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/$\mathrm{ERT}_{\mathrm{best}}$ on f_1, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

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

Table 2: 03-D, running time excess ERT/$\mathrm{ERT_{best}}$ on f_2, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
$\mathrm{ERT_{best}}$/D	6.04	9.82	12.7	13.8	14.4	14.6	14.8	15.3	15.6	16	$\mathrm{ERT_{best}}$/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]
LSfminbnd	**1.9**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	LSfminbnd [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	*36e-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$_{\text{best}}$ on f_3, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.333	0.733	12.6	274	277	278	281	282	282	284	ERT$_{\text{best}}$/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	*70e-2/2e3*	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.3**	29	42	25	160	150	150	150	150	150	BFGS [30]
Cauchy EDA	**1.1**	41	14	7.6	250	2600	*10e-2/5e4*	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	3.5	**3.2**	4.7	25	25	26	26	26	26	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1.8**	8.1	4	38	38	37	37	37	37	(1+1)-CMA-ES [2]
DASA	**1.3**	32	14	**1.4**	12	12	12	12	12	12	DASA [19]
DEPSO	**1**	**2.4**	11	**2.7**	**4.1**	**4.8**	**5.6**	**5.9**	**7.3**	8.6	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	17	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*	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	42	41	27	410	410	400	400	400	400	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$_{\text{best}}$ on f_4, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separable

ftarget ERT$_{\text{best}}$/D	1e+03 0.333	1e+02 1.8	1e+01 13.5	1e+00 269	1e-01 289	1e-02 307	1e-03 317	1e-04 330	1e-05 338	1e-07 348	ftarget ERT$_{\text{best}}$/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	17	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$_{\text{best}}$ on f_5, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.333	0.333	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	ERT$_{\text{best}}$/D
ALPS	**1**	**1.3**	27	90	98	100	110	110	110	110	ALPS [17]
AMaLGaM IDEA	**1**	**1.1**	11	20	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**	avg NEWUOA [31]
BayEDAcG	**1**	**1.3**	22	360	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**	BFGS [30]
Cauchy EDA	**1**	13	20	22	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	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**	(1+1)-CMA-ES [2]
DASA	**1**	21	19	31	36	40	44	49	53	62	DASA [19]
DEPSO	**1**	**1.4**	15	35	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	DIRECT [25]
EDA-PSO	**1**	**1.3**	8.5	16	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**	full NEWUOA [31]
G3-PCX	**1**	**1.5**	9.4	22	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*	simple GA [22]
GLOBAL	**1**	**1.3**	31	47	47	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	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1.1**	7.5	11	11	11	11	11	11	11	LSfminbnd [28]
LSstep	**1**	28	93	120	120	120	120	120	120	120	LSstep [28]
MA-LS-Chain	**1**	**1.3**	25	88	92	92	93	93	93	93	MA-LS-Chain [21]
MCS (Neum)	**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**	NELDER (Han) [16]
NELDER (Doe)	**1**	**1.5**	**1.4**	**2.4**	**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**	NEWUOA [31]
(1+1)-ES	**1**	**1.6**	**2.3**	**3**	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	POEMS [20]
PSO	**1**	**1.1**	8.2	16	18	18	18	18	18	18	PSO [7]
PSO_Bounds	**1**	**1.3**	6.3	14	15	15	15	15	15	15	PSO_Bounds [8]
Monte Carlo	**1**	**1.2**	34	1.8e4	6.5e6	*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	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1.3**	4.1	6.7	7	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	VNS (Garcia) [11]

Table 6: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_6, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

ftarget ERT$_{\text{best}}$/D	1e+03 1.38	1e+02 2.53	1e+01 11.2	1e+00 18.7	1e-01 30.1	1e-02 38.9	1e-03 49.7	1e-04 61.3	1e-05 71.6	1e-07 88.2	ftarget ERT$_{\text{best}}$/D
ALPS	4.9	3.3	9.2	35	46	53	58	61	64	72	ALPS [17]
AMaLGaM IDEA	4.8	4.3	3.7	5.5	5.5	6.3	6.4	6.6	6.9	7.5	AMaLGaM IDEA [4]
avg NEWUOA	**1.2**	**2.3**	**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	3.4	**2.9**	**2.4**	**2**	**1.8**	**1.9**	3.1	BFGS [30]
Cauchy EDA	24	33	28	31	28	27	26	25	24	25	Cauchy EDA [24]
BIPOP-CMA-ES	**1.6**	**1.6**	**2.4**	3.2	3.1	3.2	3.2	3.1	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+1)-CMA-ES [2]
DASA	33	58	30	32	30	36	55	56	54	66	DASA [19]
DEPSO	**2.4**	3.3	6	11	11	13	14	13	13	14	DEPSO [12]
DIRECT	**1.4**	**1.1**	**3**	33	440	1300	2700	*23e-3/3e4*	.	.	DIRECT [25]
EDA-PSO	3.9	3.4	**2.7**	13	28	42	59	62	66	76	EDA-PSO [6]
full NEWUOA	**1.5**	3.7	4	5.1	5.1	5.4	5.7	6	6.1	6.9	full NEWUOA [31]
G3-PCX	**3**	3.2	3.5	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	270	4200	4400	3800	4400	1.6e4	simple GA [22]
GLOBAL	**2.5**	3.7	5.2	5.5	4	3.3	**2.8**	**2.4**	**2.3**	**2.3**	GLOBAL [23]
iAMaLGaM IDEA	**2.4**	**2**	**2.1**	**2.9**	3.1	3.7	4.1	4.2	4.3	4.8	iAMaLGaM IDEA [4]
LSfminbnd	14	220	490	810	510	400	310	260	220	190	LSfminbnd [28]
LSstep	240	690	1200	990	1e3	820	670	760	670	1700	LSstep [28]
MA-LS-Chain	3.8	4.6	4.3	10	10	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	130	150	210	MCS (Neum) [18]
NELDER (Han)	**1.6**	**1.2**	**1.7**	**1.5**	**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**	NELDER (Doe) [5]
NEWUOA	**1.4**	**1.9**	**2.1**	3.4	3.8	4	4.1	4	4.1	4.8	NEWUOA [31]
(1+1)-ES	**2.1**	3.2	**1.7**	**2**	**1.8**	**1.8**	**2**	**2**	**2.1**	3	(1+1)-ES [1]
POEMS	160	91	31	74	83	93	100	92	99	110	POEMS [20]
PSO	3.8	4	**2.9**	8	13	17	18	22	25	28	PSO [7]
PSO_Bounds	**2.2**	**2.3**	**2.9**	12	26	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**	**1.8**	**1.7**	**1.6**	Rosenbrock [27]
IPOP-SEP-CMA-ES	4.5	3.6	**2.8**	3.7	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	4.6	4.3	4	3.9	3.8	VNS (Garcia) [11]

Table 7: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_7, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

ftarget ERT$_{\text{best}}$/D	1e+03 0.333	1e+02 0.867	1e+01 3.8	1e+00 21.6	1e-01 114	1e-02 155	1e-03 161	1e-04 161	1e-05 161	1e-07 178	ftarget ERT$_{\text{best}}$/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**	210	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	170	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 nal function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

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	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*	.	.	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]
LSfminbnd	10	4.4	24	810	2800	2400	2300	2200	*96e-2/1e4*	.	LSfminbnd [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$_{\text{best}}$ on f_9, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

ftarget ERT$_{\text{best}}$/D	1e+03 0.333	1e+02 0.333	1e+01 6.93	1e+00 21.8	1e-01 42.4	1e-02 49.7	1e-03 53.2	1e-04 54.9	1e-05 56.3	1e-07 59.4	ftarget ERT$_{\text{best}}$/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 (Han)	**5.2**	**12**	**1.2**	**1.2**	**1**	**1**	**1.1**	**1.1**	**1.2**	**1.3**	NELDER (Han) [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$_{\text{best}}$ on f_{10}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	9.71	18	38	50.7	55.9	60.2	64.5	68.8	72.8	80.6	ERT$_{\text{best}}$/D
ALPS	23	38	50	120	360	700	1300	1900	2600	7100	ALPS [17]
AMaLGaM IDEA	3.2	3	**2**	**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	5.8	6.9	7.9	8.8	9.5	11	avg NEWUOA [31]
BayEDAcG	88	1600	*37e+1/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.4**	**1**	**1**	**1.2**	**1.2**	**1.2**	**1.4**	**1.5**	5.9	76	BFGS [30]
Cauchy EDA	13	9.4	6.3	6.2	6.7	7.3	7.8	8.3	8.7	9.5	Cauchy EDA [24]
BIPOP-CMA-ES	8.1	5.6	4.1	4.1	4.6	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**	3	3.1	3	3	3	(1+1)-CMA-ES [2]
DASA	130	180	1.1e4	4.4e4	2.5e5	*24e-1/1e6*	.	.	.	.	DASA [19]
DEPSO	13	35	67	110	*55e-1/2e3*	.	.	.	.	.	DEPSO [12]
DIRECT	4.1	8.4	7.6	49	120	160	490	480	1e3	2e3	DIRECT [25]
EDA-PSO	20	66	210	2400	4200	7e3	1.1e4	*61e-2/1e5*	.	.	EDA-PSO [6]
full NEWUOA	**1**	**1.6**	**1.6**	**2.6**	3.9	4.4	4.9	5.6	6	7.1	full NEWUOA [31]
G3-PCX	8.8	7.2	14	21	28	30	36	39	41	42	G3-PCX [26]
simple GA	30	90	200	2e3	1.2e4	*55e-2/1e5*	.	.	.	.	simple GA [22]
GLOBAL	9.9	6	3.3	**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**	**2.6**	**2.9**	**3**	3.1	3.2	3.3	iAMaLGaM IDEA [4]
LSfminbnd	340	480	1700	2800	2500	*61e+0/1e4*	.	.	.	.	LSfminbnd [28]
LSstep	1100	2400	1700	*53e+1/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	16	13	9.6	11	12	12	13	12	12	12	MA-LS-Chain [21]
MCS (Neum)	23	14	67	170	820	4100	3800	*29e-2/2e4*	.	.	MCS (Neum) [18]
NELDER (Han)	**1.8**	**1.3**	**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**	NELDER (Doe) [5]
NEWUOA	**1.4**	**1.3**	**2.8**	5.2	8.3	10	12	13	14	16	NEWUOA [31]
(1+1)-ES	28	320	2100	6200	1.2e4	2.3e4	7.6e4	*36e-4/1e6*	.	.	(1+1)-ES [1]
POEMS	49	72	410	1600	5300	1.2e4	*51e-2/1e5*	.	.	.	POEMS [20]
PSO	9.2	12	59	1100	2400	3600	4800	6700	6500	1.8e4	PSO [7]
PSO_Bounds	13	31	2100	8e3	1.2e4	1.1e4	2.2e4	2.1e4	2e4	1.8e4	PSO_Bounds [8]
Monte Carlo	34	210	2100	6e4	2.5e5	*11e-1/1e6*	.	.	.	.	Monte Carlo [3]
Rosenbrock	**2.6**	3.9	8.5	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	9.6	9.2	8.8	8.5	8.2	7.8	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	9.3	7.1	5.9	6	5.9	5.8	5.7	5.6	5.5	5.3	VNS (Garcia) [11]

Table 11: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{11}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

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

Table 12: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{12}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	9.78	13.2	21.6	55.9	113	134	148	208	232	263	ERT$_{\text{best}}$/D
ALPS	73	85	94	100	170	460	1600	3400	1.4e4	9.3e4	ALPS [17]
AMaLGaM IDEA	5.9	6.4	4.7	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**	**1.8**	**1.8**	**1.9**	avg NEWUOA [31]
BayEDAcG	27	26	67	82	120	220	*38e-1/2e3*	.	.	.	BayEDAcG [10]
BFGS	**1.9**	**1.5**	**1.7**	**1.4**	**1**	**1**	**1**	**2**	**2.3**	43	BFGS [30]
Cauchy EDA	26	26	34	26	17	16	16	13	13	13	Cauchy EDA [24]
BIPOP-CMA-ES	5.2	4.8	7.9	5.7	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	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	*81e-1/1e6*	.	.	.	.	DASA [19]
DEPSO	24	25	80	160	260	*67e-1/2e3*	.	.	.	.	DEPSO [12]
DIRECT	4.6	4.6	7	6.5	5.7	10	58	53	49	240	DIRECT [25]
EDA-PSO	190	260	960	1700	5900	1.1e4	9500	6800	*91e-2/1e5*	.	EDA-PSO [6]
full NEWUOA	**1**	**1.9**	**2.9**	**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	8.9	9.5	9.9	8	7.9	8.1	G3-PCX [26]
simple GA	200	380	430	2400	1.3e4	1.1e4	*11e-1/1e5*	.	.	.	simple GA [22]
GLOBAL	11	8.6	5.9	3.1	**2**	**2.4**	**2.4**	**2.2**	**2.8**	4	GLOBAL [23]
iAMaLGaM IDEA	4.1	4.4	9.6	8	6.1	6	5.9	4.7	4.7	4.6	iAMaLGaM IDEA [4]
LSfminbnd	6	6.2	700	1200	*14e+0/1e4*	.	.	.	.	.	LSfminbnd [28]
LSstep	87	73	1400	790	400	*34e+0/1e4*	.	.	.	.	LSstep [28]
MA-LS-Chain	16	14	25	15	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**	**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**	**1**	**1.1**	NELDER (Han) [16]
NELDER (Doe)	**1.5**	**1.4**	**1.8**	**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**	**1.3**	**1**	**1.1**	**1.2**	NEWUOA [31]
(1+1)-ES	**2.7**	7200	2.8e4	2.7e4	3.9e4	1.1e5	*12e-1/1e6*	.	.	.	(1+1)-ES [1]
POEMS	100	170	1800	1600	3800	5e3	*69e-2/1e5*	.	.	.	POEMS [20]
PSO	30	41	2400	2700	5800	1e4	*33e-1/1e5*	.	.	.	PSO [7]
PSO_Bounds	110	280	2e3	2200	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	9.4	8.9	6.9	7.4	11	Rosenbrock [27]
IPOP-SEP-CMA-ES	5.4	5.6	10	10	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	5.6	5.6	4.6	4.4	4.4	VNS (Garcia) [11]

Table 13: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{13}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.533	5.6	16.4	28.3	36.2	45.3	71.7	84.9	93.8	122	ERT$_{\text{best}}$/D
ALPS	**1.5**	12	48	66	100	200	410	1600	5400	2.2e4	ALPS [17]
AMaLGaM IDEA	**1.4**	4.3	3.7	3.9	4.2	4.3	3.4	3.4	3.5	3.4	AMaLGaM IDEA [4]
avg NEWUOA	**2.5**	**1**	5.6	14	42	110	160	280	260	*36e-4/8e3*	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	410	*25e-6/9e3*	BFGS [30]
Cauchy EDA	39	22	14	12	12	12	9.4	9.2	9.6	9.3	Cauchy EDA [24]
BIPOP-CMA-ES	**1.6**	**2.6**	3.7	3.8	5	6.1	4.5	4.4	4.8	4.6	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	6	(1+1)-CMA-ES [2]
DASA	18	52	320	1100	1600	6100	2e4	4e4	1.5e5	*46e-5/1e6*	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	61	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	680	*51e-5/9e3*	full NEWUOA [31]
G3-PCX	**1.5**	4.8	20	73	97	110	160	220	230	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**	**2.5**	iAMaLGaM IDEA [4]
LSfminbnd	5.9	14	120	220	620	1500	*39e-2/1e4*	.	.	.	LSfminbnd [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	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**	**1**	NELDER (Han) [16]
NELDER (Doe)	**1.5**	**1.3**	**1**	**1.1**	**1.2**	**1.3**	**1.2**	**1.2**	**1.2**	**1.1**	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	3300	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	1.5e4	*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	130	320	Rosenbrock [27]
IPOP-SEP-CMA-ES	**2.6**	3	8.6	15	16	13	8.9	8.5	8.3	7.1	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	9.8	7.1	6	7.8	12	8.5	7.8	7.5	7.2	VNS (Garcia) [11]

Table 14: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{14}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

ftarget ERT$_{\text{best}}$/D	1e+03 0.333	1e+02 0.333	1e+01 0.733	1e+00 5.76	1e-01 9.47	1e-02 14.4	1e-03 23.8	1e-04 30.7	1e-05 36.7	1e-07 64.8	ftarget ERT$_{\text{best}}$/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**	58	120	110	250	280	780	*28e-4/2e3*	BayEDAcG [10]
BFGS	**1**	**2.1**	3.7	**1.5**	**1.5**	**1.3**	**1.1**	**1**	**1**	29	BFGS [30]
Cauchy EDA	**1**	**1**	20	15	17	18	14	14	14	11	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1.3**	3.1	**2.9**	3.5	4.2	4.4	6.4	7.1	5.9	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1.1**	**2.1**	**1.4**	**2.2**	**2.6**	**2.9**	4	4.2	3.6	(1+1)-CMA-ES [2]
DASA	**1**	13	43	24	20	23	51	400	2900	4.8e4	DASA [19]
DEPSO	**1**	**1**	**1.5**	4.9	12	16	17	26	130	*11e-6/2e3*	DEPSO [12]
DIRECT	**1**	**1**	**1.8**	**1.7**	**2.7**	5.5	17	45	110	480	DIRECT [25]
EDA-PSO	**1**	**1.1**	**1.8**	4.2	11	21	76	130	190	6500	EDA-PSO [6]
full NEWUOA	**1**	**1.3**	6.2	**1.4**	**1.2**	**1**	**1**	**1.5**	**2.3**	4.4	full NEWUOA [31]
G3-PCX	**1**	**1.1**	**2**	4	4.6	4.2	4.9	11	45	280	G3-PCX [26]
simple GA	**1**	**1**	**1.9**	10	160	280	320	1600	6e3	*25e-6/1e5*	simple GA [22]
GLOBAL	**1**	**1**	**2.5**	8.4	11	7.4	5.1	4.8	12	*11e-6/300*	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1.4**	**2.7**	**2.4**	3.2	3.7	3.1	3.2	3.6	**3.2**	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1**	7.2	4.4	3.5	6.1	67	600	*31e-5/1e4*	.	LSfminbnd [28]
LSstep	**1**	29	210	84	70	160	930	*22e-4/1e4*	.	.	LSstep [28]
MA-LS-Chain	**1**	**1.1**	**1.8**	6.7	11	12	9.8	11	15	13	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**2.5**	12	11	7.9	5.7	6	50	*20e-7/2e4*	MCS (Neum) [18]
NELDER (Han)	**1**	**1.3**	**1.9**	**1**	**1.2**	**1.3**	**1.2**	**1.3**	**1.3**	**1**	NELDER (Han) [16]
NELDER (Doe)	**1**	**1**	**2.7**	**1.1**	**1.4**	**1.8**	**1.5**	**1.5**	**1.6**	**1.2**	NELDER (Doe) [5]
NEWUOA	**1**	**1.1**	4.1	**1.1**	**1**	**1**	**1.2**	**2.1**	3	17	NEWUOA [31]
(1+1)-ES	**1**	**1.1**	**2.2**	**1.8**	**1.9**	**2.5**	5.8	110	2400	*16e-7/1e6*	(1+1)-ES [1]

3.527 7.97 re f Q 0 g 0 G BT /F31 6.9738 Tf 583.842 193.831 Td [(1)]TJ 1 g -ES [10.99608 rg 0.92549 0.95294 0.99608 RG ET q 1 0 0 1 602.863 199.41 cm 0 0 33.527 7..97 re f Q 0 g 0 G BT /F31 6.9738 Tf 583.842 17.831 Td [(1.1)]33.g

Table 15: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{15}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

ftarget ERT$_{\text{best}}$/D	1e+03 0.333	1e+02 0.778	1e+01 40.5	1e+00 457	1e-01 2100	1e-02 2760	1e-03 2810	1e-04 2860	1e-05 2930	1e-07 3010	ftarget ERT$_{\text{best}}$/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**	27	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$_{\text{best}}$ on f_{16}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.333	0.4	13.6	106	194	263	621	720	1070	1120	ERT$_{\text{best}}$/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]
LSfminbnd	**1**	**1.2**	**1.6**	3.5	19	50	100	*12e-3/9e3*	.	.	LSfminbnd [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**	**3.4**	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*	.	NEWUOA [31]
(1+1)-ES	**1**	**1.8**	8.6	18	40	57	120	200	230	4e3	(1+1)-ES [1]
POEMS	**1**	120	16	24	71	210	96	84	57	57	POEMS [20]
PSO	**1**	**1.6**	**1.5**	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$_{\text{best}}$ on f_{17}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.333	0.333	1.2	26.2	93.9	164	378	602	782	1160	ERT$_{\text{best}}$/D
ALPS	**1**	**1.2**	**2.4**	11	13	15	9.2	8.3	8.5	8.8	ALPS [17]
AMaLGaM IDEA	**1**	**1.3**	3.3	**1.5**	**1**	**1**	**2.6**	3.1	3.9	3	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**1.9**	3.3	8	13	150	*32e-3/5e3*	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	**1.7**	**2.3**	6.7	7.6	17	9.7	16	*32e-4/2e3*	.	BayEDAcG [10]
BFGS	**1**	**2.1**	48	44	*44e-2/2e3*	.	.	.	.	.	BFGS [30]
Cauchy EDA	1	4.9	24	7.3	4.1	3.6	**2.2**	**1.8**	**1.8**	**1.6**	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1.2**	5.3	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	7.9	32	37	75	58	*76e-5/1e4*	(1+1)-CMA-ES [2]
DASA	**1**	15	65	49	110	480	900	990	3900	1.2e4	DASA [19]
DEPSO	**1**	**1.3**	5.1	4	3.5	3.5	**2.3**	**2.2**	**2.3**	5	DEPSO [12]
DIRECT	**1**	**1**	**1.2**	**1**	**1.2**	**1.5**	**1**	**1**	**1**	**1.2**	DIRECT [25]
EDA-PSO	**1.1**	**1.3**	**2.3**	4	17	29	20	17	17	16	EDA-PSO [6]
full NEWUOA	**1**	**1.7**	3.9	5.5	7.3	31	53	*35e-4/6e3*	.	.	full NEWUOA [31]
G3-PCX	**1**	**1.3**	**2.6**	33	39	48	47	110	290	640	G3-PCX [26]
simple GA	**1**	**1.1**	**1.4**	30	57	72	72	65	120	*58e-8/1e5*	simple GA [22]
GLOBAL	**1**	**1.5**	**3**	4.2	7.3	21	*98e-3/400*	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1.4**	**2.4**	**1**	3.1	**2.7**	3.1	4.4	3.6	**3**	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1.2**	14	8.2	30	140	*21e-3/1e4*	.	.	.	LSfminbnd [28]
LSstep	**1**	**1.5**	71	200	100	880	*69e-3/1e4*	.	.	.	LSstep [28]
MA-LS-Chain	**1**	**1.4**	**2.1**	3.4	4	4.9	3.1	**2.6**	**2.3**	**2**	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1**	**2.5**	5.6	16	180	*35e-4/2e4*	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	62	22	44	95	95	110	250	400	NELDER (Han) [16]
NELDER (Doe)	**1**	**1.2**	**1.9**	3.7	8.5	36	69	*12e-4/2e4*	.	.	NELDER (Doe) [5]
NEWUOA	**1**	**1.6**	**2.7**	9	19	140	*32e-3/5e3*	.	.	.	NEWUOA [31]
(1+1)-ES	**1**	**2.5**	24	33	870	2300	4100	*12e-4/1e6*	.	.	(1+1)-ES [1]
POEMS	**1**	93	140	20	23	28	17	18	16	15	POEMS [20]
PSO	**1**	**1.1**	**2.8**	4.4	80	55	26	18	15	14	PSO [7]
PSO_Bounds	**1**	**1.3**	**2.5**	4.7	14	21	14	13	25	28	PSO_Bounds [8]
Monte Carlo	**1**	**1.1**	**2.4**	30	7200	*92e-3/1e6*	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	**1.3**	81	2200	*20e-1/8e3*	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1.2**	**2.8**	**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**	**1.2**	**1.7**	**1.3**	**2**	4.8	18	VNS (Garcia) [11]

Table 18: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{18}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.333	0.4	13.4	48.2	430	1030	1170	1310	1580	1840	ERT$_{\text{best}}$/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) [11]

Table 19: 03-D, running time excess ERT / ERT_{best} on f_{19}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Table 20: 03-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_{20}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	1.84	2.6	2.76	128	764	799	827	842	858	925	$\mathrm{ERT}_{\mathrm{best}}$/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	*13e-1/2e3*	.	.	.	.	.	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	*31e-2/5e4*	.	.	.	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	*42e-2/1e4*	.	.	.	.	.	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	1600	*94e-3/1e6*	.	.	.	.	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]

Table 21: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{21}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

ftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	ftarget
ERT$_{\text{best}}$/D	0.333	0.333	1.98	61.3	142	146	153	155	156	161	ERT$_{\text{best}}$/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*	.	.	.	.	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**	16	11	240	240	500	650	890	860	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1**	**1.7**	6.8	6	6.1	6	6	6.1	6.1	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1**	**1.9**	4.5	8.1	8	7.7	7.6	7.5	7.4	(1+1)-CMA-ES [2]
DASA	**1**	**1**	12	93	66	65	62	62	62	61	DASA [19]
DEPSO	**1**	**1**	**1.2**	4.1	3.5	4.6	5.3	6.6	7.1	7.5	DEPSO [12]
DIRECT	**1**	**1**	**1.9**	**1**	**1.4**	**1.4**	**1.4**	3.8	4.2	5.8	DIRECT [25]
EDA-PSO	**1**	**1**	**1.4**	3.2	54	55	58	59	62	65	EDA-PSO [6]
full NEWUOA	**1**	**1**	**2.4**	3.3	**2.8**	**2.7**	**2.6**	**2.6**	**2.6**	**2.6**	full NEWUOA [31]
G3-PCX	**1**	**1**	**1.6**	8.6	5.7	5.6	5.4	5.4	5.4	5.4	G3-PCX [26]
simple GA	**1**	**1**	**1.5**	**2.5**	5.3	18	29	43	99	230	simple GA [22]
GLOBAL	**1**	**1**	**1.8**	**1.4**	**1**	**1**	**1**	**1**	**1**	**1**	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1**	**1.6**	28	20	19	19	18	18	18	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1**	6.1	21	27	26	31	38	39	46	LSfminbnd [28]
LSstep	**1**	**1**	15	210	200	190	190	200	200	220	LSstep [28]
MA-LS-Chain	**1**	**1**	**1.7**	**1.7**	9.7	9.8	9.6	9.7	9.7	9.7	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	6.2	**2.1**	4.4	4.3	4.1	4.1	4.1	4.2	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	**1.6**	16	26	25	24	23	23	23	NELDER (Han) [16]
NELDER (Doe)	**1**	**1**	**2**	**2.8**	**2.9**	**2.8**	**2.7**	**2.7**	**2.7**	**2.6**	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1.6**	**2.7**	3.5	3.5	3.4	3.4	3.4	3.4	NEWUOA [31]
(1+1)-ES	**1**	**1**	**2**	15	17	17	16	16	16	16	(1+1)-ES [1]
POEMS	**1**	**1**	95	680	550	540	510	510	510	500	POEMS [20]
PSO	**1**	**1**	**1.2**	120	110	110	100	100	100	100	PSO [7]
PSO_Bounds	**1**	**1**	**1**	120	180	170	170	170	170	170	PSO_Bounds [8]
Monte Carlo	**1**	**1**	**1.5**	**2.9**	8.3	34	120	980	4500	*62e-7/1e6*	Monte Carlo [3]
Rosenbrock	**1**	**1**	17	8.1	12	11	11	11	11	11	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1**	**1**	4.6	15	17	17	17	17	17	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1**	**2.1**	9.2	11	11	11	11	11	11	VNS (Garcia) [11]

Table 22: 03-D, running time excess ERT/ERT_{best} on f_{22}, in italics is given the median nal function value and the median [redacted] function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

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	6.02	56.7	118	121	128	132	134	138	ERT_{best}/D [redacted]
ALPS	**1**	**1**	**1.8**	**2.1**	4	8.5	12	17	21	28	ALPS [17] [redacted]
AMaLGaM IDEA	**1**	**1**	**1.1**	21	56	61	59	58	57	57	AMaLGaM IDEA [redacted]
avg NEWUOA	**1**	**1**	**2.8**	**2**	**2.9**	**2.9**	**2.8**	**2.9**	**2.9**	3.1	avg NEWUOA [31 [redacted]
BayEDAcG	**1**	**1**	**2**	11	48	*36e-2/2e3*	.	.	.	.	BayEDAcG [10] [redacted]
BFGS	**1**	**1**	3.3	**2.6**	**2.1**	**2.1**	**2**	**2**	**2**	**2**	BFGS [30] [redacted]
Cauchy EDA	**1**	**1**	12	230	640	1100	2500	2500	2400	2400	Cauchy EDA [24 [redacted]
BIPOP-CMA-ES	**1**	**1**	**1.1**	6.4	13	14	13	13	13	13	BIPOP-CMA-ES [redacted]
(1+1)-CMA-ES	**1**	**1**	3.5	6.8	11	10	9.8	9.7	9.6	9.4	(1+1)-CMA-ES [redacted]
DASA	**1**	**1**	20	100	69	75	79	88	98	120	DASA [19] [redacted]
DEPSO	**1**	**1**	4.8	4.7	13	14	14	18	26	34	DEPSO [12] [redacted]
DIRECT	**1**	**1**	**1.5**	**1**	6.3	6.2	7.4	9.8	15	18	DIRECT [25] [redacted]
EDA-PSO	**1**	**1**	**1.2**	3.9	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
full NEWUOA	**1**	**1**	**2.3**	**2**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
G3-PCX	**1**	**1**	**1.4**	4.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
simple GA	**1**	**1**	**1**	3.5	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
GLOBAL	**1**	**1**	**1.6**	**1.6**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
iAMaLGaM IDEA	**1**	**1**	**1.6**	21	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
LSfminbnd	**1**	**1**	14	13	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
LSstep	**1**	**1**	64	48	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MA-LS-Chain	**1**	**1**	**1.4**	3.7	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MCS (Neum)	**1**	**1**	3.3	**1.6**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NELDER (Han)	**1**	**1**	5.5	10	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NELDER (Doe)	**1**	**1**	4.1	**2**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NEWUOA	**1**	**1**	**2.8**	**2.5**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(1+1)-ES	**1**	**1**	23	17	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
POEMS	**1**	**1**	42	170	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
PSO	**1**	**1**	**1.1**	130	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
PSO_Bounds	**1**										

Table 23: 03-D, running time excess ERT / $\mathrm{ERT}_{\mathrm{best}}$ on f_{23}

Table 24: 03-D, running time excess ERT/ERT$_{\text{best}}$ on f_{24}, in italics is given the median nal function value and the median number of function evaluations to reach this value divided by dimension

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ftarget ERT$_{\text{best}}$/D	1e+03 0.333	1e+02 0.333	1e+01 32.2	1e+00 3460	1e-01 34200	1e-02 1.19e5	1e-03 1.19e5	1e-04 1.19e5	1e-05 1.19e5	1e-07 1.19e5	ftarget ERT$_{\text{best}}$/D
ALPS	**1**	**1.1**	7.9	3.5	6.2	**2.9**	**2.9**	**3**	**3**	**3.1**	ALPS [17]
AMaLGaM IDEA	**1**	**1.2**	**1.5**	9.7	10	4.5	4.6	4.7	4.7	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	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	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**	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	20	5.2	10	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**	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	(1+1)-ES [1]
POEMS	**1**	58	16	86	42	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	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	65	110	VNS (Garcia) [11]

References

[1] Anne Auger. Benchmarking the (1+1) evolution strategy with one- fth success rule on the BBOB-2009 function testbed. In Rothlauf [32], pages 2447{2452.

[2] Anne Auger and Nikolaus Hansen. Benchmarking the (1+1)-CMA-ES on the BBOB-2009 function testbed. In Rothlauf [32], pages 2459{2466.

[3] Anne Auger and Raymond Ros. Benchmarking the pure random search on the BBOB-2009 testbed. In Rothlauf [32], pages 2479{2484.

[4] Peter A. N. Bosman, Jorn Grahl, and Dirk Thierens. AMaLGaM IDEAs in noiseless black-box optimization benchmarking. In Rothlauf [32], pages 2247{2254.

[5] Benjamin Doerr, Mahmoud Fouz, Martin Schmidt, and Magnus Wahlstrom. BBOB: Nelder-mead with resize and halfruns. In Rothlauf [32], pages 2239{2246.

[6] Mohammed El-Abd and Mohamed S. Kamel. Black-box optimization benchmarking for noiseless function testbed using an EDA and PSO hybrid. In Rothlauf [32], pages 2263{2268.

[7] Mohammed El-Abd and Mohamed S. Kamel. Black-box optimization benchmarking for noiseless function testbed using particle swarm optimization. In Rothlauf [32], pages 2269{2274.

[8] Mohammed El-Abd and Mohamed S. Kamel. Black-box optimization benchmarking for noiseless function testbed using PSO_Bounds. In Rothlauf [32], pages 2275{2280.

[9] S. Finck, N. Hansen, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Presentation of the noiseless functions. Technical Report 2009/20, Research Center PPE, 2009.

[10] Marcus Gallagher. Black-box optimization benchmarking: results for the BayEDAcG algorithm on the noiseless function testbed. In Rothlauf [32], pages 2281{2286.

[11] Carlos Garc a-Mart nez and Manuel Lozano. A continuous variable neighbourhood search based on specialised EAs: application to the noiseless BBO-benchmark 2009. In Rothlauf [32], pages 2287{2294.

[12] Jose Garc a-Nieto, Enrique Alba, and Javier Apolloni. Noiseless functions black-box optimization: evaluation of a hybrid particle swarm with di erential operators. In Rothlauf [32], pages 2231{2238.

[13] N. Hansen, A. Auger, S. Finck, and R. Ros. Real-parameter black-box optimization benchmarking 2009: Experimental setup. Technical Report RR-6828, INRIA, 2009.

[14] N. Hansen, S. Finck, R. Ros, and A. Auger. Real-parameter black-box optimization benchmarking 2009: Noiseless functions de nitions. Technical Report RR-6829, INRIA, 2009.

[15] Nikolaus Hansen. Benchmarking a bi-population CMA-ES on the BBOB-2009 function testbed. In Rothlauf [32], pages 2389{2396.

[16] Nikolaus Hansen. Benchmarking the nelder-mead downhill simplex algorithm with many local restarts. In Rothlauf [32], pages 2403{2408.

[17] Gregory S. Hornby. The Age-Layered Population Structure (ALPS) evolutionary algorithm, July 2009. Noiseless testbed.

[18] Waltraud Huyer and Arnold Neumaier. Benchmarking of MCS on the noiseless function testbed. `http://www.mat.univie.ac.at/~neum/papers.html`, 2009. P. 989.

[19] Peter Korosec and Jurij Silc. A stigmergy-based algorithm for black-box optimization: noiseless function testbed. In Rothlauf [32], pages 2295{2302.

[20] Jir Kubalik. Black-box optimization benchmarking of prototype optimization with evolved improvement steps for noiseless function testbed. In Rothlauf [32], pages 2303{2308.

[21] Daniel Molina, Manuel Lozano, and Francisco Herrera. A memetic algorithm using local search chaining for black-box optimization benchmarking 2009 for noise free functions. In Rothlauf [32], pages 2255{2262.

[22] Miguel Nicolau. Application of a simple binary genetic algorithm to a noiseless testbed benchmark. In Rothlauf [32], pages 2473{2478.

[23] Laszlo Pal, Tibor Csendes, Mihaly Csaba Markot, and Arnold Neumaier. BBO-benchmarking of the GLOBAL method for the noiseless function testbed. `http://www.mat.univie.ac.at/~neum/papers.html`, 2009. P. 986.

[24] Petr Posik. BBOB-benchmarking a simple estimation of distribution algorithm with Cauchy distribution. In Rothlauf [32], pages 2309{2314.

[25] Petr Posik. BBOB-benchmarking the DIRECT global optimization algorithm. In Rothlauf [32], pages 2315{2320.

[26] Petr Posik. BBOB-benchmarking the generalized generation gap model with parent centric crossover. In Rothlauf [32], pages 2321{2328.

[27] Petr Posik. BBOB-benchmarking the Rosenbrock's local search algorithm. In Rothlauf [32], pages 2337{2342.

[28] Petr Posik. BBOB-benchmarking two variants of the line-search algorithm. In Rothlauf [32], pages 2329{2336.

[29] Raymond Ros. Benchmarking sep-CMA-ES on the BBOB-2009 function testbed. In Rothlauf [32], pages 2435{2440.

[30] Raymond Ros. Benchmarking the BFGS algorithm on the BBOB-2009 function testbed. In Rothlauf [32], pages 2409{2414.

[31] Raymond Ros. Benchmarking the NEWUOA on the BBOB-2009 function testbed. In Rothlauf [32], pages 2421{2428.

[32] Franz Rothlauf, editor. *Genetic and Evolutionary Computation Conference, GECCO 2009, Proceedings, Montreal, Quebec, Canada, July 8-12, 2009, Companion Material*. ACM, 2009.