLOBAL	1	1.5	3	4.2	4.2	7.3	21	98e-3/400	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	1	1.4	2.4	2.4	1	3.1	2.7	3.1	4.4	3.6	3	iAMaLGaM IDEA [4]
LSfminbnd	1	1.2	14	8.2	8.2	30	140	21e-3/1e4	.	.	.	LSfminbnd [28]
LSstep	1	1.5	71	200	200	100	880	69e-3/1e4	.	.	.	LSstep [28]
MA-LS-Chain	1	1.4	2.1	3.4	3.4	4	4.9	3.1	2.6	2.3	2	MA-LS-Chain [21]
MCS (Neum)	1	1	1	2.5	2.5	5.6	16	180	35e-4/2e4	.	.	MCS (Neum) [18]
NELDER (Han)	1	1	62	22	22	44	95	95	110	250	400	NELDER (Han) [16]
NELDER (Doe)	1	1.2	1.9	3.7	3.7	8.5	36	69	12e-4/2e4	.	.	NELDER (Doe) [5]
NEWUOA	1	1.6	2.7	9	9	19	140	32e-3/5e3	.	.	.	NEWUOA [31]
(1+1)-ES	1	2.5	24	33	33	870	2300	4100	12e-4/1e6	.	.	(1+1)-ES [1]
POEMS	1	93	140	20	20	23	28	17	18	16	15	POEMS [20]
PSO	1	1.1	2.8	4.4	4.4	80	55	26	18	15	14	PSO [7]
PSO-Bounds	1	1.3	2.5	4.7	4.7	14	21	14	13	25	28	PSO-Bounds [8]
Monte Carlo	1	1.1	2.4	30	30	7200	92e-3/1e6	.	.	.	.	Monte Carlo [3]
Rosenbrock	1	1.3	81	2200	2200	20e-1/8e3	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1.2	2.8	1.8	1.8	2.1	1.8	1.4	1	1.1	1	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	1	2.9	2.9	2.9	1.2	1.7	1.3	2	4.8	18	VNS (Garcia) [11]

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												
target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget	
ERT _{best} /D	0.333	0.4	13.4	48.2	430	1030	1170	430	1580	1840	ERT _{best} /D	
ALPS	1.3	2.6	5	17	5.5	5.2	7.2	13	18	140	ALPS [17]	
AMaLGaM IDEA	1.2	3.4	1.6	6.1	3.5	3.2	3.1	2.9	2.5	2.5	AMaLGaM IDEA [4]	
avg NEWUOA	1.3	4.8	11	30	15	89	76e-3/6e3	.	.	.	avg NEWUOA [31]	
BayEDAcG	1.1	3	4.5	9.7	67	20e-2/2e3	.	.	.	.	BayEDAcG [10]	
BFGS	1	16	33	29e-1/3e3	.	.	.	.	.	.	BFGS [30]	
Cauchy EDA	1.3	31	280	80	9.4	4.3	4	8.5	7.3	6.6	Cauchy EDA [24]	
BIPOP-CMA-ES	1.1	3.4	1.4	3.4	1.8	1.1	1	1	1.1	1.3	BIPOP-CMA-ES [15]	
(1+1)-CMA-ES	1.2	3.8	2.7	5	8.3	22	40	16e-3/1e4	.	.	(1+1)-CMA-ES [2]	
DASA	5.6	93	91	980	460	1600	10e-3/1e6	.	.	.	DASA [19]	
DEPSO	1.3	2.4	3.8	12	3.4	5.1	12	18e-3/2e3	.	.	DEPSO [12]	
DIRECT	1	1.5	1.1	2.7	1	1	2	2.9	5	8.3	DIRECT [25]	
EDA-PSO	1	4.5	2.4	28	13	9.3	12	13	14	16	EDA-PSO [6]	
full NEWUOA	1.1	4.6	4.2	16	13	48e-3/7e3	.	.	.	.	full NEWUOA [31]	
G3-PCX	1.1	3.3	2.4	11	18	63	91e-4/5e4	.	.	.	G3-PCX [26]	
simple GA	1	3.2	6.3	63	42	420	1200	17e-3/1e5	.	.	simple GA [22]	
GLOBAL	1.2	2.7	3.9	5.7	4.6	21e-2/500	.	.	.	.	GLOBAL [23]	
iAMaLGaM IDEA	1.1	1.9	1	1	1.6	3.3	3.7	3.9	3.4	3.8	iAMaLGaM IDEA [4]	
LSfminbnd	1	4.4	8.7	35	33	10e-2/1e4	.	.	.	.	LSfminbnd [28]	
LSstep	1	25	42	360	330	12e-1/1e4	.	.	.	.	LSstep [28]	
MA-LS-Chain	1.1	2.3	3	4.8	5.3	12	11	13	12	11	MA-LS-Chain [21]	
MCS (Neum)	1	1	4	2.9	20	40e-3/2e4	.	.	.	.	MCS (Neum) [18]	
NELDER (Han)	1.1	4.2	25	27	30	45	120	550	98e-5/1e5	.	NELDER (Han) [16]	
NELDER (Doe)	1.1	3.5	1.9	5.4	7	16	72	200	170	63e-4/2e4	NELDER (Doe) [5]	
NEWUOA	1	5.1	7.2	17	34	12e-2/6e3	.	.	.	.	NEWUOA [31]	
(1+1)-ES	1.8	9	340	300	2800	1.4e4	1.2e4	83e-3/1e6	.	.	(1+1)-ES [1]	
POEMS	42	250	25	180	25	24	50	95	100	170	POEMS [20]	
PSO	1	2.7	2	16	57	77	99	92	110	180	PSO [7]	
PSO-Bounds	1	2.7	2	170	65	57	67	68	69	780	PSO-Bounds [8]	
Monte Carlo	1.1	2.2	4.7	450	26e-2/1e6	.	.	.	.	.	Monte Carlo [3]	
Rosenbrock	1.1	160	220	2300	50e-1/8e3	.	.	.	.	.	Rosenbrock [27]	
IPOP-SEP-CMA-ES	1.2	4.7	1.2	1.8	2.1	1	1.1	1	1	1	IPOP-SEP-CMA-ES [29]	
VNS (Garcia)	1.2	3.5	3.2	2.3	4.3	5.3	6.6	13	45	130	VNS (Garcia) [17]	

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											
	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT _{best} /D	0.333	0.333	0.333	0.333	36.5	2250	2460	2460	2470	2480	ERT _{best} /D
ALPS	1	1	11	470	46	3	4.6	5.2	5.5	7.1	ALPS [17]
AMaLgAM IDEA	1	1.2	13	120	36	3.8	5.9	6	6	6	AMaLgAM IDEA [4]
avg NEWUOA	1	1.5	13	320	120	39	76	76	76	76	avg NEWUOA [31]
BayEDAcG	1	1.1	9.9	130	43	<i>64e-3/2e3</i>	.	.	.	.	BayEDAcG [10]
BFGS	1	37	110	870	160	33	<i>86e-3/5e3</i>	.	.	.	BFGS [30]
Cauchy EDA	1	2.3	57	540	310	<i>53e-3/5e4</i>	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	1	1.5	13	100	49	2.9	3.2	3.2	3.2	3.3	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1	6.1	970	160	8.8	17	17	17	17	(1+1)-CMA-ES [2]
DASA	1	3.3	60	5100	520	230	460	460	460	480	DASA [19]
DEPSO	1	1	5.4	240	41	<i>43e-3/2e3</i>	.	.	.	.	DEPSO [12]
DIRECT	1	1	1	1	1	29	60	60	10e-3/3e4	.	DIRECT [25]

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

	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
ERT _{best} /D	1.84	2.6	2.76	128	764	799	827	842	858	925	ERT _{best} /D
ALPS	2.8	4.1	5.1	5	3.9	4.6	5.3	6.2	7.2	8.2	ALPS [17]
AMaLgAM IDEA	2.2	2.2	2.7	20	26	25	25	25	24	23	AMaLgAM IDEA [4]
avg NEWUOA	1.5	1.3	1.3	2.3	9.9	9.5	9.2	9	8.9	8.2	avg NEWUOA [31]
BayEDAcG	3.1	3	3.2	71	<i>13e-1/2e3</i>						BayEDAcG [10]
BFGS	1.8	1.7	1.9	1.7	5.5	5.3	5.1	5	4.9	4.6	BFGS [30]
Cauchy EDA	17	18	20	10	460	930	<i>31e-2/5e4</i>				Cauchy EDA [24]
BIPOP-CMA-ES	2.2	2.1	2.3	8.2	10	10	10	10	10	9.5	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	2.1	2.6	2.7	5.6	9.5	9.1	8.8	8.7	8.5	7.9	(1+1)-CMA-ES [2]
DASA	31	37	37	21	43	41	40	39	38	36	DASA [19]
DEPSO	1.1	4.1	5.9	2.4	4.9	4.8	4.8	4.9	4.8	4.7	DEPSO [12]
DIRECT	3.7	5.2	5.9	1	9	8.7	8.6	8.5	8.5	8.1	DIRECT [25]
EDA-PSO	2.3	3.4	3.6	6.7	4.5	4.9	5.1	5.3	5.6	6.1	EDA-PSO [6]
full NEWUOA	1.9	1.3	1.2	5.2	9.1	8.7	8.4	8.3	8.1	7.5	full NEWUOA [31]
G3-PCX	1.5	2.8	3.5	17	22	21	21	20	20	19	G3-PCX [26]
simple GA	3.2	4.3	5.1	14	7.1	10	14	17	21	29	simple GA [22]
GLOBAL	1.3	2.7	3.4	6	18	17	17	16	16	15	GLOBAL [23]
iAMaLgAM IDEA	2.3	2.9	3.7	16	19	18	18	18	17	16	iAMaLgAM IDEA [4]
LSfminbnd	6.4	6.1	6.8	9.9	<i>42e-2/1e4</i>						LSfminbnd [28]
LSstep	150	180	220	28	180	180	170	170	170	160	LSstep [28]
MA-LS-Chain	2.5	2.3	2.8	2.5	1	1	1	1	1	1	MA-LS-Chain [21]
MCS (Neum)	2.9	2.2	2.3	3.2	3.5	3.4	3.3	3.2	3.1	2.9	MCS (Neum) [18]
NELDER (Han)	1	1	1	19	25	24	23	23	23	21	NELDER (Han) [16]
NELDER (Doe)	1.5	1.5	1.7	3.6	10	10	9.7	9.5	9.4	8.7	NELDER (Doe) [5]
NEWUOA	1.6	1.4	1.3	1.1	3.9	3.7	3.6	3.5	3.4	3.2	NEWUOA [31]
(1+1)-ES	2.2	3.1	3.1	4.7	9.5	9.1	8.8	8.7	8.5	7.9	(1+1)-ES [1]
POEMS	110	87	84	7.4	65	63	63	69	69	66	POEMS [20]
PSO	1.4	3.2	3.7	2.6	22	22	21	21	21	20	PSO [7]
PSO-Bounds	2.1	2.7	3.2	5.2	52	78	76	85	84	80	PSO-Bounds [8]
Monte Carlo	1.3	2.6	3.1	56	<i>1600</i>	<i>94e-3/1e6</i>					Monte Carlo [3]
Rosenbrock	3	2.6	2.5	1.5	10	9.5	9.2	9.1	8.9	8.3	Rosenbrock [27]
IPOP-SEP-CMA-ES	1.7	2.1	2.8	7.9	5.5	5.5	5.4	5.5	5.4	5.2	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	3.7	2.8	2.9	4.4	5.5	5.3	5.1	5.1	5.2	5.8	VNS (Garcia) [11]

20 Schwefel $x^* \sin(x)$

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											
target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
ERT_{best}/D	0.333	0.333	1.98	61.3	142	146	153	155	156	161	ERT_{best}/D
ALPS	1	1	1.3	2.3	3.7	5.8	7.4	8.8	11	15	ALPS [17]
AMaLgAM IDEA	1	1	2.2	17	41	41	40	40	40	39	AMaLgAM IDEA [4]
avg NEWUOA	1	1	4	2.5	2.1	2	2	2	2	2	avg NEWUOA [31]
BayEDAcG	1	1	2.1	7.5	94	63e-2/2e3	3.3	3.3	3.2	3.2	BayEDAcG [10]
BFGS	1	1	2.1	3.3	3.5	3.4	3.3	3.3	3.2	3.2	BFGS [30]
Cauchy EDA	1	1	1.7	11	240	240	500	650	890	860	Cauchy EDA [24]
BIPOP-CMA-ES	1	1	1.9	4.5	8.1	6.1	6	6	6.1	6.1	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1	12	93	66	65	62	62	62	61	DASA [19]
DASA	1	1	1.2	4.1	3.5	4.6	5.3	6.6	7.1	7.5	DEPSO [12]
DEPSO	1	1	1.9	1	1.4	1.4	1.4	3.8	4.2	5.8	DIRECT [25]
DIRECT	1	1	1.4	3.2	54	55	58	59	62	65	EDA-PSO [6]
EDA-PSO	1	1	2.4	3.3	2.8	2.7	2.6	2.6	2.6	2.6	full NEWUOA [31]
full NEWUOA	1	1	1.6	8.6	5.7	5.6	5.4	5.4	5.4	5.4	G3-PCX [26]
G3-PCX	1	1	1.5	2.5	5.3	18	29	43	99	230	simple GA [22]
simple GA	1	1	1.8	1.4	1	1	1	1	1	1	GLOBAL [23]
GLOBAL	1	1	1.6	28	20	19	19	18	18	18	iAMaLgAM IDEA [4]
iAMaLgAM IDEA	1	1	6.1	21	27	26	31	38	39	46	LSfminbd [28]
LSfminbd	1	1	15	210	200	190	190	200	200	220	LSstep [28]
LSstep	1	1	1.7	1.7	9.7	9.8	9.6	9.7	9.7	9.7	MA-LS-Chain [21]
MA-LS-Chain	1	1	6.2	2.1	4.4	4.3	4.1	4.1	4.1	4.2	MCS (Neum) [18]
MCS (Neum)	1	1	1.6	16	26	25	24	23	23	23	NELDER (Han) [16]
NELDER (Han)	1	1	2	2.8	2.9	2.8	2.7	2.7	2.7	2.6	NELDER (Doe) [5]
NELDER (Doe)	1	1	1.6	2.7	3.5	3.5	3.4	3.4	3.4	3.4	NEWUOA [31]
NEWUOA	1	1	2	15	17	17	16	16	16	16	(1+1)-ES [1]
(1+1)-ES	1	1	95	680	550	540	510	510	510	500	POEMS [20]
POEMS	1	1	1.2	120	110	110	100	100	100	100	PSO [7]
PSO	1	1	1	120	180	170	170	170	170	170	PSO_Bounds [8]
PSO_Bounds	1	1	1.5	2.9	8.3	34	120	980	4500	62e-7/1e6	Monte Carlo [3]
Monte Carlo	1	1	17	8.1	12	11	11	11	11	11	Rosenbrock [27]
Rosenbrock	1	1	1	4.6	15	17	17	17	17	17	IPOP-SEP-CMA-ES [29]
IPOP-SEP-CMA-ES	1	1	2.1	9.2	11	11	11	11	11	11	VNS (Garcia) [11]
VNS (Garcia)	1	1									

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

	target	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	target
	ERT_{best}/D	0.333	0.333	6.02	56.7	118	121	128	132	134	138	ERT_{best}/D
ALPS	1	1	1	1.8	2.1	4	8.5	12	17	21	28	ALPS [17]
AMaLGaM IDEA	1	1	1	1.1	2.1	56	61	59	58	57	57	AMaLGaM IDEA [4]
avg NEWUOA	1	1	1	2.8	2	2.9	2.9	2.8	2.9	2.9	3.1	avg NEWUOA [31]
BayEDAcG	1	1	1	2	11	48	36e-2/2e3	2	2	2	2	BayEDAcG [10]
BFGS	1	1	1	3.3	2.6	2.1	2.1	2	2	2	2	BFGS [30]
Cauchy EDA	1	1	1	12	230	640	1100	2500	2500	2400	2400	Cauchy EDA [24]
BIPOP-CMA-ES	1	1	1	1.1	6.4	13	14	13	13	13	13	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1	1	3.5	6.8	11	10	9.8	9.7	9.6	9.4	(1+1)-CMA-ES [2]
DASA	1	1	1	20	100	69	75	79	88	98	120	DASA [19]
DEPSO	1	1	1	4.8	4.7	13	14	14	18	26	34	DEPSO [12]
DIRECT	1	1	1	1.5	1	6.3	6.2	7.4	9.8	15	18	DIRECT [25]
EDA-PSO	1	1	1	1.2	3.9	5.4	11	16	22	29	42	EDA-PSO [6]
full NEWUOA	1	1	1	2.3	2	1.8	1.9	1.9	1.9	1.9	2.1	full NEWUOA [31]
G3-PCX	1	1	1	1.4	4.1	10	10	9.8	9.7	9.7	9.6	G3-PCX [26]
simple GA	1	1	1	1	3.5	6.5	27	270	950	1600	3100	simple GA [22]
GLOBAL	1	1	1	1.6	1.6	1	1	1	1	1	1	GLOBAL [23]
iAMaLGaM IDEA	1	1	1	1.6	21	43	44	43	42	43	42	iAMaLGaM IDEA [4]
LSfminbnd	1	1	1	14	13	19	66	62	70	77	150	LSfminbnd [28]
LSstep	1	1	1	64	48	160	240	320	16e-2/1e4	77	150	LSstep [28]
MA-LS-Chain	1	1	1	1.4	3.7	2.7	3.3	3.4	3.5	3.8	4.3	MA-LS-Chain [21]
MCS (Neum)	1	1	1	3.3	1.6	1.2	1.2	4.6	4.6	4.5	4.6	MCS (Neum) [18]
NELDER (Han)	1	1	1	5.5	10	13	13	12	12	12	12	NELDER (Han) [16]
NELDER (Doe)	1	1	1	4.1	2	2.2	2.2	2.1	2	2	2	NELDER (Doe) [5]
NEWUOA	1	1	1	2.8	2.5	5.8	5.8	5.6	5.5	5.5	5.7	NEWUOA [31]
(1+1)-ES	1	1	1	23	17	17	17	17	18	19	20	(1+1)-ES [1]
POEMS	1	1	1	42	170	450	450	420	420	410	410	POEMS [20]
PSO	1	1	1	1.1	130	130	130	120	120	120	120	PSO [7]
PSO_Bounds	1	1	1	1.5	2.2	64	65	67	69	76	88	PSO_Bounds [8]
Monte Carlo	1	1	1	1.7	3	4.8	40	200	1500	7100	30e-7/1e6	Monte Carlo [3]
Rosenbrock	1	1	1	1.7	5.6	5.2	5.3	5.1	5.1	5.1	5	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1	1	1.7	3.9	13	31	30	30	29	29	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	1	1	1.4	10	12	13	13	14	14	15	VNS (Garcia) [11]

Table 23: 03-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

	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT_{best}/D	0.333	0.333	0.867	136	302	405	738	751	764	798	ERT_{best}/D
ALPS	1	1	3.7	12	54	200	370	890	6300	3e4	ALPS [17]
iAMaLGaM IDEA	1	1	3.9	6.3	10	8.9	5.1	5.1	5.1	5.1	iAMaLGaM IDEA [4]
avg NEWUOA	1	1	11	2.5	22	85	150	46e-3/7e3	.	.	avg NEWUOA [31]
BayEDAcG	1	1	3.2	34	11e-1/2e3	.	.	.	.	.	BayEDAcG [10]
BFGS	1	1	17	8.7	110	23e-2/5e3	.	.	.	.	BFGS [30]
Cauchy EDA	1	1	4.1	52	51e-2/5e4	7.1	4.2	4.2	4.2	4.2	Cauchy EDA [24]
BIPOP-CMA-ES	1	1	4.9	6.4	9.3	7.1	12	12	12	12	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	1	1	3.7	2	11	17	12	12	12	12	(1+1)-CMA-ES [2]
DASA	1	1	15	71	880	1700	1900	5400	5300	5100	DASA [19]
DEPSO	1	1	1.9	40	12e-1/2e3	.	.	.	.	.	DEPSO [12]
DIRECT	1	1	4.7	1.5	31	25	15	16	18	22	DIRECT [25]
EDA-PSO	1	1	2.9	23	4900	3700	263	31e-2/1e5	.	.	EDA-PSO [6]
full NEWUOA	1	1	6.7	2.4	15	40	37	170	170	160	full NEWUOA [31]
G3-PCX	1	1	4.9	2.1	14	29	17	30	43	42	G3-PCX [26]
simple GA	1	1	4.3	16	520	3700	88e-3/1e5	.	.	.	simple GA [22]
GLOBAL	1	1	3.1	1.6	3.1	81e-3/1e3	4.3	4.3	4.3	4.3	GLOBAL [23]
iAMaLGaM IDEA	1	1	4.4	8.4	9.7	7.5	4.3	4.3	4.3	4.3	iAMaLGaM IDEA [4]
LSfminbnd	1	1	3.2	7.1	420	31e-2/9e3	.	.	.	.	LSfminbnd [28]
LSstep	1	1	5.6	4.9	490	25e-2/1e4	.	.	.	.	LSstep [28]
MA-LS-Chain	1	1	4.1	2.1	6.7	5.2	2.9	3.1	3.1	3.1	MA-LS-Chain [21]
MCS (Neum)	1	1	1	2.7	12	39	330	77e-4/2e4	.	.	MCS (Neum) [18]
NELDER (Ham)	1	1	3.1	1.4	2.3	1.8	1	1	1	1	NELDER (Ham) [16]
NELDER (Doe)	1	1	6.7	1	1	1	1.1	1.4	1.4	1.4	NELDER (Doe) [5]
NEWUOA	1	1	11	2.7	24	110	68e-3/6e3	.	.	.	NEWUOA [31]
(1+1)-ES	1	1	21	2.9	13	240	510	1500	1800	3500	(1+1)-ES [1]
POEMS	1	1	18	22	130	130	73	75	76	79	POEMS [20]
PSO	1	1	3.2	11	170	360	200	200	200	190	PSO [7]
PSO_Bounds	1	1	1.9	15	460	570	440	450	930	890	PSO_Bounds [8]
Monte Carlo	1	1	2.6	13	2.3e4	13e-2/1e6	.	.	.	.	Monte Carlo [3]
Rosenbrock	1	1	2.4	1.9	10	88	48	31e-3/5e3	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1	4.6	7.1	13	11	5.9	5.9	5.9	5.8	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	1	1	4.6	6.7	27	41	23	23	24	23	VNS (Garcia) [11]

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Table 24: 03-D, running time excess ERT/ERT_{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												ftarget
ERT _{best} /D	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	1e-07	1e-07	1e-07	ERT _{best} /D
ALPS	0.333	1.1	7.9	3.5	34200	2.9	2.9	3	3	3.1	3.1	3.1	ALPS [17]	
AMaLgAM IDEA	1	1.2	1.5	9.7	10	4.5	4.6	4.7	4.7	5.1	5.1	5.1	AMaLgAM IDEA [4]	
avg NEWUOA	1	2.6	3.7	1.2	2.4	64e-2/6e3	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	1	1.3	4.3	40e-1/2e3	.	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	1	1.8	9.3	41e-1/3e3	.	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	1.1	1.7	4.2	100	31e-1/5e4	.	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	1	1	1.3	7.6	7.9	3	4.1	4.9	4.9	4.9	4.9	4.9	BIPOP-CMA-ES [15]	
(1+1)-CMA-ES	1	1	9.2	3.3	91e-2/1e4	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	1	1	69	85	420	37e-2/1e6	.	.	.	.	.	.	DASA [19]
DEPSO	1	1	5.8	48e-1/2e3	.	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	1	1	2.5	39	30e-1/3e4	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	1	1.2	6.4	30e-1/1e5	.	.	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	1	1.7	2.8	1.2	76e-2/6e3	.	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	1	1.1	19	22	10	10e-1/5e4	.	.	.	.	.	.	G3-PCX [26]
simple GA	1	1.1	18	32e-1/1e5	.	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	1	1	3.4	1.1	27e-1/2e3	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLgAM IDEA	1	1.5	5.3	5.8	9.9	8.7	8.7	8.7	8.7	8.8	8.8	8.8	iAMaLgAM IDEA [4]	
LSfminbnd	1	1.1	1.9	6.4	12e-1/1e4	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	3	3.1	6.5	41	35e-1/1e4	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	1	1.1	3.7	30e-1/2e4	.	.	.	.	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	1	1	17	2	1	1	1	1	1	1	1	1	MCS (Neum) [18]	
NELDER (Han)	1	1	20	5.2	10	6.3	6.3	6.3	6.3	6.3	6.3	6.3	NELDER (Han) [16]	
NELDER (Doe)	1	1	2.3	1.5	3.9	2.4	2.4	2.4	2.4	2.4	2.4	2.4	NELDER (Doe) [5]	
NEWUOA	1	1.5	2.5	1	45e-2/6e3	.	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	1	2.5	23	13	40	120	120	120	120	120	120	120	(1+1)-ES [1]	
POEMS	1	58	16	86	42	12	12	12	12	12	12	12	POEMS [20]	
PSO	1	1	4.7	400	31e-1/1e5	.	.	.	.	.	.	.	PSO [7]
PSO.Bounds	1	1.1	9.1	410	42	12	12	12	12	12	12	12	PSO.Bounds [8]	
Monte Carlo	1	1.3	10	450	10e-1/1e6	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	1	1.1	54	36e-1/1e4	.	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	1	1	1	5	13e-1/1e4	IPOP-SEP-CMA-ES [29]	
VNS (Garcia)	1	1.6	2.9	1.6	110	64	64	64	64	65	65	65	VNS (Garcia) [11]	

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