Comparison tables: BBOB 2009 function testbed in 20-D

The BBOBies

November 20, 2009

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: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_1, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.28	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	64	150	320	520	710	920	1100	1400	1800	ALPS [17]
AMaLGaM IDEA	**1**	58	55	130	200	260	320	390	440	550	AMaLGaM IDEA [4]
avg NEWUOA	**1**	18	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	avg NEWUOA [31]
BayEDAcG	**1**	49	110	200	310	410	500	610	710	1e3	BayEDAcG [10]
BFGS	**1**	**7.4**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	BFGS [30]
Cauchy EDA	**1**	840	730	1600	2500	3500	4300	5200	6100	7800	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	9.2	7.9	14	20	26	33	39	45	57	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	12	5.4	9.2	13	17	21	25	29	37	(1+1)-CMA-ES [2]
DASA	**1**	60	26	45	66	86	120	150	200	300	DASA [19]
DEPSO	**1**	31	30	81	190	330	560	810	1400	*44e-7/2e3*	DEPSO [12]
DIRECT	**1**	8.6	48	110	220	360	490	680	870	1400	DIRECT [25]
EDA-PSO	**1**	19	450	1100	1700	2300	2900	3600	4200	5400	EDA-PSO [6]
full NEWUOA	**1**	41	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	full NEWUOA [31]
G3-PCX	**1**	31	8	13	18	23	27	32	37	48	G3-PCX [26]
simple GA	**1**	130	880	1900	3200	1.2e4	3.1e4	2e5	6.7e5	*74e-5/1e5*	simple GA [22]
GLOBAL	**1**	37	8	8	8	8	8	8	8	8	GLOBAL [23]
iAMaLGaM IDEA	**1**	13	27	57	88	120	150	180	210	270	iAMaLGaM IDEA [4]
LSfminbnd	**1**	43	9.3	10	10	10	10	10	10	10	LSfminbnd [28]
LSstep	**1**	850	160	170	180	180	180	180	180	180	LSstep [28]
MA-LS-Chain	**1**	19	21	51	78	100	120	140	160	200	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**2.4**	6.4	6.8	7	7	7	7	7	MCS (Neum) [18]
NELDER (Han)	**1**	9.1	5.2	12	19	27	32	36	40	49	NELDER (Han) [16]
NELDER (Doe)	**1**	**6.8**	3.3	6.7	11	16	21	27	32	40	NELDER (Doe) [5]
NEWUOA	**1**	7.5	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	NEWUOA [31]
(1+1)-ES	**1**	11	4.9	8.1	11	15	18	22	25	31	(1+1)-ES [1]
POEMS	**1**	830	180	400	870	1400	1800	2300	2800	3800	POEMS [20]
PSO	**1**	16	22	3400	3400	3500	3600	3600	3700	3800	PSO [7]
PSO_Bounds	**1**	19	120	1500	2100	2800	3300	3800	4500	1.6e4	PSO_Bounds [8]
Monte Carlo	**1**	170	*29e+0/1e6*	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	19	3.8	5.8	7.2	9.1	11	12	14	17	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	13	7.1	12	18	23	29	34	39	50	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	28	10	17	23	29	36	41	48	60	VNS (Garcia) [11]

Table 2: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_2, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	18.6	19	19.2	19.3	19.3	19.4	19.5	19.5	19.6	19.7	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	45	66	88	110	140	160	190	220	260	370	ALPS [17]
AMaLGaM IDEA	22	29	35	43	50	56	62	68	76	88	AMaLGaM IDEA [4]
avg NEWUOA	3.5	10	21	43	63	89	120	140	160	200	avg NEWUOA [31]
BayEDAcG	31	42	54	64	76	94	100	*34e-5/2e3*	.	.	BayEDAcG [10]
BFGS	9.1	15	20	24	26	27	27	27	28	28	BFGS [30]
Cauchy EDA	190	310	410	510	610	710	800	900	990	1200	Cauchy EDA [24]
BIPOP-CMA-ES	15	26	35	40	44	45	47	47	48	50	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	14	22	30	37	39	41	41	42	43	44	(1+1)-CMA-ES [2]
DASA	5.6	7.8	10	14	18	23	28	34	39	49	DASA [19]
DEPSO	12	23	42	66	110	500	*39e-3/2e3*	.	.	.	DEPSO [12]
DIRECT	38	53	130	470	490	510	540	1200	*14e-1/5e3*	.	DIRECT [25]
EDA-PSO	200	270	330	400	470	540	600	670	740	880	EDA-PSO [6]
full NEWUOA	23	94	450	3800	*47e-1/1e4*	.	.	.	.	.	full NEWUOA [31]
G3-PCX	15	47	130	210	320	420	550	650	760	990	G3-PCX [26]
simple GA	300	460	3200	6800	7.3e4	*29e-1/1e5*	.	.	.	.	simple GA [22]
GLOBAL	8.4	13	18	23	26	30	33	49	51	63	GLOBAL [23]
iAMaLGaM IDEA	11	17	22	27	30	33	36	40	43	49	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	LSfminbnd [28]
LSstep	17	17	17	17	17	17	17	17	17	17	LSstep [28]
MA-LS-Chain	7.6	11	15	19	23	27	32	36	43	76	MA-LS-Chain [21]
MCS (Neum)	**1**	**2.2**	**5.4**	14	21	41	43	45	45	*30e-8/4e3*	MCS (Neum) [18]
NELDER (Han)	4.3	6	7	**7.8**	**8.6**	**9.2**	**9.7**	**10**	**11**	**12**	NELDER (Han) [16]
NELDER (Doe)	5.3	8.5	13	17	19	23	28	32	36	48	NELDER (Doe) [5]
NEWUOA	**1.9**	6.8	18	42	71	92	130	150	170	220	NEWUOA [31]
(1+1)-ES	270	1800	6900	1.6e4	2.6e4	3.8e4	7.4e4	1.8e5	3.7e5	*59e-5/1e6*	(1+1)-ES [1]
POEMS	150	190	250	300	340	410	450	500	560	660	POEMS [20]
PSO	16	1900	4600	4600	4600	4600	4500	4500	4500	4500	PSO [7]
PSO_Bounds	120	230	360	530	840	1400	1800	2100	2300	2600	PSO_Bounds [8]
Monte Carlo	*12e+4/1e6*	.	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	**1.2**	**1.4**	**1.6**	**5.8**	18	29	66	73	73	Rosenbrock [27]
IPOP-SEP-CMA-ES	4.8	6.2	7.5	8.3	9.1	**9.7**	**10**	**11**	**11**	**13**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	35	57	72	82	88	95	97	98	98	99	VNS (Garcia) [11]

Table 3: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_3, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	12.7	253	381	382	382	382	382	382	383	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	19	54	50	190	230	240	270	310	400	3200	ALPS [17]
AMaLGaM IDEA	17	43	27	*40e-1/1e6*	.	.	.	.	.	.	AMaLGaM IDEA [4]
avg NEWUOA	88	1e3	*97e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**15**	85	*73e+0/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	570	*28e+1/6e3*	.	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	2900	450	*69e+0/5e4*	.	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	25	6.7	12	*40e-1/3e5*	.	.	.	.	.	.	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	37	840	*92e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	210	5.9	**1**	**8.3**	**35**	**35**	**35**	**35**	**36**	**36**	DASA [19]
DEPSO	42	130	*84e+0/2e3*	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	28	*43e+0/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	22	150	44	*70e-1/1e5*	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	180	650	*88e+0/1e4*	.	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	24	1.2e4	*13e+1/5e4*	.	.	.	.	.	.	.	G3-PCX [26]
simple GA	26	190	29	3700	*21e-1/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	19	1400	*15e+1/2e3*	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	24	19	38	1.8e4	*20e-1/1e6*	.	.	.	.	.	iAMaLGaM IDEA [4]
LSfminbnd	190	**1.3**	*19e+0/6e3*	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	4e3	27	**1.5**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	LSstep [28]
MA-LS-Chain	20	12	**7**	95	160	160	160	160	160	**160**	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	28	*13e+0/4e3*	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	42	260	*81e+0/1e4*	.	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	24	71	*47e+0/2e4*	.	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	41	7500	*13e+1/6e3*	.	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	360	2.3e4	*81e+0/1e6*	.	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	4e3	43	9.6	**69**	**140**	**140**	**150**	**150**	**150**	160	POEMS [20]
PSO	19	21	*21e+0/1e5*	.	.	.	.	.	.	.	PSO [7]
PSO_Bounds	28	330	120	190	360	360	360	380	400	430	PSO_Bounds [8]
Monte Carlo	32	*26e+1/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	560	*23e+1/7e3*	.	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	28	**5.2**	10	*60e-1/1e4*	.	.	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	20	8.1	8.3	340	490	520	560	620	630	630	VNS (Garcia) [11]

Table 4: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_4, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	37.3	236	381	383	384	385	386	388	7050	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	92	29	150	9800	*30e-1/2e5*	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	79	20	*14e+0/1e6*	.	.	.	.	.	.	.	AMaLGaM IDEA [4]
avg NEWUOA	110	1400	*12e+1/2e4*	.	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	83	40	*69e+0/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	1700	*40e+1/8e3*	.	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	5100	4300	*11e+1/5e4*	.	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	37	**2.4**	*12e+0/3e5*	.	.	.	.	.	.	.	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	46	*14e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	290	**2.1**	**1**	**130**	1700	1700	1700	1700	1700	91	DASA [19]
DEPSO	120	120	*10e+1/2e3*	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	11	*88e+0/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	**20**	56	6e3	*15e+0/1e5*	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	270	4e3	*13e+1/1e4*	.	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	79	*19e+1/5e4*	.	.	.	.	.	.	.	.	G3-PCX [26]
simple GA	100	80	65	3800	*34e-1/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	160	*20e+1/4e3*	.	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	61	7.1	*13e+0/1e6*	.	.	.	.	.	.	.	iAMaLGaM IDEA [4]
LSfminbnd	280	**1.2**	*49e+0/7e3*	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	4400	9.5	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	LSstep [28]
MA-LS-Chain	60	6.2	53	*30e-1/1e5*	.	.	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	*21e+0/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	40	*13e+1/1e4*	.	.	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	35	1600	*11e+1/2e4*	.	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	55	4300	*17e+1/1e4*	.	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	82	3.8e5	*13e+1/1e6*	.	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	4e3	18	**13**	**140**	**220**	**240**	**250**	**250**	**250**	**14**	POEMS [20]
PSO	44	8.6	5900	*23e+0/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	66	130	190	290	**300**	**360**	**360**	**370**	**380**	**21**	PSO_Bounds [8]
Monte Carlo	130	*33e+1/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	650	*20e+1/8e3*	.	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	55	**2.5**	*14e+0/1e4*	.	.	.	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	110	3.2	27	2.8e4	1.3e5	1.3e5	*20e-1/4e6*	.	.	.	VNS (Garcia) [11]

Table 5: 20-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

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.05	1.83	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	ERT_{best}/D
ALPS	**1**	51	160	210	250	280	300	310	320	330	ALPS [17]
AMaLGaM IDEA	**1**	34	75	80	80	80	80	80	80	80	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**2.7**	**2.7**	3.2	3.3	3.3	3.3	3.3	3.3	3.3	avg NEWUOA [31]
BayEDAcG	**1**	67	150	200	200	200	210	210	210	210	BayEDAcG [10]
BFGS	**1**	**1.4**	**2.4**	**2.7**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	BFGS [30]
Cauchy EDA	**1**	110	160	170	170	170	170	170	170	170	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**2.7**	5.1	6.2	6.3	6.3	6.3	6.3	6.3	6.3	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1.6**	3.1	3.6	3.7	3.7	3.7	3.7	3.7	3.7	(1+1)-CMA-ES [2]
DASA	**1**	14	24	29	34	38	43	47	52	64	DASA [19]
DEPSO	**1**	16	39	46	48	48	48	48	48	48	DEPSO [12]
DIRECT	**1**	62	180	220	230	230	230	230	230	230	DIRECT [25]
EDA-PSO	**1**	5.2	27	34	37	39	39	39	39	39	EDA-PSO [6]
full NEWUOA	**1**	6.4	6.2	6.5	6.6	6.6	6.6	6.6	6.6	6.6	full NEWUOA [31]
G3-PCX	**1**	7.5	19	25	26	27	27	27	27	27	G3-PCX [26]
simple GA	**1**	570	2200	4600	7500	1.1e4	1.4e4	1.8e4	2.2e4	2.3e5	simple GA [22]
GLOBAL	**1**	9.5	9.9	11	11	11	11	11	11	11	GLOBAL [23]
iAMaLGaM IDEA	**1**	4.4	9.8	11	11	11	11	11	11	11	iAMaLGaM IDEA [4]
LSfminbnd	**1**	14	16	16	16	16	16	16	16	16	LSfminbnd [28]
LSstep	**1**	150	180	190	190	190	190	190	190	190	LSstep [28]
MA-LS-Chain	**1**	22	41	44	46	46	46	46	46	46	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	MCS (Neum) [18]
NELDER (Han)	**1**	3.8	7.4	8.8	9.2	9.2	9.2	9.2	9.2	9.2	NELDER (Han) [16]
NELDER (Doe)	**1**	**2.6**	5.2	6.2	6.3	6.4	6.4	6.4	6.4	6.4	NELDER (Doe) [5]
NEWUOA	**1**	**1.2**	**1.2**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	NEWUOA [31]
(1+1)-ES	**1**	**1.6**	3.1	3.5	3.6	3.6	3.6	3.6	3.6	3.6	(1+1)-ES [1]
POEMS	**1**	180	260	310	330	350	350	350	350	350	POEMS [20]
PSO	**1**	4.7	4.3e4	4.3e4	4.3e4	4.3e4	4.3e4	4.3e4	4.3e4	4.3e4	PSO [7]
PSO_Bounds	**1**	4.5	160	160	160	160	160	160	160	160	PSO_Bounds [8]
Monte Carlo	**1**	2.5e6	*11e+1/1e6*	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	3.8	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**2.9**	6.2	7.3	7.7	7.7	7.7	7.7	7.7	7.7	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	4.9	6.8	7.6	7.8	7.8	7.8	7.8	7.8	7.8	VNS (Garcia) [11]

Table 6: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_6, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	4.03	26	64.7	87.2	123	152	184	219	248	309	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	59	25	34	54	64	78	100	150	370	*14e-7/2e5*	ALPS [17]
AMaLGaM IDEA	26	22	19	22	21	22	22	21	22	22	AMaLGaM IDEA [4]
avg NEWUOA	**2.3**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [31]
BayEDAcG	46	41	*60e+0/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**2.2**	**2.7**	3.6	4.7	4.7	4.9	5	4.8	4.9	61	BFGS [30]
Cauchy EDA	6200	1500	1e3	1700	*17e-1/5e4*	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**2.9**	**2.2**	**1.5**	**1.7**	**1.6**	**1.6**	**1.6**	**1.5**	**1.6**	**1.6**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1.9**	4.5	13	180	1200	*13e-1/1e4*	.	.	.	.	(1+1)-CMA-ES [2]
DASA	12	6.8	9.9	19	25	33	49	58	63	74	DASA [19]
DEPSO	11	7.5	12	64	*13e-1/2e3*	.	.	.	.	.	DEPSO [12]
DIRECT	18	31	*40e+0/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	27	46	40	45	44	44	44	44	44	44	EDA-PSO [6]
full NEWUOA	5	**1.9**	**1.5**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	full NEWUOA [31]
G3-PCX	4.1	**1.4**	**1.4**	**2**	**2.1**	**2.1**	**2.2**	**2.2**	**2.3**	**2.4**	G3-PCX [26]
simple GA	320	130	2e3	*11e+0/1e5*	.	.	.	.	.	.	simple GA [22]
GLOBAL	5	**2.9**	3.6	4.9	8.5	*42e-3/2e3*	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	5.1	5.6	5.4	6.8	7.1	7.7	7.8	7.7	8	8.3	iAMaLGaM IDEA [4]
LSfminbnd	9	31	160	760	1100	960	*72e-1/1e4*	.	.	.	LSfminbnd [28]
LSstep	140	260	2300	*59e+0/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	11	4.9	7.5	8.9	8	7.7	7.2	6.7	6.5	6	MA-LS-Chain [21]
MCS (Neum)	**1.8**	33	*42e+0/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**2.2**	**2.4**	**2.7**	3.3	3.2	3.5	3.5	3.5	4	7.4	NELDER (Han) [16]
NELDER (Doe)	**1.5**	**2.3**	9.1	20	28	65	110	430	*46e-5/2e4*	.	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1**	**1.3**	**1.4**	**1.5**	**1.6**	**1.6**	**1.7**	**1.7**	NEWUOA [31]
(1+1)-ES	**2**	**2.2**	**2.1**	**2.8**	3.9	5.2	6.1	6.5	6.4	6.7	(1+1)-ES [1]
POEMS	89	26	31	37	36	36	36	35	36	37	POEMS [20]
PSO	6.4	280	1100	1400	980	820	710	620	570	790	PSO [7]
PSO_Bounds	9.5	45	120	150	140	140	140	130	160	220	PSO_Bounds [8]
Monte Carlo	2.4e5	*48e+1/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**2.1**	3.9	31	76	210	230	810	*21e-2/1e4*	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.2	**2.1**	**1.7**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**2**	**2**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	5	**2.8**	**1.9**	**1.9**	**1.7**	**1.7**	**1.7**	**1.6**	**1.6**	**1.6**	VNS (Garcia) [11]

Table 7: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_7, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.53	7.59	67.5	214	475	826	826	826	826	848	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	5	26	30	850	930	*48e-2/2e5*	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**3**	10	3.6	**2.1**	**1.3**	**1**	**1**	**1**	**1**	**1**	AMaLGaM IDEA [4]
avg NEWUOA	7.1	**1.4**	100	*51e-1/2e4*	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	4.3	31	57	*11e+0/2e3*	.	.	.	.	.	.	BayEDAcG [10]
BFGS	69	*67e+1/100*	.	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	130	130	44	29	18	14	14	14	14	14	Cauchy EDA [24]
BIPOP-CMA-ES	**2.5**	**2.8**	**1**	4.9	3.5	**2.2**	**2.2**	**2.2**	**2.2**	**2.1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1.6**	16	30	54	300	*92e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [2]
DASA	16	49	1.8e4	*13e+0/4e5*	.	.	.	.	.	.	DASA [19]
DEPSO	**2.7**	7.9	18	*77e-1/2e3*	.	.	.	.	.	.	DEPSO [12]
DIRECT	3.5	7	*15e+0/6e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	**2.5**	65	26	950	*15e-1/1e5*	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	14	**1.9**	4.6	700	*27e-1/1e4*	.	.	.	.	.	full NEWUOA [31]
G3-PCX	4.7	**2.8**	760	*12e+0/1e4*	.	.	.	.	.	.	G3-PCX [26]
simple GA	5.8	180	77	*32e-1/1e5*	.	.	.	.	.	.	simple GA [22]
GLOBAL	4.6	**2.9**	*22e+0/700*	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**2**	5.8	**1.7**	**1**	**1**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	iAMaLGaM IDEA [4]
LSfminbnd	23	21	1e3	*15e+0/1e4*	.	.	.	.	.	.	LSfminbnd [28]
LSstep	230	180	2200	*29e+0/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	3.4	5.4	4.3	120	360	390	390	390	390	380	MA-LS-Chain [21]
MCS (Neum)	**1**	57	*38e+0/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	4.5	4.6	2200	*16e+0/1e4*	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**2.5**	**1**	370	*97e-1/2e4*	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	3.6	43	*18e+0/2e4*	.	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	3.1	1100	*27e+0/1e6*	.	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	440	55	21	2e3	3100	*12e-1/1e5*	.	.	.	.	POEMS [20]
PSO	**2.5**	4.8	430	*62e-1/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	3.3	26	9700	*22e+0/1e5*	.	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	3.2	2.1e5	*10e+1/1e6*	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	500	*38e+1/3e3*	.	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.4	**2.8**	**2.3**	**4**	**2.4**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1.1**	3.7	5.4	78	72	2400	2400	2400	2400	2300	VNS (Garcia) [11]

Table 8: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_8, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	5.52	21	97.9	187	202	207	211	215	219	222	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	70	51	100	460	600	740	1e3	1200	3100	*26e-6 /2e5*	ALPS [17]
AMaLGaM IDEA	25	16	20	18	19	20	20	21	21	22	AMaLGaM IDEA [4]
avg NEWUOA	**2**	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	avg NEWUOA [31]
BayEDAcG	55	35	*48e+0 /2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.9**	**2**	**1.9**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	BFGS [30]
Cauchy EDA	360	200	200	180	210	250	260	290	360	550	Cauchy EDA [24]
BIPOP-CMA-ES	4	**2.4**	4.2	4.2	4.3	4.5	4.5	4.6	4.6	4.7	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**2.7**	**1.8**	3.9	6.5	6.6	6.6	6.6	6.7	6.6	6.7	(1+1)-CMA-ES [2]
DASA	15	26	34	57	120	200	280	350	420	550	DASA [19]
DEPSO	16	16	*17e+0 /2e3*	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	25	82	*64e+0 /5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	220	110	190	220	260	330	410	*17e-5 /1e5*	.	.	EDA-PSO [6]
full NEWUOA	3.4	**2.6**	**1.4**	**1.6**	**1.6**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	full NEWUOA [31]
G3-PCX	3.9	**2**	**2.7**	5.6	5.5	5.5	5.5	5.5	5.5	5.7	G3-PCX [26]
simple GA	480	250	*17e+0 /1e5*	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	4.1	**2.4**	**1.7**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	GLOBAL [23]
iAMaLGaM IDEA	13	6.4	8.6	9.2	9.5	9.8	10	10	10	11	iAMaLGaM IDEA [4]
LSfminbnd	7.1	17	9.6	120	710	720	*40e-1 /1e4*	.	.	.	LSfminbnd [28]
LSstep	150	71	25	130	220	350	*12e-1 /1e4*	.	.	.	LSstep [28]
MA-LS-Chain	12	10	14	13	13	13	14	13	13	14	MA-LS-Chain [21]
MCS (Neum)	**1.4**	**1.2**	**1.6**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	MCS (Neum) [18]
NELDER (Han)	3.2	**2.9**	3.4	3.9	4.1	4.5	4.9	5.1	5.3	5.6	NELDER (Han) [16]
NELDER (Doe)	3.2	**3**	**2.9**	4.9	5.5	6	6.5	7.2	7.7	9.2	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	NEWUOA [31]
(1+1)-ES	**2.5**	11	13	120	120	140	160	180	200	240	(1+1)-ES [1]
POEMS	100	84	590	7600	*74e-1 /1e5*	.	.	.	.	.	POEMS [20]
PSO	15	19	93	320	350	410	470	580	890	3300	PSO [7]
PSO_Bounds	88	160	540	450	1800	7200	*15e-2 /1e5*	.	.	.	PSO_Bounds [8]
Monte Carlo	*80e+2 /1e6*	.	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**2**	**1.1**	4	25	28	35	42	55	62	670	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.5	**1.7**	5.6	5.6	5.7	5.7	5.8	5.8	5.8	5.8	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	6	3.1	6	6.3	6.3	6.4	6.4	6.4	6.4	6.4	VNS (Garcia) [11]

Table 9: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_9, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	17.8	85.8	155	164	169	173	176	180	186	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	4800	37	350	*48e-1/2e5*	.	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	2e3	11	22	22	23	24	24	25	25	25	AMaLGaM IDEA [4]
avg NEWUOA	230	**1.5**	**1**	**1.2**	**1.2**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**	avg NEWUOA [31]
BayEDAcG	4800	27	*18e+0/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	210	**1.9**	**2.2**	**2.2**	**2.1**	**2.1**	**2**	**2**	**2**	**1.9**	BFGS [30]
Cauchy EDA	3.3e4	220	190	270	290	300	310	340	470	630	Cauchy EDA [24]
BIPOP-CMA-ES	390	**2.6**	4.7	5.7	6	6.1	6.1	6.1	6.1	6.1	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	260	**2.4**	4.5	6.7	7	7	7	7	7	6.9	(1+1)-CMA-ES [2]
DASA	2e3	77	210	1300	1500	1800	2100	2400	2700	3700	DASA [19]
DEPSO	1400	25	*18e+0/2e3*	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	4.7	*22e+0/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	2.2e4	130	280	450	*14e-2/1e5*	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	460	**3**	**1.8**	**2.2**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.2**	full NEWUOA [31]
G3-PCX	410	3.6	**2.9**	3.8	4	4.1	4.1	4.1	4.1	4.2	G3-PCX [26]
simple GA	4.4e4	270	*19e+0/1e5*	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	420	**2**	**1.7**	**1.7**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.5**	GLOBAL [23]
iAMaLGaM IDEA	1400	7.5	9.6	11	12	12	12	12	12	13	iAMaLGaM IDEA [4]
LSfminbnd	740	6.5	52	470	*32e-1/1e4*	.	.	.	.	.	LSfminbnd [28]
LSstep	1.5e4	130	*18e+0/1e4*	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	820	7.3	17	25	27	29	31	31	30	30	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1**	**1.3**	**1.5**	**1.6**	**1.6**	**1.7**	**1.7**	**1.6**	MCS (Neum) [18]
NELDER (Han)	200	**2.3**	3.6	6.6	7.2	7.8	8.4	8.6	8.8	8.9	NELDER (Han) [16]
NELDER (Doe)	150	**1.4**	3.3	6.1	6.6	7	7.5	7.9	8.4	9.4	NELDER (Doe) [5]
NEWUOA	**130**	**1.3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	NEWUOA [31]
(1+1)-ES	260	**2.2**	12	52	65	86	110	130	160	200	(1+1)-ES [1]
POEMS	1e4	74	2e3	*99e-1/1e5*	.	.	.	.	.	.	POEMS [20]
PSO	1600	40	670	*75e-1/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	8.2e4	650	700	9700	*20e-1/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	*68e+2/1e6*	.	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	190	**1.2**	8.4	31	37	49	63	850	*35e-5/1e4*	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	320	**2.2**	6.9	7	7.2	7.3	7.3	7.3	7.2	7.2	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	510	3.2	6.9	8.2	8.7	8.7	8.7	8.6	8.6	8.5	VNS (Garcia) [11]

Table 10: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_{10}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	94	263	371	433	537	682	746	810	854	874	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	330	2500	*16e+1/2e5*	.	.	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	3.9	**1.9**	**1.8**	**2**	**1.9**	**1.7**	**1.7**	**1.8**	**1.8**	**2.1**	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**1**	**1.5**	**2.6**	3.1	3.1	3.6	3.9	4.2	5	avg NEWUOA [31]
BayEDAcG	*42e+3/2e3*	.	.	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.6**	**1**	**1**	**1**	**1**	**1.1**	**1.1**	**1.3**	3.1	*77e-8/5e4*	BFGS [30]
Cauchy EDA	36	21	20	22	20	19	20	21	21	25	Cauchy EDA [24]
BIPOP-CMA-ES	3.1	**1.9**	**1.9**	**1.8**	**1.6**	**1.3**	**1.2**	**1.1**	**1.1**	**1.1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**2.5**	**1.7**	**1.7**	**1.7**	**1.4**	**1.2**	**1.1**	**1**	**1**	**1**	(1+1)-CMA-ES [2]
DASA	390	1200	3400	*72e-1/1e6*	.	.	.	.	.	.	DASA [19]
DEPSO	*17e+3/2e3*	.	.	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	*94e+2/5e3*	.	.	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	480	*36e+1/1e5*	.	.	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	9.9	15	34	*67e-1/1e4*	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	3.1	3.4	6.5	10	12	13	15	16	18	23	G3-PCX [26]
simple GA	*15e+3/1e5*	.	.	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	**1.7**	**1**	**1**	**1.1**	**1.1**	**1.2**	**2**	**2.6**	5.9	*19e-6/2e3*	GLOBAL [23]
iAMaLGaM IDEA	**2.3**	**1.3**	**1.3**	**1.3**	**1.2**	**1**	**1**	**1**	**1**	**1.1**	iAMaLGaM IDEA [4]
LSfminbnd	290	*22e+2/1e4*	.	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	*18e+3/1e4*	.	.	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	11	12	11	13	11	8.5	7.8	7.2	6.9	6.8	MA-LS-Chain [21]
MCS (Neum)	*72e+2/4e3*	.	.	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**2.9**	5.3	390	*30e+0/1e4*	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**2.2**	4.2	30	*57e-1/2e4*	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1.2**	**1.1**	**1.7**	**2.6**	3.3	3.3	4	4.3	4.7	5.8	NEWUOA [31]
(1+1)-ES	50	110	300	700	1e3	1e3	2200	3500	8700	*94e-5/1e6*	(1+1)-ES [1]
POEMS	5100	*12e+2/1e5*	.	.	.	.	.	.	.	.	POEMS [20]
PSO	1200	5600	*84e+1/1e5*	.	.	.	.	.	.	.	PSO [7]
PSO_Bounds	650	*41e+1/1e5*	.	.	.	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	*11e+4/1e6*	.	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	27	140	*27e+1/1e4*	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	7.2	3.8	3.1	**2.9**	**2.4**	**2**	**1.8**	**1.7**	**1.6**	**1.6**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	8.2	5.7	4.8	4.7	4.2	3.4	3.1	**2.9**	**2.8**	**2.7**	VNS (Garcia) [11]

Table 11: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{11}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	1.35	24.1	50.1	111	314	429	488	554	614	742	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	5	59	490	980	2200	*12e-2/2e5*	.	.	.	.	ALPS [17]
AMaLGaM IDEA	7	**3.3**	5	3.7	**1.9**	**1.6**	**1.7**	**1.8**	**1.8**	**1.9**	AMaLGaM IDEA [4]
avg NEWUOA	6	11	15	11	5.7	5.1	5.6	5.5	5.8	6.1	avg NEWUOA [31]
BayEDAcG	4.9	250	*14e+1/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**2.9**	**1**	**1**	**1**	**1.3**	**2.6**	150	*31e-4/1e4*	.	.	BFGS [30]
Cauchy EDA	100	71	64	44	22	20	22	24	25	26	Cauchy EDA [24]
BIPOP-CMA-ES	4.1	18	10	5.1	**1.9**	**1.5**	**1.4**	**1.3**	**1.2**	**1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**2.4**	5.6	7	5.1	**2.4**	**2.3**	**2.4**	**2.4**	**2.3**	**2**	(1+1)-CMA-ES [2]
DASA	4.4	120	570	690	420	550	730	810	980	1500	DASA [19]
DEPSO	8.2	110	*95e+0/2e3*	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**2.1**	23	*76e+0/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	4.3	74	1900	1.3e4	*79e-1/1e5*	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	5	40	57	45	21	18	36	88	*75e-5/1e4*	.	full NEWUOA [31]
G3-PCX	4	9.7	18	14	7	6.5	7.1	7.3	7.6	8	G3-PCX [26]
simple GA	4.2	120	2.9e4	*20e+0/1e5*	.	.	.	.	.	.	simple GA [22]
GLOBAL	5	**1.5**	**1.2**	**1**	**1**	**2.2**	*74e-4/1e3*	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	4.4	5.2	**4.4**	**2.7**	**1.2**	**1**	**1**	**1**	**1**	**1**	iAMaLGaM IDEA [4]
LSfminbnd	**2**	*22e+1/1e4*	.	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	**2.4**	*29e+1/1e4*	.	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**2.6**	30	63	35	14	12	11	10	9.3	7.8	MA-LS-Chain [21]
MCS (Neum)	**1**	53	*62e+0/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	3.3	5.2	41	290	*16e-1/1e4*	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	4.4	4.4	17	24	74	*75e-3/2e4*	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1.5**	15	15	13	5.8	5.6	6.1	6.2	6.6	6.5	NEWUOA [31]
(1+1)-ES	2100	1400	1600	1200	580	560	610	620	670	680	(1+1)-ES [1]
POEMS	130	52	440	410	190	190	980	*34e-4/1e5*	.	.	POEMS [20]
PSO	4.1	46	140	190	110	110	130	140	150	2e3	PSO [7]
PSO_Bounds	4.4	210	570	440	220	240	480	660	1200	*12e-4/1e5*	PSO_Bounds [8]
Monte Carlo	5.5	930	*67e+0/1e6*	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**2.9**	880	*11e+1/1e4*	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.1	34	20	10	3.7	**2.8**	**2.5**	**2.3**	**2.1**	**1.8**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	44	23	12	6.2	**2.4**	**1.9**	**1.8**	**1.6**	**1.6**	**1.4**	VNS (Garcia) [11]

Table 12: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{12}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$	25.4	29.6	52.1	96.9	137	158	207	321	620	691	$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$
ALPS	80	90	87	240	840	3500	*33e-3/2e5*	.	.	.	ALPS [17]
AMaLGaM IDEA	28	29	19	12	13	16	15	12	7.6	8.4	AMaLGaM IDEA [4]
avg NEWUOA	**1.4**	**1.3**	11	15	18	24	24	20	12	21	avg NEWUOA [31]
BayEDAcG	55	60	42	77	*21e-1/2e3*	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.7**	**1.6**	**2.2**	**1.8**	45	BFGS [30]
Cauchy EDA	450	520	510	440	420	400	380	360	390	1100	Cauchy EDA [24]
BIPOP-CMA-ES	**3**	3	3	4	4.5	4.9	4.5	3.3	**1.9**	**2**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1.8**	3.1	7.7	9.6	9.9	9.6	8.3	6	3.4	3.6	(1+1)-CMA-ES [2]
DASA	13	16	2.2e4	2.8e4	4.7e4	8.9e4	6.8e4	4.4e4	2.3e4	*13e+0/1e6*	DASA [19]
DEPSO	39	48	68	*77e-1/2e3*	.	.	.	.	.	.	DEPSO [12]
DIRECT	340	330	420	240	*25e+3/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	230	250	300	260	720	2600	6800	4400	2300	*57e-3/1e5*	EDA-PSO [6]
full NEWUOA	**2.3**	6.7	11	15	26	27	38	37	35	100	full NEWUOA [31]
G3-PCX	**2.4**	**2.5**	**2.7**	**2.8**	**3**	3.3	**2.9**	**2.1**	**1.2**	**1.3**	G3-PCX [26]
simple GA	7100	1.5e4	*14e+2/1e5*	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	**1.1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1.1**	3.4	GLOBAL [23]
iAMaLGaM IDEA	12	13	8.7	6.6	7.2	8.1	7.8	6	3.6	3.9	iAMaLGaM IDEA [4]
LSfminbnd	**2.9**	3	97	410	*76e-1/1e4*	.	.	.	.	.	LSfminbnd [28]
LSstep	29	35	230	680	*16e+0/1e4*	.	.	.	.	.	LSstep [28]
MA-LS-Chain	11	12	7.4	9.8	130	140	150	97	51	47	MA-LS-Chain [21]
MCS (Neum)	**1.3**	**1.3**	**1.1**	8.4	12	24	43	87	94	*16e-4/4e3*	MCS (Neum) [18]
NELDER (Han)	**2.7**	5.5	19	26	57	78	340	460	*54e-4/1e4*	.	NELDER (Han) [16]
NELDER (Doe)	**2.3**	4.1	13	45	61	400	1400	*21e-3/2e4*	.	.	NELDER (Doe) [5]
NEWUOA	**1.3**	**1.3**	**3**	3	3	**3**	**2.5**	**1.8**	**1**	**1**	NEWUOA [31]
(1+1)-ES	**1.7**	**1.7**	1.2e4	6.7e4	*52e-1/1e6*	.	.	.	.	.	(1+1)-ES [1]
POEMS	160	170	420	2100	*37e-1/1e5*	.	.	.	.	.	POEMS [20]
PSO	640	550	1700	*64e-1/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	240	270	700	3e3	5100	*64e-1/1e5*	.	.	.	.	PSO_Bounds [8]
Monte Carlo	*28e+6/1e6*	.	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	**1**	14	56	210	910	*70e-2/1e4*	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**2.7**	**2.8**	5.8	6.7	6.4	6.8	5.9	4.3	**2.4**	**2.5**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	3.3	3.4	5.9	5.9	6.6	9.1	8.3	7.4	4.1	4.4	VNS (Garcia) [11]

Table 13: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{13}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	3.21	8.51	32.6	101	138	175	937	1090	1220	1510	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	49	130	97	130	420	2700	*14e-3/2e5*	.	.	.	ALPS [17]
AMaLGaM IDEA	18	41	18	8	8	7.7	**1.7**	**1.7**	**1.7**	**1.7**	AMaLGaM IDEA [4]
avg NEWUOA	**2.1**	**1.8**	**1.5**	5.3	14	30	14	57	170	*67e-5/2e4*	avg NEWUOA [31]
BayEDAcG	45	150	910	*49e+0/2e3*	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.2**	**1.6**	**1.7**	**1**	**1**	**1**	23	87	*96e-5/2e4*	.	BFGS [30]
Cauchy EDA	260	410	210	100	100	100	23	23	23	23	Cauchy EDA [24]
BIPOP-CMA-ES	3.6	5.1	4.3	**2.7**	5.1	6.2	**1.5**	**1.6**	**2.3**	3	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**2.9**	3.4	4.9	7.1	10	11	4.2	5.7	6.3	14	(1+1)-CMA-ES [2]
DASA	15	22	380	230	570	1600	670	1200	3700	*51e-6/1e6*	DASA [19]
DEPSO	11	40	64	*53e-1/2e3*	.	.	.	.	.	.	DEPSO [12]
DIRECT	15	2400	*13e+1/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	110	330	160	330	1200	*12e-2/1e5*	.	.	.	.	EDA-PSO [6]
full NEWUOA	4.1	3.6	**1.8**	6	18	49	26	40	120	*30e-4/1e4*	full NEWUOA [31]
G3-PCX	4.3	4.8	9.3	17	43	75	47	110	130	330	G3-PCX [26]
simple GA	290	700	5100	*10e+0/1e5*	.	.	.	.	.	.	simple GA [22]
GLOBAL	5.7	3.1	**2**	**1.1**	**1.1**	**1.1**	4.5	4.2	*16e-4/1e3*	.	GLOBAL [23]
iAMaLGaM IDEA	9.2	18	8.7	4.1	**4.3**	**4.4**	**1**	**1**	**1**	**1**	iAMaLGaM IDEA [4]
LSfminbnd	6.2	8.7	19	19	68	150	160	130	*53e-3/1e4*	.	LSfminbnd [28]
LSstep	180	310	460	1400	*12e+0/1e4*	.	.	.	.	.	LSstep [28]
MA-LS-Chain	7.3	22	11	390	700	1800	1500	1300	*27e-3/1e5*	.	MA-LS-Chain [21]
MCS (Neum)	**1.3**	8.4	34	37	61	330	*60e-2/4e3*	.	.	.	MCS (Neum) [18]
NELDER (Han)	**2.3**	6.4	11	29	60	180	77	130	*35e-3/1e4*	.	NELDER (Han) [16]
NELDER (Doe)	**1.5**	3.4	12	18	31	87	98	270	*36e-4/2e4*	.	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1**	3	9.3	37	19	130	*43e-4/9e3*	.	NEWUOA [31]
(1+1)-ES	**2.5**	3.3	7.4	13	26	95	50	110	410	2e3	(1+1)-ES [1]
POEMS	100	200	1700	1.4e4	*59e-1/1e5*	.	.	.	.	.	POEMS [20]
PSO	6.1	1800	6200	6400	1e4	8e3	1500	1300	*22e+0/1e5*	.	PSO [7]
PSO_Bounds	12	310	2300	4100	*50e-1/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	1.5e5	*92e+1/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**2.2**	**2**	**2.5**	4.2	8.3	31	17	43	120	*18e-4/1e4*	Rosenbrock [27]
IPOP-SEP-CMA-ES	3.6	5	5.8	5.4	7.7	8	**1.7**	**1.9**	**1.9**	**2**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	5.8	6.2	4.3	55	120	180	130	320	540	1500	VNS (Garcia) [11]

Table 14: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{14}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$	0.05	0.05	3.75	12	15.2	22.5	46.6	66.6	82.4	783	$\mathrm{ERT}_{\mathrm{best}}/\mathrm{D}$
ALPS	**1**	3.7	41	56	78	93	190	1200	*34e-6/2e5*	.	ALPS [17]
AMaLGaM IDEA	**1**	4.7	19	22	30	28	17	15	14	**1.9**	AMaLGaM IDEA [4]
avg NEWUOA	**1**	38	**2.7**	**1.5**	**1.6**	**1.6**	**1.3**	**2.7**	9.3	26	avg NEWUOA [31]
BayEDAcG	**1**	7.2	55	67	150	250	*15e-3/2e3*	.	.	.	BayEDAcG [10]
BFGS	**1**	23	**2.7**	**1.8**	**2**	**1.8**	**1.2**	**1.1**	**1.1**	*18e-7/1e4*	BFGS [30]
Cauchy EDA	**1**	930	280	270	350	340	210	180	180	25	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	7.6	3.9	**2.9**	3.7	4.3	4.1	5	6.2	**1.2**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	18	3.1	**1.9**	**2.3**	**2.5**	**2.3**	3.4	**5.6**	**1.2**	(1+1)-CMA-ES [2]
DASA	**1**	93	16	10	12	22	75	560	5200	*43e-7/1e6*	DASA [19]
DEPSO	**1**	13	14	14	25	49	*44e-4/2e3*	.	.	.	DEPSO [12]
DIRECT	**1**	**1**	8.4	150	290	*90e-3/5e3*	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	3.8	85	140	200	190	130	350	*21e-6/1e5*	.	EDA-PSO [6]
full NEWUOA	**1**	47	5.9	3	3.6	3.3	**2.6**	5	20	*12e-7/1e4*	full NEWUOA [31]
G3-PCX	**1**	5.7	4.1	**2.4**	**2.8**	3	**2.7**	4.5	13	59	G3-PCX [26]
simple GA	**1**	4.1	280	320	480	2900	*72e-4/1e5*	.	.	.	simple GA [22]
GLOBAL	**1**	7.5	5	**2.2**	**2.1**	**1.8**	**1.1**	**1**	**1**	*28e-7/400*	GLOBAL [23]
iAMaLGaM IDEA	**1**	4.3	11	9.3	13	12	7.8	6.9	6.9	**1**	iAMaLGaM IDEA [4]
LSfminbnd	**1**	83	8.4	5.2	5.6	9.3	57	*31e-5/1e4*	.	.	LSfminbnd [28]
LSstep	**1**	910	190	110	120	210	*46e-4/1e4*	.	.	.	LSstep [28]
MA-LS-Chain	**1**	4.1	7.6	11	13	16	14	23	23	6	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1**	**2.1**	3.4	3.7	3.2	*15e-5/4e3*	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	23	**2.3**	**3**	3.9	3.6	**2.9**	4.9	36	*44e-7/1e4*	NELDER (Han) [16]
NELDER (Doe)	**1**	11	**2**	**2.1**	3.5	3.7	3	5.4	21	*26e-7/2e4*	NELDER (Doe) [5]
NEWUOA	**1**	20	**1.5**	**1**	**1**	**1**	**1**	**2.3**	9.1	43	NEWUOA [31]
(1+1)-ES	**1**	17	**2.5**	**1.8**	**2**	**2.2**	4.8	38	470	*71e-8/1e6*	(1+1)-ES [1]
POEMS	**1**	3100	110	66	120	160	130	2e3	*94e-6/1e5*	.	POEMS [20]
PSO	**1**	7.2	6.7	12	20	27	54	580	*44e-6/1e5*	.	PSO [7]
PSO_Bounds	**1**	4.6	23	100	170	240	380	1300	*78e-6/1e5*	.	PSO_Bounds [8]
Monte Carlo	**1**	5.3	4.5e4	*80e-1/1e6*	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	80	**2.4**	**1.2**	**1.3**	**1.8**	7.4	97	*71e-6/1e4*	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	14	3.3	**2.6**	3.2	3.7	6.8	8.8	10	**1.6**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**3.6**	6.4	3.9	4.4	5.1	5	6.4	7.8	**1.4**	VNS (Garcia) [11]

Table 15: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{15}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget $\mathrm{ERT}_{\mathrm{best}}$/D	1e+03 0.06	1e+02 83.5	1e+01 1520	1e+00 7330	1e-01 15600	1e-02 15800	1e-03 16000	1e-04 16100	1e-05 22500	1e-07 23000	Δftarget $\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	18	10	*20e+0/2e5*	.	.	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	12	7.1	**1.5**	**2**	**1.7**	**1.7**	**1.7**	**1.7**	**1.2**	**1.2**	AMaLGaM IDEA [4]
avg NEWUOA	56	120	*95e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	13	23	*93e+0/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	670	*25e+1/6e3*	.	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	1700	68	*67e+0/5e4*	.	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	17	**1.2**	**1**	**2**	**1.4**	**1.4**	**1.4**	**1.4**	**1**	**1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	33	73	*85e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	160	3e4	*11e+1/1e6*	.	.	.	.	.	.	.	DASA [19]
DEPSO	12	*12e+1/2e3*	.	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	110	*10e+1/5e3*	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	20	22	36	*80e-1/1e5*	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	120	81	*77e+0/1e4*	.	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	21	550	*92e+0/5e4*	.	.	.	.	.	.	.	G3-PCX [26]
simple GA	21	59	*25e+0/1e5*	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	13	*25e+1/1e3*	.	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	12	3.1	**2.8**	14	7.5	7.5	7.4	7.4	5.3	**5.2**	iAMaLGaM IDEA [4]
LSfminbnd	130	*14e+1/1e4*	.	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	2400	*22e+1/1e4*	.	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**10**	3.7	6.9	*60e-1/1e5*	.	.	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	70	*10e+1/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	28	54	*80e+0/1e4*	.	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	25	17	*54e+0/2e4*	.	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	29	1100	*12e+1/6e3*	.	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	340	5400	*82e+0/1e6*	.	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	2700	23	*34e+0/1e5*	.	.	.	.	.	.	.	POEMS [20]
PSO	16	92	*49e+0/1e5*	.	.	.	.	.	.	.	PSO [7]
PSO_Bounds	14	220	*51e+0/1e5*	.	.	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	16	*26e+1/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	7700	*35e+1/1e4*	.	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	14	**1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1.1**	6.4	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	22	**1.5**	310	*60e-1/6e6*	.	.	.	.	.	.	VNS (Garcia) [11]

Table 16: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_{16}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	69.2	1360	3850	6960	9400	9760	9890	11000	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	**1.2**	9.3	110	*78e-2/2e5*	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**1**	**1.1**	14	3.3	**5.2**	**5.4**	**6.2**	**6.1**	**6.1**	**5.7**	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**1.5**	3.6	*31e-1/2e4*	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	**1.2**	*21e+0/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1**	140	*26e+0/2e4*	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	**1**	3.5	*16e+0/5e4*	.	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1.3**	**1.7**	**1**	**1.2**	**1**	**1**	**1**	**1**	**1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1.1**	34	*53e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	**1**	**2.3**	980	*44e-1/1e6*	.	.	.	.	.	.	DASA [19]
DEPSO	**1**	**1.2**	*23e+0/2e3*	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	**1**	8.3	7	*12e-1/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	**1.3**	530	55	380	*75e-2/1e5*	.	.	.	.	EDA-PSO [6]
full NEWUOA	**1**	**1.9**	4.6	110	*25e-1/1e4*	.	.	.	.	.	full NEWUOA [31]
G3-PCX	**1**	**1.3**	17	*32e-1/5e4*	.	.	.	.	.	.	G3-PCX [26]
simple GA	**1**	**1.3**	140	1e3	*24e-1/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	**1**	**1.2**	**1**	*42e-1/600*	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1.2**	3.6	**1.7**	13	18	29	29	28	26	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1.1**	160	*95e-1/1e4*	.	.	.	.	.	.	LSfminbnd [28]
LSstep	**1**	**1**	240	*10e+0/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1**	**1.1**	19	*18e-1/1e5*	.	.	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	11	*75e-1/4e3*	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	**1.3**	17	*47e-1/1e4*	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1**	**1.4**	7.2	*30e-1/2e4*	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1**	**1.1**	16	*53e-1/1e4*	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	**1**	**1.2**	1400	*72e-1/1e6*	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	**1**	250	15	21	100	*58e-2/1e5*	.	.	.	.	POEMS [20]
PSO	**1**	**1.3**	110	*47e-1/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	**1**	**1.2**	130	1e3	*25e-1/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	**1**	**1.3**	6.5e4	*11e+0/1e6*	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	3.4	*29e+0/1e4*	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1.2**	**3.1**	**1**	**1**	**1.1**	**1.4**	**1.9**	**1.9**	**1.7**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1**	3.6	9.1	500	*72e-3/3e6*	.	.	.	.	VNS (Garcia) [11]

Table 17: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{17}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	3.15	51.5	200	612	1530	2230	2810	4020	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	**1.5**	19	28	5100	*16e-2/2e5*	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**1**	**1.1**	14	7.7	4.3	5.1	**4.7**	**3.5**	**5.1**	**5.4**	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**2.1**	**2.4**	*29e-1/4e4*	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	**2**	19	19	48	*15e-2/2e3*	.	.	.	.	BayEDAcG [10]
BFGS	**1**	350	360	*56e-1/2e4*	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	**1.1**	200	260	120	62	30	16	16	23	*37e-7/5e4*	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	4	**2.2**	**1**	**1**	**1**	**1.2**	**1.4**	**1.3**	**1.4**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1.9**	29	*49e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	**1**	8.5	6.6e4	*57e-1/1e6*	.	.	.	.	.	.	DASA [19]
DEPSO	**1**	**1.5**	8.3	18	150	*43e-2/2e3*	.	.	.	.	DEPSO [12]
DIRECT	**1**	**1**	**1.8**	55	*55e-2/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	**1.3**	13	36	20	22	10	8.1	18	21	EDA-PSO [6]
full NEWUOA	**1**	9.4	13	*37e-1/1e4*	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	**1**	**1.2**	4	*35e-1/5e4*	.	.	.	.	.	.	G3-PCX [26]
simple GA	**1**	**1.2**	57	92	7100	*21e-2/1e5*	.	.	.	.	simple GA [22]
GLOBAL	**1**	**1.6**	6.2	*44e-1/3e3*	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1.5**	6.4	**2.9**	**1.5**	**1.4**	6.1	22	29	23	iAMaLGaM IDEA [4]
LSfminbnd	**1**	6.8	990	*82e-1/1e4*	.	.	.	.	.	.	LSfminbnd [28]
LSstep	**1**	55	1700	*78e-1/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1**	**1.3**	3.5	5.1	7.7	10	12	33	59	86	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1**	*42e-1/4e3*	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	**1.3**	240	*62e-1/1e4*	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1**	4	**2.1**	*46e-1/2e4*	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1**	5.1	16	*38e-1/8e4*	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	**1**	5.7	5.2e4	*73e-1/1e6*	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	**1**	540	94	25	19	200	270	*11e-3/1e5*	.	.	POEMS [20]
PSO	**1**	**1.1**	3.2	2500	*10e-1/1e5*	.	.	.	.	.	PSO [7]
PSO_Bounds	**1**	**1.3**	**3**	830	*85e-2/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	**1**	**1.1**	120	*50e-1/1e6*	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	1.6e4	2.1e4	*19e+0/1e4*	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1.4**	**2.8**	4	3.1	**1.6**	**1**	**1**	**1**	**1**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1.2**	5.3	**1.2**	**1.5**	5.8	34	2500	*10e-5/4e6*	.	VNS (Garcia) [11]

Table 18: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{18}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.14	31	199	978	1430	3380	4980	6530	7330	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1.1**	3.8	15	430	*69e-2/2e5*	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**1.2**	3.8	7.3	3	**1**	**1**	**1.7**	**2.7**	**2.8**	**3.7**	AMaLGaM IDEA [4]
avg NEWUOA	**1.3**	19	3200	*10e+0/6e4*	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	6.4	15	17	*95e-2/2e3*	.	.	.	.	.	BayEDAcG [10]
BFGS	**1**	920	*21e+0/2e4*	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	**2.5**	270	96	42	15	16	12	13	38	*25e-6/5e4*	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	5.3	**1**	**2.4**	**1.2**	**1.6**	**1.1**	**1.8**	**1.7**	**1.6**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	12	4800	*16e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	**1**	60	4.6e5	*25e+0/1e6*	.	.	.	.	.	.	DASA [19]
DEPSO	**1**	7.9	7.1	49	*16e-1/2e3*	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	6.5	9.1	110	*12e-1/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1.1**	4.2	30	15	5.2	5.4	18	83	220	*47e-5/1e5*	EDA-PSO [6]
full NEWUOA	**1.1**	23	950	*12e+0/1e4*	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	**1.1**	**2.2**	7100	*14e+0/5e4*	.	.	.	.	.	.	G3-PCX [26]
simple GA	**1.1**	7.8	76	310	*73e-2/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	**1.1**	5.9	*17e+0/4e3*	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1.2**	3.4	**2.7**	**1.2**	**2.3**	3.7	19	18	16	18	iAMaLGaM IDEA [4]
LSfminbnd	**2.2**	31	4500	*26e+0/1e4*	.	.	.	.	.	.	LSfminbnd [28]
LSstep	**1.1**	610	*31e+0/1e4*	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1.1**	5.8	3.6	3.6	26	78	210	*43e-4/1e5*	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	*17e+0/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	830	*20e+0/1e4*	.	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1**	6.5	4300	*14e+0/2e4*	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	3.9	320	1.2e4	*11e+0/8e4*	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	**1**	2.9e5	*24e+0/1e6*	.	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	5.1	1100	21	140	210	990	*38e-2/1e5*	.	.	.	POEMS [20]
PSO	**1.1**	5.2	240	*29e-1/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	**1.1**	**2.4**	69	7100	*22e-1/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	**1.1**	7.7	*18e+0/1e6*	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	1.4e4	4.8e4	*97e+0/1e4*	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	8.5	**1**	**1**	**1.1**	**1.2**	**1**	**1**	**1**	**1**	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**2.5**	**1.3**	**1**	14	250	*40e-4/4e6*	.	.	.	VNS (Garcia) [11]

Table 19: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{19}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget $\mathrm{ERT}_{\mathrm{best}}$/D	1e+03 0.05	1e+02 0.05	1e+01 0.05	1e+00 0.05	1e-01 17200	1e-02 2.34e5	1e-03 3.11e5	1e-04 3.33e5	1e-05 3.34e5	1e-07 3.37e5	Δftarget $\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	**1**	1200	6.2e5	*31e-2/2e5*	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**1**	**1.2**	740	3.4e4	**7.6**	**4.5**	**8.8**	**8.2**	**8.2**	**8.1**	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**2.9**	210	8e6	*20e-1/1e5*	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	**1.1**	1500	*41e-1/2e3*	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1**	170	1.2e6	*12e+0/1e4*	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	**1**	3.4	8400	*34e-1/5e4*	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1**	170	**2.4e4**	**1.2**	**1**	**1**	**1**	**1**	**1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1**	1400	2.8e6	*18e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	**1**	**2.1**	1.8e6	*58e-1/1e6*	.	.	.	.	.	.	DASA [19]
DEPSO	**1**	**1.1**	430	*50e-1/2e3*	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	**1**	**1**	**1**	*21e-2/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	**1.1**	4600	2.8e7	*26e-1/1e5*	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	**1**	**1.3**	480	*21e-1/1e4*	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	**1**	**1.1**	800	*26e-1/5e4*	.	.	.	.	.	.	G3-PCX [26]
simple GA	**1**	**1.1**	1.4e4	6.5e5	*44e-2/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	**1**	**1**	5600	*57e-1/3e3*	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1.1**	460	1.8e6	44	***72e-3/1e6***	.	.	.	.	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**2.6**	1200	*38e-1/1e4*	.	.	.	.	.	.	LSfminbnd [28]
LSstep	**1**	130	7800	*41e-1/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1**	**1.1**	280	2.9e4	13	***11e-2/1e5***	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1**	**1**	**1**	***25e-2/4e3***	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	160	1.4e6	*19e-1/1e4*	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1**	**1**	**73**	4.3e5	*96e-2/2e4*	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1**	**1.1**	76	4.3e6	*12e-1/1e5*	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	**1**	**2.5**	6.3e6	*56e-1/1e6*	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	**1**	170	6200	1.4e6	*94e-2/1e5*	.	.	.	.	.	POEMS [20]
PSO	**1**	**1.1**	380	*32e-1/1e5*	.	.	.	.	.	.	PSO [7]
PSO_Bounds	**1**	**1.1**	820	*31e-1/1e5*	.	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	**1**	**1.1**	5.9e5	*78e-1/1e6*	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	3.1e4	*33e+0/1e4*	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1**	150	2.7e4	8.7	***29e-2/1e4***	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1**	330	8.2e4	*21e-2/6e6*	.	.	.	.	.	VNS (Garcia) [11]

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

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	2.78	3.53	4.09	2310	1.55e5	2.76e5	2.77e5	2.78e5	2.8e5	2.82e5	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	48	54	53	9.2	*47e-2/2e5*	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	20	22	20	88	*68e-2/1e6*	.	.	.	.	.	AMaLGaM IDEA [4]
avg NEWUOA	**1.8**	**1.4**	**1.3**	110	*12e-1/2e4*	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	47	51	49	*31e-1/2e3*	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1.7**	**1.9**	**2.1**	5.8	*90e-2/2e4*	.	.	.	.	.	BFGS [30]
Cauchy EDA	310	330	340	*27e-1/5e4*	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	4.7	4.4	4.3	9.2	**1**	**1**	**1**	**1**	**1**	**1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	3.5	3.6	3.4	21	*11e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	22	21	20	**2.1**	*40e-2/1e6*	.	.	.	.	.	DASA [19]
DEPSO	15	16	15	*21e-1/2e3*	.	.	.	.	.	.	DEPSO [12]
DIRECT	17	36	31	*18e-1/5e3*	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	210	230	230	15	*63e-2/1e5*	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	4.2	3.4	3.1	64	*12e-1/1e4*	.	.	.	.	.	full NEWUOA [31]
G3-PCX	5.6	5.4	5	*12e-1/5e4*	.	.	.	.	.	.	G3-PCX [26]
simple GA	470	520	500	**2.8**	*32e-2/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	6.6	5.6	5.2	**1.6**	*99e-2/4e3*	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	14	14	14	240	*88e-2/1e6*	.	.	.	.	.	iAMaLGaM IDEA [4]
LSfminbnd	11	11	11	5.9	*97e-2/1e4*	.	.	.	.	.	LSfminbnd [28]
LSstep	230	260	280	11	*10e-1/1e4*	.	.	.	.	.	LSstep [28]
MA-LS-Chain	8	9.7	9.4	3.3	**4.8**	*24e-2/1e5*	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	5.9	5.4	4.7	12	*12e-1/4e3*	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	3.1	3.4	3.5	*13e-1/1e4*	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1.9**	**2.1**	**2.2**	28	*11e-1/2e4*	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1**	15	*10e-1/2e4*	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	3.4	3.2	3.1	110	*88e-2/1e6*	.	.	.	.	.	(1+1)-ES [1]
POEMS	130	120	120	**1**	*30e-2/1e5*	.	.	.	.	.	POEMS [20]
PSO	12	15	17	50	*11e-1/1e5*	.	.	.	.	.	PSO [7]
PSO_Bounds	66	79	86	11	*53e-2/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	1.7e6	*15e+2/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	3	**2.7**	**2.6**	**2.9**	*97e-2/1e4*	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	4.4	4.7	4.5	13	*11e-1/1e4*	.	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	8.1	7.7	7.1	**1.1**	*30e-2/1e7*	.	.	.	.	.	VNS (Garcia) [11]

Table 21: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{21}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	28.1	327	705	716	732	754	778	879	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	**1**	14	13	7	7.7	8.3	9.2	9.8	11	ALPS [17]
AMaLGaM IDEA	**1**	**1**	51	2400	1500	1500	1500	1500	1400	1300	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**1**	3.2	5.7	3.5	3.5	3.4	3.3	3.3	**2.9**	avg NEWUOA [31]
BayEDAcG	**1**	**1**	55	*60e-1/2e3*	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1**	**1**	**1.9**	5.5	4.6	4.6	4.5	4.4	4.3	7.3	BFGS [30]
Cauchy EDA	**1**	**1**	1e3	*32e-1/5e4*	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1**	3.2	55	48	47	46	45	43	39	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1**	3.6	7.6	5.8	5.7	5.6	5.4	5.3	4.7	(1+1)-CMA-ES [2]
DASA	**1**	**1**	240	100	100	100	99	96	93	83	DASA [19]
DEPSO	**1**	**1**	22	13	8.3	8.6	8.9	9.3	19	*20e-1/2e3*	DEPSO [12]
DIRECT	**1**	**1**	3.3	27	*19e-1/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	**1**	35	850	570	560	550	530	520	460	EDA-PSO [6]
full NEWUOA	**1**	**1**	7.4	**3.4**	4.5	4.5	4.4	4.2	4.1	3.7	full NEWUOA [31]
G3-PCX	**1**	**1**	12	7.2	5.1	5	4.9	4.8	4.6	4.1	G3-PCX [26]
simple GA	**1**	**1**	90	620	400	400	900	890	*20e-1/1e5*	.	simple GA [22]
GLOBAL	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2.1**	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1**	10	670	540	540	530	520	540	490	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1**	30	27	20	20	19	19	18	16	LSfminbnd [28]
LSstep	**1**	**1**	120	200	200	200	200	190	190	170	LSstep [28]
MA-LS-Chain	**1**	**1**	140	310	230	230	220	210	210	180	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	26	32	26	25	25	24	23	32	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	7.7	20	24	24	23	23	22	20	NELDER (Han) [16]
NELDER (Doe)	**1**	**1**	7.6	4	**2**	**2.1**	**2.1**	**2**	**2**	**1.8**	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1.7**	**2.2**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1**	NEWUOA [31]
(1+1)-ES	**1**	**1**	8.3	13	9.4	9.3	9.1	8.8	8.6	7.6	(1+1)-ES [1]
POEMS	**1**	**1**	2500	*67e-1/1e5*	.	.	.	.	.	.	POEMS [20]
PSO	**1**	**1**	1800	4300	2e3	2e3	1900	1900	1800	1600	PSO [7]
PSO_Bounds	**1**	**1**	560	1200	2e3	2e3	1900	1900	1800	1600	PSO_Bounds [8]
Monte Carlo	**1**	**1**	*26e+0/1e6*	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	**1**	7.8	7.6	4.7	4.6	4.5	4.4	4.3	3.8	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1**	15	50	58	57	56	54	53	47	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1**	11	55	29	29	29	28	27	25	VNS (Garcia) [11]

Table 22: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ on f_{22}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	23.3	279	1170	1210	1250	1310	1340	6740	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	**1**	19	9.7	79	81	86	110	180	130	ALPS [17]
AMaLGaM IDEA	**1**	**1**	8.2	1900	*69e-2/1e6*	.	.	.	.	.	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**1**	**2**	5.6	14	13	13	12	12	**2.4**	avg NEWUOA [31]
BayEDAcG	**1**	**1**	34	31	*20e-1/2e3*	.	.	.	.	.	BayEDAcG [10]
BFGS	**1**	**1**	**2.5**	**1.8**	8.1	7.9	7.7	7.4	9.5	14	BFGS [30]
Cauchy EDA	**1.1**	**1.1**	470	1200	*51e-1/5e4*	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1**	6.8	13	210	210	200	190	190	37	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1**	3.5	**4.2**	**5.6**	**5.5**	**5.3**	**5.1**	**5**	**1**	(1+1)-CMA-ES [2]
DASA	**1**	**1**	34	75	220	210	210	200	200	40	DASA [19]
DEPSO	**1**	**1**	20	16	*26e-1/2e3*	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	**1**	9.8	16	*71e-2/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	**1**	1600	1e3	*26e-1/1e5*	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	**1**	**1**	**2.2**	12	60	59	57	54	53	11	full NEWUOA [31]
G3-PCX	**1**	**1**	11	6.6	23	22	22	21	20	4	G3-PCX [26]
simple GA	**1**	**1**	110	1500	*20e-1/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	**1**	**1**	**1.1**	**1**	**1**	**1**	**1**	**1**	**1**	**1.3**	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1**	8.1	440	*69e-2/1e6*	.	.	.	.	.	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1**	59	16	37	36	36	35	34	7.2	LSfminbnd [28]
LSstep	**1**	**1**	280	*51e-1/1e4*	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1**	**1**	3.8	810	*20e-1/1e5*	.	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	17	20	50	48	47	*20e-1/4e3*	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	17	18	61	59	58	55	54	11	NELDER (Han) [16]
NELDER (Doe)	**1**	**1**	5.2	6.5	8.3	8.2	8	7.7	7.5	**1.5**	NELDER (Doe) [5]
NEWUOA	**1**	**1**	**1**	4.9	**6.8**	**6.6**	**6.4**	**6.2**	**6**	**1.2**	NEWUOA [31]
(1+1)-ES	**1**	**1**	11	5	11	11	11	10	10	**2.1**	(1+1)-ES [1]
POEMS	**1**	**1**	2300	5e3	*51e-1/1e5*	.	.	.	.	.	POEMS [20]
PSO	**1**	**1**	5	410	*20e-1/1e5*	.	.	.	.	.	PSO [7]
PSO_Bounds	**1**	**1**	680	730	1200	1200	1100	1100	1100	210	PSO_Bounds [8]
Monte Carlo	**1**	**1**	6.4e5	*30e+0/1e6*	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	**1**	3.4	4.3	12	12	12	11	11	**2.2**	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1**	6.2	23	*69e-2/1e4*	.	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1**	14	67	1300	1200	1200	1200	1100	440	VNS (Garcia) [11]

Table 23: 20-D, running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best}}$ on f_{23}, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	0.05	0.16	80.7	3370	18300	24400	25500	40600	41900	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	**1**	**1.9**	82	*29e-2/2e5*	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**1**	**1**	**1.7**	23	**1.1**	**1**	**1**	**1**	**1**	**1**	AMaLGaM IDEA [4]
avg NEWUOA	**1**	**1**	15	4.7	*20e-2/2e4*	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	**1**	**1.6**	*23e-1/2e3*	.	.	.	.	.	.	BayEDAcG [10]
BFGS	**1**	**1**	47	300	*13e-1/5e3*	.	.	.	.	.	BFGS [30]
Cauchy EDA	**1**	**1**	**1.9**	*19e-1/5e4*	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	**1**	4.3	32	**1**	**1.7**	**2**	**1.9**	**1.2**	**1.2**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	**1**	5.8	9.1	*37e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	**1**	**1**	3.4	64	*31e-2/1e6*	.	.	.	.	.	DASA [19]
DEPSO	**1**	**1**	**1.6**	*26e-1/2e3*	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	**1**	4.1	52	*38e-2/5e3*	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1**	**1**	**2.1**	*16e-1/1e5*	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	**1**	**1**	14	7	44	*25e-2/1e4*	.	.	.	.	full NEWUOA [31]
G3-PCX	**1**	**1**	**2.8**	7.8	*30e-2/3e4*	.	.	.	.	.	G3-PCX [26]
simple GA	**1**	**1**	**1.7**	4600	*12e-1/1e5*	.	.	.	.	.	simple GA [22]
GLOBAL	**1**	**1**	**2.8**	**1**	*43e-2/500*	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1**	**1**	**1.9**	5.4	**1.6**	**2.3**	**5.1**	**5.2**	**3.3**	**3.2**	iAMaLGaM IDEA [4]
LSfminbnd	**1**	**1**	4.4	210	*10e-1/1e4*	.	.	.	.	.	LSfminbnd [28]
LSstep	**1**	**1**	**2.2**	81	*91e-2/1e4*	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1**	**1**	**1.8**	7.1	8.9	*61e-3/1e5*	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	**1**	**1.3**	120	*11e-1/4e3*	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	**1**	**2.1**	**3.3**	43	*20e-2/1e4*	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1**	**1**	**1.9**	**1.4**	86	*17e-2/2e4*	.	.	.	.	NELDER (Doe) [5]
NEWUOA	**1**	**1**	12	3.5	32	*39e-2/8e3*	.	.	.	.	NEWUOA [31]
(1+1)-ES	**1**	**1**	27	32	*31e-2/1e6*	.	.	.	.	.	(1+1)-ES [1]
POEMS	**1**	**1**	23	42	13	*59e-3/1e5*	.	.	.	.	POEMS [20]
PSO	**1**	**1**	**2.2**	1600	*95e-2/1e5*	.	.	.	.	.	PSO [7]
PSO_Bounds	**1**	**1**	**3**	8400	*12e-1/1e5*	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	**1**	**1**	**2.6**	5.5e4	*11e-1/1e6*	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1**	**1**	**1.7**	4.6	*50e-2/4e3*	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1**	4.9	18	3.8	*81e-3/1e4*	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1**	**1**	25	10	1700	*23e-3/2e6*	.	.	.	VNS (Garcia) [11]

Table 24: 20-D, running time excess ERT/$\mathrm{ERT}_{\mathrm{best}}$ 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

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Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	0.05	331	66900	3.74e5	2.6e6	2.6e6	2.6e6	2.6e6	2.6e6	2.6e6	$\mathrm{ERT}_{\mathrm{best}}$/D
ALPS	**1**	5.7	*22e+0/2e5*	.	.	.	.	.	.	.	ALPS [17]
AMaLGaM IDEA	**1.1**	4.2	5.1	**19**	***23e-1/1e6***	.	.	.	.	.	AMaLGaM IDEA [4]
avg NEWUOA	14	3.3	*74e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [31]
BayEDAcG	**1**	44	*11e+1/2e3*	.	.	.	.	.	.	.	BayEDAcG [10]
BFGS	8	*31e+1/6e3*	.	.	.	.	.	.	.	.	BFGS [30]
Cauchy EDA	**1.7**	76	*91e+0/5e4*	.	.	.	.	.	.	.	Cauchy EDA [24]
BIPOP-CMA-ES	**1**	5.5	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	BIPOP-CMA-ES [15]
(1+1)-CMA-ES	**1**	24	*90e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [2]
DASA	**1.1**	*16e+1/1e6*	.	.	.	.	.	.	.	.	DASA [19]
DEPSO	**1.1**	*14e+1/2e3*	.	.	.	.	.	.	.	.	DEPSO [12]
DIRECT	**1**	*15e+1/5e3*	.	.	.	.	.	.	.	.	DIRECT [25]
EDA-PSO	**1.1**	28	*86e+0/1e5*	.	.	.	.	.	.	.	EDA-PSO [6]
full NEWUOA	3.7	4.5	*71e+0/1e4*	.	.	.	.	.	.	.	full NEWUOA [31]
G3-PCX	**1.1**	190	*11e+1/5e4*	.	.	.	.	.	.	.	G3-PCX [26]
simple GA	**1.1**	35	*42e+0/1e5*	.	.	.	.	.	.	.	simple GA [22]
GLOBAL	**1**	*21e+1/1e3*	.	.	.	.	.	.	.	.	GLOBAL [23]
iAMaLGaM IDEA	**1.1**	**1.3**	**2.8**	***21e-1/1e6***	.	.	.	.	.	.	iAMaLGaM IDEA [4]
LSfminbnd	7.1	*15e+1/1e4*	.	.	.	.	.	.	.	.	LSfminbnd [28]
LSstep	3.1	210	*19e+1/1e4*	.	.	.	.	.	.	.	LSstep [28]
MA-LS-Chain	**1.1**	**2.1**	42	***25e+0/1e5***	.	.	.	.	.	.	MA-LS-Chain [21]
MCS (Neum)	**1**	12	*10e+1/4e3*	.	.	.	.	.	.	.	MCS (Neum) [18]
NELDER (Han)	**1**	49	*10e+1/1e4*	.	.	.	.	.	.	.	NELDER (Han) [16]
NELDER (Doe)	**1**	3.7	*50e+0/2e4*	.	.	.	.	.	.	.	NELDER (Doe) [5]
NEWUOA	6.5	4.3	*83e+0/8e3*	.	.	.	.	.	.	.	NEWUOA [31]
(1+1)-ES	4.1	3100	*93e+0/1e6*	.	.	.	.	.	.	.	(1+1)-ES [1]
POEMS	**2.7**	10	*46e+0/1e5*	.	.	.	.	.	.	.	POEMS [20]
PSO	**1**	63	*60e+0/1e5*	.	.	.	.	.	.	.	PSO [7]
PSO_Bounds	**1.1**	81	*66e+0/1e5*	.	.	.	.	.	.	.	PSO_Bounds [8]
Monte Carlo	**1**	*26e+1/1e6*	.	.	.	.	.	.	.	.	Monte Carlo [3]
Rosenbrock	**1.4**	*37e+1/1e4*	.	.	.	.	.	.	.	.	Rosenbrock [27]
IPOP-SEP-CMA-ES	**1**	**1**	**1**	***23e+0/1e4***	.	.	.	.	.	.	IPOP-SEP-CMA-ES [29]
VNS (Garcia)	**1**	**1.8**	68	***88e-1/1e7***	.	.	.	.	.	.	VNS (Garcia) [11]

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