

Comparison tables: BBOB 2009 function testbed in 2-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: 02-D, running time excess ERT/ERT_{best} on f_1 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | | 1 Sphere | | | | | | | | | | | |
|----------------------------|-----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------------|----------------------------|-----------------------|
| Δf_{target} | ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} | ERT_{best}/D |
| | | 0.5 | 0.5 | 0.9 | 2.83 | 2.83 | 3 | 3 | 3 | 3 | 3 | | |
| ALPS | 1 | 1 | 1 | 2.8 | 9.7 | 56 | 170 | 290 | 440 | 640 | 970 | | ALPS [17] |
| AMaLGaM IDEA | 1 | 1.1 | 1.1 | 2.1 | 4.4 | 11 | 14 | 23 | 28 | 32 | 46 | | AMaLGaM IDEA [4] |
| avg NEWUOA | 1 | 1 | 1 | 1.9 | 1.1 | 1.1 | 1 | 1 | 1 | 1 | 1 | | avg NEWUOA [31] |
| BayEDAeG | 1 | 1 | 1 | 1.9 | 4.2 | 18 | 79 | 110 | 140 | 160 | 210 | | BayEDAeG [10] |
| BFGS | 1 | 1 | 1 | 3.3 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | | BFGS [30] |
| Cauchy EDA | 1 | 1 | 1 | 19 | 15 | 27 | 39 | 50 | 63 | 75 | 100 | | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1 | 1 | 1 | 3.3 | 3.8 | 8.5 | 13 | 19 | 24 | 29 | 39 | | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1 | 1 | 1 | 3.3 | 3.6 | 7.6 | 11 | 14 | 18 | 22 | 29 | | (1+1)-CMA-ES [2] |
| DASA | 1 | 1 | 1 | 39 | 23 | 44 | 52 | 62 | 76 | 95 | 120 | | DASA [19] |
| DEPSO | 1 | 1 | 1 | 2.1 | 12 | 27 | 46 | 51 | 96 | 120 | 170 | | DEPSO [12] |
| DIRECT | 1 | 1 | 1 | 1 | 1.4 | 2.5 | 9.4 | 15 | 20 | 32 | 56 | | DIRECT [25] |
| EDA-PSO | 1 | 1 | 1 | 1.9 | 5 | 20 | 34 | 53 | 80 | 110 | 210 | | EDA-PSO [6] |
| full NEWUOA | 1 | 1 | 1 | 2.7 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | | full NEWUOA [31] |
| G3-PCX | 1 | 1 | 1 | 1.9 | 6 | 17 | 19 | 24 | 29 | 34 | 46 | | G3-PCX [26] |
| simple GA | 1 | 1 | 1 | 2.7 | 7.2 | 62 | 310 | 1100 | 1800 | 2600 | 4500 | | simple GA [22] |
| GLOBAL | 1 | 1 | 1 | 1.9 | 5.7 | 39 | 50 | 54 | 55 | 56 | 58 | | GLOBAL [23] |
| iAMaLGaM IDEA | 1 | 1 | 1 | 2.3 | 3.8 | 6.7 | 12 | 14 | 19 | 22 | 31 | | iAMaLGaM IDEA [4] |
| LSfminbnd | 1 | 1 | 1 | 7.8 | 3.2 | 3.6 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | | LSfminbnd [28] |
| LSstep | 1 | 1 | 1 | 46 | 34 | 62 | 63 | 68 | 68 | 69 | 69 | | LSstep [28] |
| MA-LS-Chain | 1 | 1 | 1 | 2.4 | 7.4 | 26 | 40 | 67 | 85 | 92 | 100 | | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1 | 1 | 1 | 1.5 | 2.2 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | | MCS (Neum) [18] |
| NELDER (Han) | 1 | 1 | 1 | 2.1 | 1.3 | 3 | 3.9 | 5.1 | 6.3 | 7.4 | 9.8 | | NELDER (Han) [16] |
| NELDER (Doe) | 1 | 1 | 1 | 1 | 1.5 | 2.9 | 4.1 | 5.3 | 6.5 | 7.6 | 10 | | NELDER (Doe) [5] |
| NEWUOA | 1 | 1 | 1 | 2.8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | NEWUOA [31] |
| (1+1)-ES | 1 | 1 | 1 | 3.5 | 2.8 | 6.7 | 10 | 14 | 18 | 23 | 30 | | (1+1)-ES [1] |
| POEMS | 1 | 1 | 1 | 170 | 80 | 110 | 400 | 680 | 1100 | 1300 | 2100 | | POEMS [20] |
| PSO | 1 | 1 | 1 | 2.1 | 5.3 | 20 | 59 | 120 | 200 | 250 | 470 | | PSO [7] |
| PSO_Bounds | 1 | 1 | 1 | 2.4 | 6 | 26 | 89 | 270 | 460 | 770 | 1200 | | PSO_Bounds [8] |
| Monte Carlo | 1 | 1 | 1 | 1.5 | 9.7 | 49 | 540 | 5900 | 4.8e4 | 6.8e5 | <i>11e-6/1e6</i> | | Monte Carlo [3] |
| Rosenbrock | 1 | 1 | 1 | 5.6 | 3.1 | 3.9 | 4.9 | 6.2 | 7.6 | 8.8 | 11 | | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1 | 1 | 1 | 3.9 | 5.9 | 9.5 | 14 | 18 | 24 | 28 | 38 | | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1 | 1 | 1 | 2.6 | 8.9 | 25 | 33 | 37 | 43 | 48 | 60 | | VNS (Garcia) [11] |

Table 2: 02-D, running time excess ERT/ERT_{best} on f_2 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | | 2 Ellipsoid separable | | | | | | | | | | | | |
|----------------------------|-----------------------|------------------------------|------------|------------|------------|------------|------------|------------------|------------|------------|----------|----------------------------|---------------------------|--|
| Δf_{target} | ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} | ERT_{best}/D | |
| ALPS | | 11 | 24 | 58 | 120 | 130 | 160 | 200 | 230 | 260 | 330 | | ALPS [17] | |
| AMaLgAM IDEA | | 4.9 | 4.8 | 6.2 | 7.6 | 7.5 | 9.1 | 10 | 11 | 13 | 16 | | AMaLgAM IDEA [4] | |
| avg NEWUOA | | 1.2 | 1.1 | 1.9 | 5.6 | 8.5 | 10 | 14 | 17 | 20 | 27 | | avg NEWUOA [31] | |
| BayEDA _{cG} | | 37 | 62 | 80 | 78 | 82 | 87 | 110 | 110 | 140 | 140 | | BayEDA _{cG} [10] | |
| BFGS | | 1.7 | 1.6 | 2.5 | 4 | 3.7 | 3.9 | 4.1 | 4.1 | 4.1 | 4.4 | | BFGS [30] | |
| Cauchy EDA | | 13 | 17 | 18 | 18 | 18 | 20 | 23 | 24 | 25 | 29 | | Cauchy EDA [24] | |
| BIPOP-CMA-ES | | 4 | 5.4 | 13 | 19 | 18 | 18 | 20 | 20 | 20 | 22 | | BIPOP-CMA-ES [15] | |
| (1+1)-CMA-ES | | 4.1 | 5.1 | 10 | 13 | 13 | 13 | 14 | 14 | 15 | 16 | | (1+1)-CMA-ES [2] | |
| DASA | | 21 | 19 | 19 | 22 | 21 | 21 | 23 | 25 | 26 | 31 | | DASA [19] | |
| DEPSO | | 10 | 16 | 18 | 26 | 27 | 31 | 35 | 40 | 45 | 53 | | DEPSO [12] | |
| DIRECT | | 5.9 | 5.1 | 7.5 | 8 | 7.1 | 8.5 | 9.4 | 12 | 13 | 46 | | DIRECT [25] | |
| EDA-PSO | | 8.8 | 11 | 13 | 19 | 20 | 26 | 39 | 49 | 65 | 88 | | EDA-PSO [6] | |
| full NEWUOA | | 1.2 | 1.2 | 2.4 | 5.8 | 8.3 | 10 | 13 | 15 | 18 | 23 | | full NEWUOA [31] | |
| G3-PCX | | 8.6 | 8.4 | 14 | 64 | 69 | 76 | 83 | 82 | 82 | 82 | | G3-PCX [26] | |
| simple GA | | 11 | 44 | 130 | 320 | 420 | 540 | 780 | 990 | 1300 | 1900 | | simple GA [22] | |
| GLOBAL | | 11 | 19 | 19 | 17 | 13 | 13 | 13 | 13 | 13 | 13 | | GLOBAL [23] | |
| iAMaLgAM IDEA | | 2.6 | 3.8 | 5.1 | 9.2 | 9.1 | 10 | 11 | 12 | 12 | 14 | | iAMaLgAM IDEA [4] | |
| LSfminbnd | | 1.4 | 1.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | LSfminbnd [28] | |
| LSstep | | 14 | 12 | 9.5 | 9.9 | 7.9 | 7.9 | 7.8 | 7.5 | 7.3 | 7.3 | | LSstep [28] | |
| MA-LS-Chain | | 12 | 14 | 17 | 22 | 20 | 24 | 28 | 28 | 29 | 34 | | MA-LS-Chain [21] | |
| MCS (Neum) | | 1.5 | 1.6 | 1.4 | 1.8 | 1.7 | 2.6 | 3.2 | 3.3 | 3.7 | 23 | | MCS (Neum) [18] | |
| NELDER (Han) | | 1.9 | 1.8 | 1.7 | 1.8 | 1.8 | 2 | 2.2 | 2.4 | 2.6 | 3 | | NELDER (Han) [16] | |
| NELDER (Doe) | | 1.6 | 1.7 | 1.6 | 1.9 | 1.7 | 1.9 | 2.2 | 2.3 | 2.5 | 3 | | NELDER (Doe) [5] | |
| NEWUOA | | 1 | 1 | 2.2 | 8.8 | 12 | 15 | 19 | 23 | 26 | 35 | | NEWUOA [31] | |
| (1+1)-ES | | 3.2 | 2400 | 8700 | 4.7e4 | 1.2e5 | 3.8e5 | <i>74e-3/1e6</i> | . | . | . | | (1+1)-ES [1] | |
| POEMS | | 140 | 250 | 380 | 420 | 400 | 460 | 510 | 570 | 630 | 780 | | POEMS [20] | |
| PSO | | 7.5 | 14 | 56 | 83 | 83 | 98 | 120 | 130 | 160 | 200 | | PSO [7] | |
| PSO_Bounds | | 6.9 | 24 | 54 | 170 | 310 | 360 | 400 | 440 | 530 | 780 | | PSO_Bounds [8] | |
| Monte Carlo | | 21 | 50 | 240 | 1200 | 5600 | 1e5 | <i>94e-4/1e6</i> | . | . | . | | Monte Carlo [3] | |
| Rosenbrock | | 2.6 | 3.1 | 2.5 | 3.7 | 4.4 | 5.4 | 6.3 | 6.5 | 6.9 | 7.9 | | Rosenbrock [27] | |
| IPOP-SEP-CMA-ES | | 4.5 | 5.4 | 14 | 19 | 16 | 17 | 18 | 18 | 18 | 20 | | IPOP-SEP-CMA-ES [29] | |
| VNS (Garcia) | | 8.4 | 15 | 22 | 27 | 24 | 25 | 26 | 26 | 26 | 29 | | VNS (Garcia) [11] | |

Table 3: 02-D, running time excess ERT/ERT_{best} on f_3 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 3 Rastrigin separable | | | | | | | | | | | | |
|---|------------|------------|------------|------------|------------|------------|--------------|------------------|------------|------------|---|--|
| Δf_{target} ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT_{best}/D | |
| ALPS | 1.1 | 1.6 | 9.2 | 6.7 | 6.4 | 11 | 12 | 15 | 19 | 23 | ALPS [17] | |
| AMaLGA _M IDEA | 1.1 | 1.1 | 3.7 | 4.6 | 12 | 12 | 12 | 12 | 13 | 13 | AMaLGA _M IDEA [4] | |
| avg NEWUOA | 1 | 2.7 | 5.1 | 1.6 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.1 | avg NEWUOA [31] | |
| BayEDA _{cG} | 1.1 | 1.2 | 4.4 | 4 | 9.7 | 18 | 41 | 65 | 65 | 64 | BayEDA _{cG} [10] | |
| BFGS | 1.2 | 18 | 14 | 3.1 | 10 | 10 | 10 | 10 | 10 | 10 | BFGS [30] | |
| Cauchy EDA | 1.1 | 9.6 | 9.6 | 3.3 | 8.4 | 33 | 43 | 43 | 43 | 43 | Cauchy EDA [24] | |
| BIPOP-CMA-ES | 1 | 2.2 | 3.5 | 3.5 | 5.2 | 6.2 | 6.4 | 6.5 | 6.5 | 6.7 | BIPOP-CMA-ES [15] | |
| (1+1)-CMA-ES | 1 | 1.9 | 6.9 | 3.8 | 7.9 | 7.9 | 7.9 | 7.9 | 7.9 | 7.8 | (1+1)-CMA-ES [2] | |
| DASA | 6.3 | 22 | 18 | 1.8 | 6.9 | 7 | 7.1 | 7.2 | 7.4 | 7.6 | DASA [19] | |
| DEPSO | 1.8 | 2 | 5.7 | 2.3 | 2.7 | 4 | 4.5 | 5 | 5.4 | 6.4 | DEPSO [12] | |
| DIRECT | 1 | 1.1 | 2.7 | 1 | 2.4 | 2.4 | 2.5 | 2.6 | 2.7 | 3 | DIRECT [25] | |
| EDA-PSO | 1.2 | 1.4 | 4.8 | 6.4 | 14 | 19 | 20 | 20 | 21 | 22 | EDA-PSO [6] | |
| full NEWUOA | 1 | 4 | 2.3 | 1.8 | 2.2 | 2.2 | 2.2 | 2.1 | 2.1 | 2.1 | full NEWUOA [31] | |
| G3-PCX | 1.1 | 2 | 4.1 | 7.8 | 40 | 40 | 39 | 39 | 39 | 39 | G3-PCX [26] | |
| simple GA | 1 | 2 | 8.3 | 13 | 19 | 27 | 40 | 55 | 70 | 110 | simple GA [22] | |
| GLOBAL | 1.1 | 1.6 | 7 | 1.8 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | GLOBAL [23] | |
| iAMaLGA _M IDEA | 1.1 | 1.4 | 1.8 | 6.3 | 17 | 17 | 17 | 17 | 17 | 17 | iAMaLGA _M IDEA [4] | |
| LSfminbnd | 2.1 | 4.7 | 17 | 32 | 43 | 64 | 63 | 63 | 63 | 61 | LSfminbnd [28] | |
| LSstep | 28 | 120 | 24 | 1.5 | 1 | 1 | 1 | 1 | 1 | 1 | LSstep [28] | |
| MA-LS-Chain | 1 | 1.5 | 5.7 | 1.7 | 2.5 | 2.6 | 2.7 | 2.7 | 2.8 | 2.9 | MA-LS-Chain [21] | |
| MCS (Neum) | 1 | 1.1 | 1.5 | 1.1 | 1.5 | 1.6 | 1.6 | 2.6 | 2.6 | 2.6 | MCS (Neum) [18] | |
| NELDER (Han) | 1.2 | 1.8 | 1.4 | 4 | 13 | 13 | 13 | 13 | 12 | 12 | NELDER (Han) [16] | |
| NELDER (Doe) | 1 | 1 | 1 | 1 | 1.7 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | NELDER (Doe) [5] | |
| NEWUOA | 1.5 | 2.4 | 4.8 | 1.5 | 4.2 | 4.2 | 4.2 | 4.1 | 4.1 | 4.1 | NEWUOA [31] | |
| (1+1)-ES | 1.1 | 2.4 | 12 | 5 | 15 | 15 | 15 | 15 | 15 | 14 | (1+1)-ES [1] | |
| POEMS | 31 | 200 | 42 | 11 | 14 | 20 | 24 | 29 | 32 | 41 | POEMS [20] | |
| PSO | 1.1 | 1.6 | 5.1 | 3.3 | 3.4 | 4.7 | 6 | 7.2 | 8.8 | 11 | PSO [7] | |
| PSO_Bounds | 1.1 | 1.8 | 4.8 | 5.3 | 8.3 | 14 | 18 | 22 | 26 | 34 | PSO_Bounds [8] | |
| Monte Carlo | 1.1 | 1.5 | 14 | 67 | 460 | 3100 | <i>2.1e4</i> | <i>39e-4/1e6</i> | . | . | Monte Carlo [3] | |
| Rosenbrock | 1 | 16 | 45 | 15 | 26 | 26 | 26 | 26 | 26 | 25 | Rosenbrock [27] | |
| IPOP-SEP-CMA-ES | 1 | 1.5 | 2.3 | 3.4 | 7.6 | 8.4 | 9.2 | 9.4 | 9.6 | 9.8 | IPOP-SEP-CMA-ES [29] | |
| VNS (Garcia) | 1 | 1.9 | 8.8 | 2.9 | 4.1 | 4.2 | 4.2 | 4.5 | 4.7 | 7.7 | VNS (Garcia) [11] | |

Table 4: 02-D, running time excess ERT/ERT_{best} on f_4 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separable

| Δf_{target} ERT _{best} /D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT _{best} /D |
|---|------------|------------|------------|------------|------------|------------|------------------|------------------|------------------|------------|---|
| ALPS | 1 | 0.5 | 9 | 7.1 | 8.3 | 9.7 | 12 | 15 | 17 | 20 | ALPS [17] |
| AMaLGaM IDEA | 1 | 2.5 | 2.6 | 5.6 | 51 | 48 | 48 | 46 | 47 | 45 | AMaLGaM IDEA [4] |
| avg NEWUOA | 1 | 4.5 | 6.2 | 4 | 14 | 13 | 12 | 12 | 12 | 11 | avg NEWUOA [31] |
| BayEDA _c G | 1 | 2.3 | 4.5 | 13 | 62 | 120 | 110 | <i>10e-1/2e3</i> | . | . | BayEDA _c G [10] |
| BFGS | 1 | 13 | 11 | 5.7 | 12 | 11 | 11 | 10 | 10 | 9.8 | BFGS [30] |
| Cauchy EDA | 1 | 19 | 6.8 | 13 | 75 | 410 | 470 | 450 | 450 | 430 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1 | 3.8 | 2.6 | 6.9 | 55 | 97 | 99 | 98 | 99 | 110 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1 | 2.4 | 5.2 | 5.5 | 27 | 25 | 24 | 23 | 23 | 22 | (1+1)-CMA-ES [2] |
| DASA | 1 | 82 | 15 | 2 | 3.6 | 3.4 | 3.3 | 3.3 | 3.4 | 3.4 | DASA [19] |
| DEPSO | 1 | 2.4 | 7.2 | 4.2 | 6.5 | 11 | 17 | 17 | 17 | 35 | DEPSO [12] |
| DIRECT | 1 | 1 | 1.8 | 1.8 | 6.6 | 6.1 | 14 | 14 | 16 | 16 | DIRECT [25] |
| EDA-PSO | 1 | 2.6 | 4.2 | 9.9 | 18 | 19 | 19 | 19 | 19 | 20 | EDA-PSO [6] |
| full NEWUOA | 1 | 3.8 | 5.4 | 3.9 | 15 | 14 | 13 | 13 | 13 | 12 | full NEWUOA [31] |
| G3-PCX | 1 | 2.1 | 20 | 17 | 76 | 70 | 67 | 65 | 64 | 62 | G3-PCX [26] |
| simple GA | 1 | 2.6 | 10 | 16 | 22 | 28 | 37 | 49 | 60 | 100 | simple GA [22] |
| GLOBAL | 1 | 2.4 | 8.5 | 1.2 | 5.2 | 4.8 | 4.6 | 4.5 | 4.5 | 4.3 | GLOBAL [23] |
| iAMaLGaM IDEA | 1 | 3.8 | 2.5 | 9.5 | 61 | 57 | 56 | 55 | 55 | 54 | iAMaLGaM IDEA [4] |
| LSfminbd | 1 | 4.6 | 1 | 45 | 120 | 230 | <i>10e-1/4e3</i> | . | . | . | LSfminbd [28] |
| LSstep | 1 | 220 | 19 | 1.3 | 1 | 1 | 1 | 1 | 1 | 1 | LSstep [28] |
| MA-LS-Chain | 1 | 2.3 | 5.6 | 1.8 | 4.4 | 4.2 | 4.1 | 4 | 4.1 | 4.1 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1 | 2 | 1 | 2.9 | 2.7 | 2.7 | 2.7 | 2.7 | 2.6 | MCS (Neum) [18] |
| NELDER (Han) | 1 | 3.1 | 5 | 5.3 | 27 | 25 | 24 | 23 | 23 | 22 | NELDER (Han) [16] |
| NELDER (Doe) | 1 | 2.1 | 1.9 | 1.4 | 3.5 | 3.2 | 3.1 | 3 | 3 | 3 | NELDER (Doe) [5] |
| NEWUOA | 1 | 3 | 5 | 4.5 | 18 | 16 | 16 | 15 | 15 | 14 | NEWUOA [31] |
| (1+1)-ES | 1 | 3.1 | 4.5 | 5.5 | 23 | 21 | 20 | 20 | 20 | 19 | (1+1)-ES [1] |
| POEMS | 1 | 240 | 36 | 9.8 | 22 | 23 | 29 | 32 | 35 | 41 | POEMS [20] |
| PSO | 1.1 | 3.2 | 4 | 3.3 | 4.6 | 5.6 | 6.4 | 7.4 | 8.7 | 11 | PSO [7] |
| PSO_Bounds | 1 | 3.3 | 4.4 | 6.3 | 9.6 | 17 | 21 | 24 | 27 | 33 | PSO_Bounds [8] |
| Monte Carlo | 1 | 3.3 | 8.6 | 67 | 620 | 8200 | 2.8e4 | 5.5e4 | <i>11e-3/1e6</i> | . | Monte Carlo [3] |
| Rosenbrock | 1 | 71 | 27 | 15 | 52 | 48 | 46 | 44 | 44 | 42 | Rosenbrock [27] |
| IPOP-SEF-CMA-ES | 1 | 3.5 | 3 | 8.7 | 75 | 180 | 270 | 260 | 260 | 250 | IPOP-SEF-CMA-ES [29] |
| VNS (Garcia) | 1 | 2.6 | 5.1 | 4.1 | 8.8 | 8.2 | 7.9 | 8.3 | 8.8 | 17 | VNS (Garcia) [11] |

Table 5: 02-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 | | | | | | | | | | | | |
|----------------------------|-----------------------|-------|-------|-------|-------|-----------|-------|-------|-------|-------|-------|-------------------------------|
| Δf_{target} | ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
| ERT_{best}/D | | 0.5 | 0.5 | 1.83 | 76 | 100 | 100 | 100 | 100 | 100 | 100 | ERT_{best}/D |
| ALPS | 1 | 1.1 | 1.1 | 8.8 | 76 | 100 | 100 | 100 | 100 | 100 | 100 | ALPS [17] |
| AMaLGA _M IDEA | 1 | 1.1 | 1.1 | 5.3 | 16 | 18 | 18 | 18 | 18 | 18 | 18 | AMaLGA _M IDEA [4] |
| avg NEWUOA | 1 | 1.2 | 1.1 | 1.5 | 1.5 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | avg NEWUOA [31] |
| BayEDA _{cG} | 1 | 1 | 3.3 | 92 | 92 | 100 | 100 | 100 | 100 | 100 | 100 | BayEDA _{cG} [10] |
| BFGS | 1 | 1 | 1.5 | 2.8 | 2.8 | 2.8 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | BFGS [30] |
| Cauchy EDA | 1 | 1 | 1.6 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1 | 1 | 3.4 | 5.3 | 5.3 | 5.7 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1 | 1 | 1.9 | 3.1 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | (1+1)-CMA-ES [2] |
| DASA | 1 | 1.9 | 1.9 | 32 | 40 | 46 | 53 | 60 | 66 | 80 | 80 | DASA [19] |
| DEPSO | 1 | 1 | 6.1 | 34 | 35 | 36 | 36 | 36 | 36 | 36 | 36 | DEPSO [12] |
| DIRECT | 1 | 1 | 3.4 | 2.8 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | DIRECT [25] |
| EDA-PSO | 1 | 1 | 5 | 15 | 16 | 17 | 17 | 17 | 17 | 17 | 17 | EDA-PSO [6] |
| full NEWUOA | 1 | 1.3 | 1 | 1.4 | 1.2 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | full NEWUOA [31] |
| G3-PCX | 1 | 1.1 | 4.1 | 29 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | G3-PCX [26] |
| simple GA | 1 | 1 | 4.2 | 310 | 2e3 | 4200 | 6300 | 9800 | 1.5e4 | 6.8e5 | 6.8e5 | simple GA [22] |
| GLOBAL | 1 | 1.1 | 4.4 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | GLOBAL [23] |
| iAMaLGA _M IDEA | 1 | 1 | 4.6 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | iAMaLGA _M IDEA [4] |
| LSfminbd | 1 | 1 | 4.9 | 7.3 | 8.5 | 9.1 | 9.1 | 9.1 | 9.1 | 9.1 | 9.1 | LSfminbd [28] |
| LSstep | 1 | 1.2 | 5.9 | 79 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | LSstep [28] |
| MA-LS-Chain | 1 | 1.1 | 4.7 | 81 | 120 | 130 | 130 | 130 | 130 | 130 | 130 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1 | 1.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MCS (Neum) [18] |
| NELDER (Han) | 1 | 1 | 1.8 | 2.1 | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | NELDER (Han) [16] |
| NELDER (Doe) | 1 | 1 | 1.3 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | NELDER (Doe) [5] |
| NEWUOA | 1 | 1 | 1.1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | NEWUOA [31] |
| (1+1)-ES | 1 | 1 | 1.9 | 2.4 | 2.4 | 2.5 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | (1+1)-ES [1] |
| POEMS | 1 | 1 | 1.40 | 150 | 170 | 180 | 180 | 190 | 190 | 190 | 190 | POEMS [20] |
| PSO | 1 | 1.1 | 4.2 | 18 | 20 | 21 | 21 | 21 | 21 | 21 | 21 | PSO [7] |
| PSO_Bounds | 1 | 1 | 6.1 | 13 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | PSO_Bounds [8] |
| Monte Carlo | 1 | 1 | 4.4 | 530 | 4.9e4 | 22e-3/1e6 | . | . | . | . | . | Monte Carlo [3] |
| Rosenbrock | 1 | 1 | 3.5 | 3.4 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1 | 1 | 4 | 6.6 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1 | 1 | 6.3 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | VNS (Garcia) [11] |

Table 6: 02-D, running time excess ERT/ERT_{best} on f_6 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 6 Attractive sector | | | | | | | | | | | | |
|---|------------|------------|------------|------------|------------|------------------|------------|------------|------------------|------------------|---|--|
| Δf_{target} ERT _{best} /D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT _{best} /D | |
| ALPS | 0.833 | 1.4 | 6.33 | 11.4 | 20.5 | 26.9 | 33.5 | 39.9 | 47.3 | 62.2 | ALPS [17] | |
| AMaLGA _M IDEA | 3.2 | 3.2 | 2.2 | 1.2 | 31 | 50 | 62 | 73 | 80 | 83 | AMaLGA _M IDEA [4] | |
| avg NEWUOA | 1.1 | 1.4 | 2.1 | 4.5 | 4.9 | 5.5 | 6.2 | 6.5 | 6.7 | 7 | avg NEWUOA [31] | |
| BayEDA _{cG} | 1.4 | 2.1 | 3.1 | 4.7 | 3.9 | 4.4 | 4.4 | 4.5 | 4.7 | 4.6 | BayEDA _{cG} [10] | |
| BFGS | 2.8 | 1.9 | 1.5 | 1.60 | 640 | <i>72e-2/2e3</i> | 2 | 1.9 | 1.7 | 1.6 | BFGS [30] | |
| Cauchy EDA | 4.3 | 4.4 | 4.2 | 3.4 | 2.7 | 2.4 | 2 | 1.9 | 1.7 | 1.6 | Cauchy EDA [24] | |
| BIPOP-CMA-ES | 11 | 10 | 16 | 18 | 17 | 17 | 17 | 17 | 16 | 16 | BIPOP-CMA-ES [15] | |
| (1+1)-CMA-ES | 3.9 | 3 | 2 | 2.8 | 3.6 | 3.9 | 4.2 | 4.2 | 4.1 | 4.3 | (1+1)-CMA-ES [2] | |
| DASA | 4.2 | 3.3 | 2.1 | 3 | 2.3 | 2.2 | 2.2 | 2.3 | 2.2 | 2.1 | DASA [19] | |
| DEPSO | 30 | 29 | 23 | 22 | 18 | 19 | 19 | 18 | 18 | 18 | DEPSO [12] | |
| DIRECT | 1.7 | 1.7 | 3.8 | 11 | 12 | 14 | 14 | 15 | 16 | 17 | DIRECT [25] | |
| EDA-PSO | 1.4 | 1 | 1.4 | 7.6 | 5.8 | 120 | 800 | 1500 | 1200 | 970 | EDA-PSO [6] | |
| full NEWUOA | 3.4 | 2.4 | 3.1 | 12 | 12 | 15 | 19 | 27 | 29 | 34 | full NEWUOA [31] | |
| G3-PCX | 1 | 2.2 | 3.4 | 3.7 | 3.2 | 3.5 | 3.7 | 3.7 | 4.1 | 4.5 | G3-PCX [26] | |
| simple GA | 2.3 | 1.5 | 2.3 | 4.5 | 3.7 | 3.9 | 3.9 | 3.8 | 3.8 | 4.1 | simple GA [22] | |
| GLOBAL | 4.8 | 3.4 | 3.5 | 14 | 85 | 1e3 | 3100 | 4100 | 3600 | 4900 | GLOBAL [23] | |
| iAMaLGA _M IDEA | 3.7 | 2.9 | 2.3 | 8.8 | 7.4 | 6.2 | 5.2 | 4.5 | 3.9 | 3.2 | iAMaLGA _M IDEA [4] | |
| LSfminbd | 2.7 | 1.9 | 2.4 | 3.6 | 3.8 | 4 | 4.1 | 4.2 | 4.3 | 4.4 | LSfminbd [28] | |
| LSstep | 19 | 190 | 280 | 370 | 290 | 260 | 210 | 180 | 150 | 120 | LSstep [28] | |
| MA-LS-Chain | 53 | 330 | 910 | 580 | 380 | 330 | 710 | 1200 | <i>17e-4/1e4</i> | . | MA-LS-Chain [21] | |
| MCS (Neum) | 4.4 | 2.9 | 2.2 | 13 | 14 | 14 | 12 | 12 | 10 | 10 | MCS (Neum) [18] | |
| NELDER (Han) | 1.4 | 190 | 52 | 29 | 19 | 42 | 100 | 110 | 100 | 120 | NELDER (Han) [16] | |
| NELDER (Doe) | 2.1 | 1.5 | 1 | 1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | NELDER (Doe) [5] | |
| NEWUOA | 1.6 | 2 | 1.3 | 1.3 | 1 | 1 | 1 | 1 | 1 | 1 | NEWUOA [31] | |
| (1+1)-ES | 1.2 | 2.4 | 2.4 | 4.4 | 3.9 | 4.4 | 4.7 | 4.8 | 5 | 4.9 | (1+1)-ES [1] | |
| POEMS | 2.4 | 2.2 | 2.5 | 3.7 | 3.6 | 3.6 | 3.4 | 3.4 | 3.3 | 3.2 | POEMS [20] | |
| PSO | 200 | 160 | 99 | 130 | 120 | 140 | 130 | 140 | 180 | 180 | PSO [7] | |
| PSO.Bounds | 1.5 | 1.1 | 2.1 | 4.6 | 7.9 | 18 | 23 | 29 | 32 | 36 | PSO.Bounds [8] | |
| Monte Carlo | 2.2 | 1.5 | 2.6 | 7 | 37 | 77 | 130 | 140 | 140 | 170 | Monte Carlo [3] | |
| Rosenbrock | 3 | 2.3 | 2.7 | 16 | 53 | 780 | 1.3e4 | 8.1e4 | 1.5e5 | <i>28e-5/1e6</i> | Rosenbrock [27] | |
| IPOP-SEFP-CMA-ES | 4 | 3 | 2.2 | 2.1 | 1.8 | 1.8 | 1.8 | 1.8 | 1.7 | 1.5 | IPOP-SEFP-CMA-ES [29] | |
| VNS (Garcia) | 4.7 | 3.1 | 1.7 | 4.1 | 3.8 | 4.5 | 4.6 | 4.7 | 4.6 | 4.4 | VNS (Garcia) [11] | |
| | 2.6 | 2.7 | 1.9 | 7.2 | 6.9 | 6.7 | 6.3 | 6.3 | 6.1 | 5.7 | | |

Table 7: 02-D, running time excess ERT/ERT_{best} on f_7 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT_{best}/D |
|-----------------|---------------------------------------|-------|-------|-------|-------|-------|------------------|------------------|-------|-------|-------|---------------------------------------|
| ALPS | | 1.1 | 1.4 | 4.1 | 4.7 | 12 | 9.5 | 11 | 11 | 11 | 13 | ALPS [17] |
| AMaLGaM IDEA | | 1.1 | 1.5 | 3.4 | 20 | 8.1 | 2.7 | 2.5 | 2.5 | 2.5 | 2.4 | AMaLGaM IDEA [4] |
| avg NEWUOA | | 1.7 | 2.7 | 4 | 3.7 | 6.8 | 5 | 10 | 10 | 10 | 9 | avg NEWUOA [31] |
| BayEDA-cG | | 1.5 | 1.7 | 4.2 | 3.1 | 79 | 85 | 76 | 76 | 76 | 110 | BayEDA-cG [10] |
| BFGS | | 1.6 | 3.7 | 10 | 19 | 34 | <i>76e-2/200</i> | . | . | . | . | BFGS [30] |
| Cauchy-EDA | | 5.5 | 8.4 | 19 | 7.6 | 5.3 | 2 | 1.9 | 1.9 | 1.9 | 2.1 | Cauchy-EDA [24] |
| BIPOP-CMA-ES | | 1.9 | 1.9 | 3.2 | 2.6 | 3.4 | 1.5 | 1.5 | 1.5 | 1.5 | 1.6 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | | 1.5 | 1.4 | 2.7 | 1.8 | 2.8 | 1 | 1 | 1 | 1 | 1 | (1+1)-CMA-ES [2] |
| DASA | | 30 | 59 | 170 | 170 | 310 | 240 | 440 | 440 | 440 | 390 | DASA [19] |
| DEPSO | | 1.7 | 1.7 | 6.5 | 4.8 | 4.9 | 2.6 | 3.1 | 3.1 | 3.1 | 3.6 | DEPSO [12] |
| DIRECT | | 1.4 | 1 | 2.1 | 1.3 | 1 | 2.7 | 3 | 3 | 3 | 2.7 | DIRECT [25] |
| EDA-PSO | | 1.5 | 1.8 | 3.7 | 3.1 | 6.2 | 6.2 | 9 | 9 | 9 | 14 | EDA-PSO [6] |
| full NEWUOA | | 1.9 | 2.7 | 2 | 3.7 | 3.7 | 1.7 | 2.9 | 2.9 | 2.9 | 2.7 | full NEWUOA [31] |
| G3-PCX | | 1.3 | 1.5 | 4.5 | 12 | 35 | 19 | 21 | 21 | 21 | 19 | G3-PCX [26] |
| simple GA | | 1.6 | 1.6 | 5.2 | 3.9 | 22 | 24 | 47 | 47 | 47 | 67 | simple GA [22] |
| GLOBAL | | 1.2 | 1.8 | 6.8 | 4.1 | 7.5 | 2.7 | 4.4 | 4.4 | 4.4 | 3.9 | GLOBAL [23] |
| iAMaLGaM IDEA | | 1.8 | 1.8 | 3.9 | 12 | 4.7 | 2.8 | 2.5 | 2.5 | 2.5 | 2.4 | iAMaLGaM IDEA [4] |
| LSfminbnd | | 1.3 | 1.1 | 6.3 | 11 | 66 | 55 | 500 | 500 | 500 | 960 | LSfminbnd [28] |
| LStep | | 28 | 28 | 260 | 250 | 460 | 1500 | <i>29e-3/1e4</i> | . | . | . | LStep [28] |
| MA-LS-Chain | | 1.7 | 2.3 | 5.8 | 3.4 | 4.7 | 3.6 | 4.6 | 4.6 | 4.6 | 4.7 | MA-LS-Chain [21] |
| MCS (Neum) | | 1.4 | 1.4 | 1 | 4.1 | 4.5 | 2.2 | 6.5 | 6.5 | 6.5 | 6 | MCS (Neum) [18] |
| NELDER (Han) | | 1.5 | 1.3 | 2.5 | 25 | 18 | 6.6 | 6.5 | 6.5 | 6.5 | 5.9 | NELDER (Han) [16] |
| NELDER (Doe) | | 1.8 | 1.6 | 2.6 | 1 | 8.5 | 5.4 | 5.2 | 5.2 | 5.2 | 5.4 | NELDER (Doe) [5] |
| NEWUOA | | 1.7 | 2 | 2.5 | 9.3 | 9.3 | 6 | 14 | 14 | 14 | 12 | NEWUOA [31] |
| (1+1)-ES | | 2.3 | 3.3 | 5.6 | 4.1 | 4.3 | 1.8 | 3.3 | 3.3 | 3.3 | 3 | (1+1)-ES [1] |
| POEMS | | 220 | 210 | 180 | 45 | 41 | 21 | 23 | 23 | 23 | 28 | POEMS [20] |
| PSO | | 1.5 | 1.3 | 4.1 | 3.5 | 4.8 | 3.2 | 3.6 | 3.6 | 3.6 | 4.4 | PSO [7] |
| PSO_Bounds | | 1.3 | 1.6 | 6.2 | 3.4 | 5.8 | 5 | 6.7 | 6.7 | 6.7 | 14 | PSO_Bounds [8] |
| Monte Carlo | | 1.7 | 1.5 | 4.6 | 4.5 | 43 | 87 | 150 | 150 | 150 | 950 | Monte Carlo [3] |
| Rosenbrock | | 16 | 42 | 150 | 120 | 170 | 78 | 190 | 190 | 190 | 170 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | | 1 | 2.1 | 5.5 | 2.7 | 2.8 | 1.2 | 1.3 | 1.3 | 1.3 | 1.5 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | | 1 | 2.4 | 3.9 | 3.8 | 5.1 | 2.1 | 2 | 2 | 2 | 2 | VNS (Garcia) [11] |

Table 8: 02-D, running time excess ERT/ERT_{best} on f_8 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT_{best}/D |
|------------------|---|------------|------------|------------|------------|------------|------------|------------------|------------|------------------|------------------|---|
| ALPS | | 0.6 | 1.6 | 2.7 | 6 | 18.3 | 23.1 | 54 | 74 | 94 | 130 | ALPS [17] |
| AMaLgAM IDEA | | 2.9 | 2.8 | 4.7 | 19 | 31 | 66 | 54 | 74 | 94 | 130 | AMaLgAM IDEA [4] |
| avg NEWUOA | | 3.9 | 2.5 | 2.6 | 4.6 | 6.8 | 7 | 4.4 | 4.7 | 5.1 | 5 | avg NEWUOA [31] |
| BayEDAcG | | 2.3 | 2.9 | 5.6 | 11 | 48 | 350 | <i>53e-3/2e3</i> | 1.4 | 1.4 | 1.3 | BayEDAcG [10] |
| BFGS | | 7.5 | 4.9 | 4.1 | 5.1 | 2.4 | 2.2 | 1.3 | 1.3 | 1.3 | 1.1 | BFGS [30] |
| Cauchy EDA | | 15 | 11 | 10 | 24 | 19 | 21 | 12 | 13 | 14 | 13 | Cauchy EDA [24] |
| BIPOP-CMA-ES | | 3.1 | 3.3 | 3.5 | 7.1 | 9.2 | 11 | 6.4 | 6.5 | 6.7 | 6.2 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | | 6.4 | 4.3 | 3.8 | 11 | 6.9 | 7 | 4.2 | 4.1 | 4.3 | 4 | (1+1)-CMA-ES [2] |
| DASA | | 31 | 33 | 110 | 520 | 480 | 680 | 520 | 580 | 700 | 820 | DASA [19] |
| DEPSO | | 4 | 3.3 | 3.6 | 14 | 15 | 25 | 28 | 42 | 65 | <i>76e-7/2e3</i> | DEPSO [12] |
| DIRECT | | 1 | 1 | 1.4 | 5 | 4.4 | 8.7 | 10 | 16 | 17 | 21 | DIRECT [25] |
| EDA-PSO | | 1.9 | 3 | 5.4 | 11 | 50 | 98 | 97 | 140 | 180 | 220 | EDA-PSO [6] |
| full NEWUOA | | 6.6 | 3.9 | 7 | 7 | 3.2 | 2.8 | 1.6 | 1.5 | 1.5 | 1.3 | full NEWUOA [31] |
| G3-PCX | | 2.8 | 4 | 5 | 24 | 16 | 18 | 11 | 11 | 11 | 9.6 | G3-PCX [26] |
| simple GA | | 2 | 2.9 | 8.4 | 34 | 87 | 170 | 1300 | 8900 | <i>61e-5/1e5</i> | . | simple GA [22] |
| GLOBAL | | 4.4 | 4.5 | 14 | 19 | 8.2 | 7.2 | 4.1 | 3.9 | 3.9 | 3.4 | GLOBAL [23] |
| iAMaLgAM IDEA | | 2.3 | 2.8 | 4.4 | 12 | 8 | 8.4 | 5 | 5.2 | 5.5 | 5.2 | iAMaLgAM IDEA [4] |
| LSfminbd | | 16 | 7 | 420 | 1500 | 2300 | 6300 | <i>90e-2/1e4</i> | . | . | . | LSfminbd [28] |
| LSstep | | 67 | 51 | 37 | 1500 | 3600 | 6100 | <i>32e-2/1e4</i> | . | . | . | LSstep [28] |
| MA-LS-Chain | | 2.7 | 3.6 | 7.2 | 16 | 10 | 15 | 9 | 8.8 | 9 | 8.5 | MA-LS-Chain [21] |
| MCS (Neum) | | 1 | 1.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MCS (Neum) [18] |
| NELDER (Han) | | 1.9 | 1.4 | 2.1 | 3.7 | 2 | 2 | 1.1 | 1.2 | 1.2 | 1.2 | NELDER (Han) [16] |
| NELDER (Doe) | | 3 | 3.2 | 4.6 | 6.2 | 2.9 | 2.7 | 1.6 | 1.5 | 1.6 | 1.5 | NELDER (Doe) [5] |
| NEWUOA | | 3.8 | 2.8 | 4.3 | 7 | 3.5 | 3.2 | 1.9 | 1.8 | 1.8 | 1.6 | NEWUOA [31] |
| (1+1)-ES | | 2.3 | 2.2 | 47 | 59 | 23 | 34 | 35 | 51 | 70 | 95 | (1+1)-ES [1] |
| POEMS | | 230 | 110 | 120 | 110 | 76 | 110 | 74 | 91 | 120 | 130 | POEMS [20] |
| PSO | | 2.7 | 2.6 | 6.5 | 11 | 16 | 27 | 26 | 37 | 49 | 67 | PSO [7] |
| PSO.Bounds | | 3.7 | 4.3 | 6 | 19 | 24 | 61 | 69 | 120 | 150 | 200 | PSO.Bounds [8] |
| Monte Carlo | | 2.7 | 3.2 | 5.8 | 19 | 72 | 670 | 2200 | 3.9e4 | 3.1e5 | <i>17e-5/1e6</i> | Monte Carlo [3] |
| Rosenbrock | | 5.8 | 3.4 | 4.9 | 10 | 5.2 | 4.8 | 2.8 | 2.7 | 2.8 | 2.5 | Rosenbrock [27] |
| IPOP-SEFP-CMA-ES | | 6.4 | 3.9 | 5.2 | 19 | 17 | 17 | 9.5 | 9.3 | 9.6 | 8.7 | IPOP-SEFP-CMA-ES [29] |
| VNS (Garcia) | | 9.5 | 4.8 | 8.1 | 16 | 10 | 11 | 6.9 | 6.8 | 7.2 | 6.7 | VNS (Garcia) [11] |

Table 9: 02-D, running time excess ERT/ERT_{best} on f_9 , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} ERT _{best} /D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT _{best} /D |
|----------------------|---|------------|-----------|------------|------------|------------|------------------|------------------|------------|------------------|------------------|---|
| ALPS [17] | 0.5 | 0.5 | 0.5 | 0.5 | 8.9 | 15 | 21.9 | 33.8 | 38.5 | 40.7 | 46.2 | ALPS [17] |
| AMaLGaM IDEA [4] | 3.3 | 7.2 | 33 | 19 | 6.3 | 9.5 | 62 | 64 | 81 | 100 | 140 | AMaLGaM IDEA [4] |
| avg NEWUOA [31] | 4.2 | 13 | 22 | 6.3 | 4.7 | 4 | 9.5 | 7.5 | 7.4 | 7.7 | 7.6 | avg NEWUOA [31] |
| BayEDAacG [10] | 7.7 | 10 | 22 | 4.7 | 2.3 | 3.2 | 2.3 | 2.3 | 2.1 | 2 | 1.9 | BayEDAacG [10] |
| BFGS [30] | 3.8 | 11 | 29 | 10 | 99 | 600 | <i>66e-3/2e3</i> | <i>66e-3/2e3</i> | | | | BFGS [30] |
| Cauchy EDA [24] | 4.2 | 9.2 | 16 | 2.4 | 2.3 | 1.9 | 1.4 | 1.3 | 1.3 | 1.2 | 1.1 | Cauchy EDA [24] |
| BIPOP-CMA-ES [15] | 16 | 37 | 59 | 14 | 20 | 19 | 14 | 14 | 14 | 14 | 14 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES [2] | 2.6 | 10 | 19 | 4.6 | 7.1 | 7.5 | 5.8 | 5.6 | 5.6 | 5.8 | 5.9 | (1+1)-CMA-ES [2] |
| DASA [19] | 3.5 | 9.9 | 26 | 8.8 | 8 | 7.3 | 5.4 | 5 | 5 | 5 | 4.9 | DASA [19] |
| DEPSO [12] | 65 | 110 | 320 | 250 | 290 | 330 | 320 | 320 | 380 | 550 | 740 | DEPSO [12] |
| DIRECT [25] | 2.7 | 12 | 58 | 12 | 20 | 20 | 19 | 19 | 25 | 45 | 97 | DIRECT [25] |
| EDA-PSO [6] | 1 | 1 | 1 | 2 | 5 | 5.8 | 8.3 | 8.3 | 14 | 18 | 25 | EDA-PSO [6] |
| full NEWUOA [31] | 3.8 | 12 | 47 | 8.5 | 27 | 51 | 78 | 78 | 120 | 150 | 200 | full NEWUOA [31] |
| G3-PCX [26] | 7.1 | 12 | 24 | 2.7 | 2.2 | 1.8 | 1.3 | 1.3 | 1.2 | 1.1 | 1.1 | G3-PCX [26] |
| simple GA [22] | 4.1 | 10 | 28 | 15 | 20 | 18 | 14 | 13 | 13 | 13 | 11 | simple GA [22] |
| GLOBAL [23] | 5 | 15 | 44 | 22 | 90 | 190 | 2200 | 2200 | 2200 | 1e4 | 1.5e4 | GLOBAL [23] |
| iAMaLGaM IDEA [4] | 3.5 | 11 | 30 | 9.1 | 11 | 7.9 | 5.2 | 5.2 | 4.7 | 4.5 | 4.2 | iAMaLGaM IDEA [4] |
| LSfminbd [28] | 3.1 | 7.9 | 29 | 6 | 7.2 | 6.9 | 5.3 | 5.1 | 5.1 | 5.3 | 5.3 | LSfminbd [28] |
| LSstep [28] | 6.2 | 15 | 20 | 210 | 670 | 3100 | 4100 | 4100 | 3600 | 3400 | <i>76e-3/1e4</i> | LSstep [28] |
| MA-LS-Chain [21] | 270 | 610 | 750 | 230 | 670 | 1800 | 2100 | 2100 | 3800 | <i>76e-3/1e4</i> | | MA-LS-Chain [21] |
| MCS (Neum) [18] | 5 | 9.5 | 35 | 8.6 | 13 | 13 | 11 | 11 | 10 | 10 | 11 | MCS (Neum) [18] |
| NELDER (Han) [16] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | NELDER (Han) [16] |
| NELDER (Doe) [5] | 2.7 | 3.6 | 10 | 1.6 | 2 | 1.8 | 1.3 | 1.3 | 1.2 | 1.2 | 1.2 | NELDER (Doe) [5] |
| NEWUOA [31] | 4.1 | 6.9 | 11 | 2.3 | 2.6 | 2.1 | 1.5 | 1.5 | 1.4 | 1.4 | 1.4 | NEWUOA [31] |
| (1+1)-ES [1] | 5.2 | 8.3 | 24 | 3.6 | 3.3 | 2.7 | 1.9 | 1.8 | 1.8 | 1.8 | 1.7 | (1+1)-ES [1] |
| POEMS [20] | 4.4 | 8.1 | 19 | 81 | 120 | 120 | 100 | 100 | 110 | 130 | 160 | POEMS [20] |
| PSO [7] | 360 | 450 | 560 | 65 | 78 | 110 | 98 | 98 | 110 | 130 | 160 | PSO [7] |
| PSO_Bounds [8] | 4 | 15 | 37 | 8.7 | 12 | 24 | 28 | 28 | 38 | 49 | 67 | PSO_Bounds [8] |
| Monte Carlo [3] | 3.9 | 9 | 48 | 11 | 27 | 96 | 120 | 120 | 160 | 200 | 240 | Monte Carlo [3] |
| Rosenbrock [27] | 3 | 10 | 47 | 17 | 110 | 900 | 3600 | 3600 | 6.9e4 | 3.7e5 | <i>16e-5/1e6</i> | Rosenbrock [27] |
| IPOP-SEP-CMA-ES [29] | 8.9 | 12 | 22 | 2.6 | 3.1 | 2.9 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) [11] | 3.1 | 9.5 | 16 | 7.6 | 15 | 14 | 10 | 10 | 9.3 | 9.4 | 9 | VNS (Garcia) [11] |
| | 4.8 | 21 | 45 | 14 | 15 | 12 | 9.8 | 9.8 | 9.4 | 9.8 | 10 | |

Table 10: 02-D, running time excess ERT/ERT_{best} on f_{10} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δ ftarget |
|------------------------|------------|------------|------------|------------|------------------|------------------|------------------|------------------|------------------|----------|----------------------------|
| ERT _{best} /D | 2.9 | 5.7 | 14.9 | 22.9 | 26.9 | 30.4 | 34.2 | 37.9 | 40.9 | 48.8 | ERT _{best} /D |
| ALPS | 22 | 25 | 47 | 69 | 160 | 350 | 780 | 1600 | 2100 | 3200 | ALPS [17] |
| AMaLGaM IDEA | 6.7 | 5.7 | 3 | 3 | 3.8 | 4 | 4.1 | 4.1 | 4.3 | 4.4 | AMaLGaM IDEA [4] |
| avg NEWUOA | 2.6 | 3.6 | 3.8 | 4.8 | 6.9 | 7.6 | 8.8 | 9.5 | 9.9 | 11 | avg NEWUOA [31] |
| BayEDA _c G | 17 | 13 | 60 | 190 | 310 | <i>33e-1/2e3</i> | . | . | . | . | BayEDA _c G [10] |
| BFGS | 2.3 | 1.5 | 1 | 1.4 | 1.4 | 1.4 | 1.4 | 2.6 | 6.3 | 24 | BFGS [30] |
| Cauchy EDA | 14 | 13 | 7.4 | 6.4 | 7 | 7 | 7.4 | 7.7 | 8 | 8.4 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 12 | 12 | 7.9 | 9 | 8.5 | 7.9 | 7.7 | 7.4 | 7.3 | 6.8 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 7.3 | 5.8 | 7.2 | 6.6 | 6.3 | 5.8 | 5.5 | 5.3 | 5.2 | 4.8 | (1+1)-CMA-ES [2] |
| DASA | 22 | 15 | 8900 | 5.2e4 | 6.1e4 | 9.5e4 | 1.2e5 | 1.1e5 | 1e5 | 8.6e4 | DASA [19] |
| DEPSO | 16 | 26 | 80 | 110 | 330 | 310 | <i>51e-2/2e3</i> | . | . | . | DEPSO [12] |
| DIRECT | 3.9 | 4.3 | 3.9 | 9.5 | 20 | 68 | 120 | 190 | 220 | 460 | DIRECT [25] |
| EDA-PSO | 17 | 26 | 43 | 140 | 330 | 640 | 1100 | 2100 | 3e3 | 8600 | EDA-PSO [6] |
| full NEWUOA | 2 | 3 | 3.8 | 4.5 | 6 | 6.4 | 7.1 | 7.7 | 8.2 | 9 | full NEWUOA [31] |
| G3-PCX | 11 | 9.5 | 26 | 39 | 39 | 37 | 34 | 31 | 29 | 25 | G3-PCX [26] |
| simple GA | 27 | 51 | 77 | 700 | 2800 | 4300 | 4.2e4 | 3.8e4 | <i>23e-3/1e5</i> | . | simple GA [22] |
| GLOBAL | 18 | 19 | 11 | 7.4 | 6.4 | 5.8 | 5.3 | 4.9 | 4.6 | 4 | GLOBAL [23] |
| iAMaLGaM IDEA | 5.5 | 4 | 3.3 | 3.7 | 4.1 | 4.1 | 4 | 4.1 | 4.2 | 4.1 | iAMaLGaM IDEA [4] |
| LSfminbd | 1.8 | 1 | 770 | 6300 | <i>15e+0/1e4</i> | . | . | . | . | . | LSfminbd [28] |
| LSstep | 2.1 | 1.2 | 770 | 2800 | <i>15e+0/1e4</i> | . | . | . | . | . | LSstep [28] |
| MA-LS-Chain | 16 | 20 | 13 | 18 | 19 | 20 | 19 | 18 | 18 | 17 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1.2 | 1.7 | 8.7 | 47 | 130 | 520 | 1100 | 1300 | 3700 | MCS (Neum) [18] |
| NELDER (Han) | 3 | 2.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1 | NELDER (Han) [16] |
| NELDER (Doe) | 3.2 | 2.2 | 1.2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | NELDER (Doe) [5] |
| NEWUOA | 2.3 | 1.9 | 3.1 | 4.3 | 6.5 | 7.3 | 8.5 | 9.6 | 10 | 11 | NEWUOA [31] |
| (1+1)-ES | 6.3 | 5.3 | 8700 | 2.4e4 | 7.7e4 | 1.5e5 | 4.3e5 | <i>13e-2/1e6</i> | . | . | (1+1)-ES [1] |
| POEMS | 110 | 90 | 300 | 540 | 1400 | 2100 | 2400 | 3200 | 3700 | 6400 | POEMS [20] |
| PSO | 23 | 26 | 180 | 280 | 480 | 650 | 850 | 990 | 1100 | 1900 | PSO [7] |
| PSO_Bounds | 21 | 24 | 530 | 770 | 740 | 830 | 1500 | 1900 | 1900 | 2100 | PSO_Bounds [8] |
| Monte Carlo | 23 | 55 | 110 | 690 | 3900 | 4.4e4 | 1.3e5 | 3.8e5 | <i>61e-4/1e6</i> | . | Monte Carlo [3] |
| Rosenbrock | 4.8 | 2.8 | 3.1 | 3.4 | 3.2 | 3 | 2.9 | 2.8 | 3.2 | 3 | Rosenbrock [27] |
| IPOP-SFEP-CMA-ES | 8.3 | 12 | 16 | 14 | 16 | 15 | 13 | 12 | 12 | 11 | IPOP-SFEP-CMA-ES [29] |
| VNS (Garcia) | 22 | 25 | 17 | 12 | 12 | 11 | 10 | 9.4 | 9.1 | 8.3 | VNS (Garcia) [11] |

Table 11: 02-D, running time excess ERT/ERT_{best} on f_{11} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
|-----------------|----------------------------|------------|------------|------------|------------------|------------|------------------|------------------|------------------|------------|------------------|----------------------------|
| | ERT_{best}/D | 4.7 | 5.67 | 17.6 | 22.5 | 25.2 | 30.8 | 33.7 | 37.6 | 40.7 | 48.5 | ERT_{best}/D |
| ALPS | 17 | 40 | 35 | 80 | 200 | 200 | 410 | 880 | 1200 | 1700 | 3400 | ALPS [17] |
| AMaLGaM IDEA | 4.8 | 5.4 | 3 | 3.5 | 4.2 | 4.2 | 3.9 | 4.2 | 4.4 | 4.4 | 4.6 | AMaLGaM IDEA [4] |
| avg NEWUOA | 1.3 | 1.5 | 1.5 | 3.3 | 5.1 | 5.4 | 5.4 | 6.8 | 7.3 | 8 | 8.8 | avg NEWUOA [31] |
| BayEDAacG | 9.3 | 18 | 31 | 150 | 1100 | 1100 | <i>14e-1/2e3</i> | | | | | BayEDAacG [10] |
| BFGS | 1.6 | 1.7 | 1.2 | 1.6 | 2 | 2 | 1.7 | 1.9 | 2.7 | 5.7 | 36 | BFGS [30] |
| Cauchy EDA | 13 | 15 | 6.7 | 7.4 | 8.1 | 8.1 | 8 | 8.3 | 8.1 | 8.9 | 9 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 4.7 | 8.7 | 7.9 | 8.8 | 9.2 | 9.2 | 8.2 | 8 | 7.6 | 7.5 | 6.8 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 4.8 | 5.9 | 5.8 | 6.4 | 6.6 | 6.6 | 5.7 | 5.6 | 5.4 | 5.1 | 4.7 | (1+1)-CMA-ES [2] |
| DASA | 15 | 15 | 9e3 | 4e4 | 5.4e4 | 5.4e4 | 5.7e4 | 5.3e4 | 5e4 | 4.7e4 | 4.2e4 | DASA [19] |
| DEPSO | 24 | 34 | 34 | 110 | <i>45e-2/2e3</i> | | | | | | | DEPSO [12] |
| DIRECT | 3.3 | 5.1 | 2.6 | 5.2 | 28 | 28 | 49 | 58 | 190 | 270 | 460 | DIRECT [25] |
| EDA-PSO | 8.6 | 27 | 96 | 260 | 460 | 460 | 990 | 1900 | 2900 | 6500 | <i>36e-6/1e5</i> | EDA-PSO [6] |
| full NEWUOA | 1.6 | 3.5 | 2.7 | 4.4 | 6.2 | 6.2 | 6.2 | 7 | 7.7 | 8 | 8.6 | full NEWUOA [31] |
| G3-PCX | 9.5 | 9.1 | 9.7 | 25 | 28 | 28 | 36 | 35 | 33 | 32 | 27 | G3-PCX [26] |
| simple GA | 20 | 57 | 53 | 220 | 5e3 | 5e3 | 4.6e4 | <i>14e-2/1e5</i> | | | | simple GA [22] |
| GLOBAL | 17 | 23 | 9.2 | 7.5 | 6.9 | 6.9 | 5.8 | 5.4 | 4.9 | 4.6 | 4 | GLOBAL [23] |
| iAMaLGaM IDEA | 4.5 | 6 | 2.8 | 3.3 | 4 | 4 | 3.8 | 4 | 3.9 | 3.9 | 4 | iAMaLGaM IDEA [4] |
| LSfminbnd | 2.1 | 1.8 | 500 | 2900 | 5500 | 5500 | <i>96e-1/1e4</i> | | | | | LSfminbnd [28] |
| LSstep | 1 | 1 | 380 | 1800 | 2600 | 2600 | <i>81e-1/1e4</i> | | | | | LSstep [28] |
| MA-LS-Chain | 12 | 15 | 11 | 18 | 23 | 23 | 21 | 20 | 20 | 20 | 17 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1.1 | 87 | 120 | 170 | 170 | 300 | 920 | 1300 | 2e3 | <i>91e-5/3e4</i> | MCS (Neum) [18] |
| NELDER (Han) | 2 | 2.1 | 1 | 1.1 | 1.1 | 1.1 | 1 | 1.1 | 1.1 | 1.1 | 1 | NELDER (Han) [16] |
| NELDER (Doe) | 2.2 | 2.4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | NELDER (Doe) [5] |
| NEWUOA | 1.2 | 1.5 | 1.5 | 3.2 | 5.5 | 6.1 | 6.1 | 6.9 | 7.7 | 8.4 | 11 | NEWUOA [31] |
| (1+1)-ES | 4.2 | 850 | 7700 | 2.1e4 | 6e4 | 6e4 | 2.3e5 | 4.4e5 | <i>63e-3/1e6</i> | | | (1+1)-ES [1] |
| POEMS | 55 | 83 | 1e3 | 1400 | 2100 | 2100 | 2800 | 4e3 | 6500 | 7900 | 7100 | POEMS [20] |
| PSO | 10 | 23 | 480 | 530 | 660 | 660 | 670 | 860 | 1e3 | 1300 | 1900 | PSO [7] |
| PSO_Bounds | 11 | 21 | 3200 | 5200 | 6300 | 6300 | 5500 | 6700 | 6300 | 6100 | 5500 | PSO_Bounds [8] |
| Monte Carlo | 16 | 51 | 94 | 870 | 6300 | 6300 | 4.3e4 | 2.1e5 | <i>97e-4/1e6</i> | | | Monte Carlo [3] |
| Rosenbrock | 2.3 | 2.9 | 2.4 | 2.7 | 3 | 3 | 2.7 | 2.6 | 2.5 | 2.6 | 2.5 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 5.4 | 6.9 | 13 | 17 | 17 | 17 | 14 | 13 | 13 | 12 | 11 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 8.4 | 14 | 12 | 12 | 12 | 12 | 11 | 10 | 9.7 | 9.4 | 8.6 | VNS (Garcia) [11] |

Table 12: 02-D, running time excess ERT/ERT_{best} on f_{12} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT_{best}/D |
|-----------------|---------------------------------------|------------|------------|------------|------------|------------------|------------|------------------|------------|------------|------------------|---------------------------------------|
| ALPS | | 19 | 37 | 40 | 51 | 76 | 94 | 130 | 210 | 230 | 370 | ALPS [17] |
| AMaLgAm IDEA | 5.4 | 5.4 | 4.1 | 5.8 | 13 | 17 | 17 | 17 | 18 | 16 | 15 | AMaLgAm IDEA [4] |
| avg NEWUOA | 1.7 | 1.7 | 1.1 | 1 | 1.6 | 1.5 | 1.5 | 1.5 | 1.5 | 1.4 | 1.4 | avg NEWUOA [31] |
| BayEDAacG | 40 | 26 | 69 | 87 | 87 | <i>67e-2/2e3</i> | | | | | | BayEDAacG [10] |
| BFGS | 1.8 | 1.8 | 1.1 | 1.2 | 3.2 | 3.1 | 2.9 | 2.8 | 2.6 | 2.4 | 4.2 | BFGS [30] |
| Cauchy EDA | 11 | 9.9 | 14 | 24 | 24 | 19 | 18 | 18 | 17 | 15 | 14 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 6 | 6.1 | 7.9 | 12 | 12 | 9.9 | 9.1 | 9 | 11 | 9.6 | 8.2 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 4.9 | 7 | 9.4 | 13 | 13 | 10 | 8.9 | 8.7 | 7.6 | 6.5 | 5.6 | (1+1)-CMA-ES [2] |
| DASA | 16 | 64 | 2700 | 6800 | 6800 | 6100 | 8800 | 1.4e4 | 1.2e4 | 9700 | 7900 | DASA [19] |
| DEPSO | 17 | 16 | 41 | 55 | 51 | 48 | 45 | 45 | 40 | 35 | 45 | DEPSO [12] |
| DIRECT | 3 | 3.3 | 6.2 | 35 | 80 | 70 | 70 | 160 | 270 | 250 | 290 | DIRECT [25] |
| EDA-PSO | 11 | 24 | 40 | 98 | 160 | 160 | 300 | 790 | 1e3 | 1e3 | 820 | EDA-PSO [6] |
| full NEWUOA | 1.4 | 1.9 | 4.6 | 5.2 | 3.8 | 3.4 | 3.4 | 3.3 | 3 | 2.7 | 2.4 | full NEWUOA [31] |
| G3-PCX | 9.1 | 6.1 | 12 | 29 | 34 | 34 | 34 | 32 | 31 | 29 | 28 | G3-PCX [26] |
| simple GA | 23 | 39 | 93 | 170 | 580 | 1e3 | 2400 | 2700 | 2700 | 2200 | 1900 | simple GA [22] |
| GLOBAL | 11 | 11 | 8.1 | 8.3 | 7.2 | 6.4 | 6.3 | 6.4 | 5.9 | 5 | 4.4 | GLOBAL [23] |
| iAMaLgAm IDEA | 4.1 | 2.5 | 4.5 | 7 | 6.4 | 6.4 | 6.4 | 6.4 | 6 | 5.8 | 5.4 | iAMaLgAm IDEA [4] |
| LSfmind | 1.7 | 1 | 590 | 1200 | 770 | 630 | 630 | 570 | 490 | 410 | 330 | LSfmind [28] |
| LSstep | 500 | 280 | 300 | 230 | 230 | 350 | 350 | 720 | 600 | 820 | 640 | LSstep [28] |
| MA-LS-Chain | 13 | 13 | 12 | 15 | 13 | 12 | 12 | 13 | 13 | 12 | 10 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1.1 | 62 | 49 | 32 | 26 | 24 | 24 | 28 | 39 | 30 | MCS (Neum) [18] |
| NELDER (Han) | 1.9 | 1.4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | NELDER (Han) [16] |
| NELDER (Doe) | 2 | 1.4 | 1.1 | 1.6 | 1.6 | 1.6 | 1.7 | 1.7 | 1.6 | 1.4 | 1.3 | NELDER (Doe) [5] |
| NEWUOA | 1.5 | 1.1 | 1.9 | 2.9 | 2.3 | 2.1 | 2 | 1.8 | 1.8 | 1.6 | 1.4 | NEWUOA [31] |
| (1+1)-ES | 3.8 | 1500 | 6800 | 1.7e4 | 2.3e4 | 5.5e4 | 1.3e5 | 2.3e5 | 2.3e5 | 1.9e5 | <i>25e-3/1e6</i> | (1+1)-ES [1] |
| POEMS | 64 | 79 | 83 | 650 | 1100 | 1200 | 1600 | 2100 | 2900 | 2900 | 1.5e4 | POEMS [20] |
| PSO | 11 | 12 | 19 | 57 | 110 | 130 | 160 | 180 | 180 | 220 | 300 | PSO [7] |
| PSO.Bounds | 12 | 19 | 230 | 440 | 390 | 510 | 690 | 630 | 560 | 560 | 560 | PSO.Bounds [8] |
| Monte Carlo | 18 | 27 | 97 | 580 | 3200 | 1.6e4 | 1.4e5 | <i>38e-4/1e6</i> | | | | Monte Carlo [3] |
| Rosenbrock | 3.3 | 2.9 | 2.5 | 3.6 | 3 | 5.4 | 5.1 | 4.5 | 4.5 | 3.9 | 3.3 | Rosenbrock [27] |
| IPOP-SEF-CMA-ES | 7.4 | 9.2 | 7.6 | 9.5 | 9.6 | 8.8 | 8.5 | 8.1 | 8.1 | 7 | 6.3 | IPOP-SEF-CMA-ES [29] |
| VNS (Garcia) | 17 | 17 | 15 | 13 | 8.8 | 7.5 | 7.1 | 6.4 | 6.4 | 5.6 | 4.9 | VNS (Garcia) [11] |

Table 13: 02-D, running time excess ERT/ERT_{best} on f_{13} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT_{best}/D |
|-----------------|---|------------|------------|------------|------------|------------------|------------------|----------|------------------|------------|------------------|---|
| ALPS | | 0.5 | 2.3 | 11.3 | 17.6 | 23.2 | 30 | 35.4 | 41.5 | 47.4 | 61.1 | ALPS [17] |
| AMaLGA_M IDEA | 1.1 | 3.2 | 13 | 2.6 | 3.2 | 3.6 | 3.7 | 3.9 | 4 | 3.9 | 4.1 | AMaLGA_M IDEA [4] |
| avg NEWUOA | 1.8 | 6.7 | 6.7 | 17 | 38 | 54 | 73 | 130 | 130 | 140 | 770 | avg NEWUOA [31] |
| BayEDA_cG | 1.4 | 2.4 | 52 | 140 | 950 | <i>11e-1/2e3</i> | 660 | 660 | 660 | 580 | <i>67e-5/5e3</i> | BayEDA_cG [10] |
| BFGS | 1.2 | 5 | 6.8 | 15 | 45 | 74 | 160 | 160 | 6.6 | 8.5 | 8.5 | BFGS [30] |
| Cauchy EDA | 4.1 | 15 | 7.3 | 7.7 | 7.7 | 8.2 | 8.5 | 8.5 | 6.1 | 6.6 | 7 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1.3 | 4.3 | 3.2 | 5.4 | 5.7 | 5.9 | 6.4 | 6.4 | 7.6 | 7.9 | 7.6 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1.1 | 4.4 | 5.2 | 7.3 | 7 | 7.3 | 8.1 | 8.1 | 4.7e4 | 1.4e5 | <i>62e-5/1e6</i> | (1+1)-CMA-ES [2] |
| DASA | 13 | 90 | 540 | 850 | 2600 | 4900 | 1.6e4 | 1.6e4 | 74 | 74 | 120 | DASA [19] |
| DEPSO | 1.1 | 6.1 | 8.4 | 25 | 63 | 120 | <i>18e-3/2e3</i> | 49 | 49 | 120 | 120 | DEPSO [12] |
| DIRECT | 1 | 1 | 2.5 | 4.2 | 5.1 | 8.7 | 24 | 24 | 4e3 | 3.1e4 | 1800 | DIRECT [25] |
| EDA-PSO | 1.4 | 3.5 | 6.4 | 42 | 180 | 270 | 710 | 710 | 290 | 760 | 61 | EDA-PSO [6] |
| full NEWUOA | 1.5 | 5.2 | 8.5 | 12 | 31 | 76 | 140 | 140 | 70 | 70 | 61 | full NEWUOA [31] |
| G3-PCX | 1.2 | 3.9 | 13 | 30 | 36 | 47 | 50 | 50 | 70 | 70 | 61 | G3-PCX [26] |
| simple GA | 1.3 | 3.7 | 25 | 170 | 1100 | 2.2e4 | <i>25e-3/1e5</i> | 13 | 67e-5/400 | 3.6 | 3.7 | simple GA [22] |
| GLOBAL | 1.3 | 2.8 | 9.2 | 9.3 | 7.3 | 6 | 6 | 13 | 3.6 | 3.6 | 3.7 | GLOBAL [23] |
| iAMaLGA_M IDEA | 1.1 | 3.3 | 2.6 | 52 | 110 | 470 | 850 | 850 | <i>13e-3/1e4</i> | 3.6 | 3.7 | iAMaLGA_M IDEA [4] |
| LSfminbnd | 1 | 16 | 52 | 170 | 170 | 470 | 850 | 850 | 19 | 19 | 22 | LSfminbnd [28] |
| LSstep | 28 | 420 | 280 | 570 | 1e3 | 1500 | <i>35e-2/1e4</i> | 21 | 21 | 22 | 22 | LSstep [28] |
| MA-LS-Chain | 1.1 | 3.3 | 8.7 | 17 | 18 | 21 | 23 | 23 | 2500 | 2500 | 2500 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 4.7 | 23 | 20 | 170 | 960 | 2200 | 2200 | <i>75e-4/3e4</i> | 75e-4/3e4 | 75e-4/3e4 | MCS (Neum) [18] |
| NELDER (Han) | 1.7 | 1.6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | NELDER (Han) [16] |
| NELDER (Doe) | 1.3 | 2.2 | 1.1 | 1.1 | 1.1 | 1 | 1 | 1 | 1 | 1.1 | 1 | NELDER (Doe) [5] |
| NEWUOA | 1.6 | 2.8 | 6.3 | 10 | 22 | 25 | 72 | 72 | 91 | 91 | 150 | NEWUOA [31] |
| (1+1)-ES | 1.9 | 31 | 37 | 94 | 210 | 370 | 790 | 790 | 4200 | 8100 | 3.7e4 | (1+1)-ES [1] |
| POEMS | 170 | 110 | 48 | 93 | 140 | 330 | 1100 | 1100 | 2300 | 6300 | 2.4e4 | POEMS [20] |
| PSO | 1.6 | 3.3 | 9 | 27 | 76 | 140 | 330 | 330 | 2900 | 2900 | 1.1e4 | PSO [7] |
| PSO_Bounds | 1.1 | 3.8 | 9.2 | 43 | 120 | 260 | 620 | 620 | 3e3 | 3e3 | <i>93e-7/1e5</i> | PSO_Bounds [8] |
| Monte Carlo | 1.6 | 5.4 | 18 | 280 | 1.2e4 | 1.1e5 | <i>32e-3/1e6</i> | 28 | 43 | 70 | 170 | Monte Carlo [3] |
| Rosenbrock | 3.2 | 4.8 | 5.6 | 7 | 7.5 | 18 | 18 | 14 | 14 | 13 | 11 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1.1 | 3.7 | 13 | 20 | 18 | 15 | 15 | 14 | 14 | 13 | 11 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1.4 | 3.9 | 8.8 | 9.7 | 9.6 | 8.8 | 9.2 | 9.1 | 9.1 | 8.6 | 8.4 | VNS (Garcia) [11] |

Table 14: 02-D, running time excess ERT/ERT_{best} on f_{14} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 14 Sum of different powers | | | | | | | | | | | | | |
|----------------------------|----------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------------|------------------|----------------------------|--|
| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} | |
| | ERT_{best}/D | 0.5 | 0.5 | 0.7 | 3.7 | 8.1 | 12.2 | 18.9 | 27.8 | 33.7 | 45.1 | ERT_{best}/D | |
| ALPS | 1 | 1 | 1 | 1.6 | 2.4 | 14 | 60 | 75 | 83 | 130 | 530 | ALPS [17] | |
| AMaLgAM IDEA | 1 | 1.2 | 1.6 | 3.3 | 3.3 | 3.9 | 4.7 | 4.2 | 3.9 | 3.8 | 4.2 | AMaLgAM IDEA [4] | |
| avg NEWUOA | 1 | 1.4 | 3.4 | 2.2 | 2.2 | 1.4 | 1.3 | 1.6 | 1.8 | 2.2 | 6.8 | avg NEWUOA [31] | |
| BayEDA-cG | 1 | 1 | 1.9 | 1.8 | 1.8 | 10 | 25 | 67 | 98 | 180 | <i>12e-5/2e3</i> | BayEDA-cG [10] | |
| BFGS | 1 | 1.4 | 2.1 | 2.8 | 1.8 | 1.7 | 1.4 | 1.4 | 1.1 | 1 | 6 | BFGS [30] | |
| Cauchy-EDA | 1 | 4.6 | 13 | 13 | 13 | 12 | 11 | 10 | 8.6 | 8.9 | 8.5 | Cauchy-EDA [24] | |
| BIPOP-CMA-ES | 1 | 1.1 | 1.9 | 2.5 | 2.5 | 3 | 4.2 | 4.6 | 5.3 | 5.5 | 7.1 | BIPOP-CMA-ES [15] | |
| (1+1)-CMA-ES | 1 | 1.4 | 1.7 | 3.1 | 3.4 | 3.6 | 4 | 3.9 | 4.4 | 4.4 | 4.7 | (1+1)-CMA-ES [2] | |
| DASA | 1 | 18 | 22 | 22 | 22 | 16 | 18 | 33 | 590 | 9300 | <i>3.1e5</i> | DASA [19] | |
| DEPSO | 1 | 1 | 1.4 | 5.2 | 10 | 16 | 17 | 18 | 18 | 55 | <i>17e-7/2e3</i> | DEPSO [12] | |
| DIRECT | 1 | 1 | 1 | 1 | 1.3 | 2.1 | 2.8 | 6 | 8.6 | 12 | 32 | DIRECT [25] | |
| EDA-PSO | 1 | 1.2 | 1.4 | 2.9 | 8.2 | 12 | 15 | 74 | 160 | 1100 | 1100 | EDA-PSO [6] | |
| full NEWUOA | 1 | 1.4 | 3.2 | 1.4 | 1 | 1 | 1 | 1.1 | 1.1 | 1.5 | 3.7 | full NEWUOA [31] | |
| G3-PCX | 1 | 1.2 | 1.8 | 6.3 | 6.3 | 5.9 | 6.6 | 7.6 | 9.1 | 9.1 | 11 | G3-PCX [26] | |
| simple GA | 1 | 1.1 | 1 | 1 | 4 | 41 | 200 | 280 | 630 | 3200 | <i>58e-7/1e5</i> | simple GA [22] | |
| GLOBAL | 1 | 1.1 | 1.7 | 5.5 | 13 | 13 | 13 | 8.8 | 6.2 | 8.2 | <i>34e-7/300</i> | GLOBAL [23] | |
| iAMaLgAM IDEA | 1 | 1.5 | 1.6 | 3.7 | 3.9 | 4 | 3.9 | 3.4 | 3.4 | 3.5 | 3.6 | iAMaLgAM IDEA [4] | |
| LSfminbd | 1 | 1.3 | 4.7 | 5.4 | 5.4 | 3 | 6.2 | 76 | 1500 | <i>23e-5/1e4</i> | . | LSfminbd [28] | |
| LSstep | 1 | 55 | 40 | 73 | 73 | 50 | 120 | 1600 | 5100 | <i>23e-4/1e4</i> | . | LSstep [28] | |
| MA-LS-Chain | 1 | 1.3 | 1.7 | 3.1 | 3.1 | 9.6 | 15 | 13 | 12 | 12 | 17 | MA-LS-Chain [21] | |
| MCS (Neum) | 1 | 1 | 1 | 1 | 1.4 | 1.7 | 2.8 | 3.1 | 23 | 23 | 8200 | MCS (Neum) [18] | |
| NELDER (Han) | 1 | 1.5 | 2.1 | 1.4 | 1.4 | 1.4 | 1.4 | 1.2 | 1 | 1 | 1.1 | NELDER (Han) [16] | |
| NELDER (Doe) | 1 | 1.1 | 1.3 | 1.4 | 1.3 | 1.3 | 1.1 | 1.1 | 1 | 1 | 1 | NELDER (Doe) [5] | |
| NEWUOA | 1 | 1.1 | 3.7 | 2.4 | 1.6 | 1.5 | 1.6 | 1.8 | 1.8 | 2.1 | 5.4 | NEWUOA [31] | |
| (1+1)-ES | 1 | 1.7 | 2.3 | 2.5 | 2.5 | 2.5 | 3.4 | 9.2 | 160 | 3400 | <i>22e-7/1e6</i> | (1+1)-ES [1] | |
| POEMS | 1 | 140 | 190 | 86 | 73 | 160 | 180 | 180 | 330 | 3300 | 3300 | POEMS [20] | |
| PSO | 1 | 1.1 | 1.4 | 4.8 | 13 | 25 | 36 | 48 | 85 | 1700 | 1700 | PSO [7] | |
| PSO-Bounds | 1 | 1.1 | 1.5 | 2.7 | 14 | 45 | 72 | 110 | 180 | 180 | 1200 | PSO-Bounds [8] | |
| Monte Carlo | 1 | 1 | 1.8 | 2.6 | 31 | 560 | 7200 | 1.1e5 | 4.2e5 | 4.2e5 | <i>15e-5/1e6</i> | Monte Carlo [3] | |
| Rosenbrock | 1 | 2.2 | 4 | 1.9 | 1.6 | 1.6 | 1.9 | 1.8 | 2.4 | 2.4 | 3 | Rosenbrock [27] | |
| IPOP-SEP-CMA-ES | 1 | 1.2 | 1.6 | 1.8 | 4.4 | 4.9 | 7.4 | 9.7 | 10 | 10 | 11 | IPOP-SEP-CMA-ES [29] | |
| VNS (Garcia) | 1 | 1 | 2.1 | 6.2 | 10 | 9.4 | 9 | 8.1 | 8.6 | 8.6 | 9.3 | VNS (Garcia) [11] | |

Table 15: 02-D, running time excess ERT/ERT_{best} on f_{15} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 15 Rastrigin | | | | | | | | | | | | | | |
|---------------------|---------------------|------------|------------|------------|------------|------------|------------------|------------|------------------|------------|------------|----------------------|----------------|--|
| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} | ERT_{best}/D | |
| | ERT_{best}/D | 0.5 | 0.6 | 18.6 | 146 | 517 | 533 | 556 | 582 | 616 | 706 | ERT_{best}/D | | |
| ALPS | 1.1 | 1.6 | 2.7 | 6.8 | 3.4 | 4.8 | 5.7 | 7.1 | 7.9 | 9.1 | 9.1 | ALPS [17] | | |
| AMaLGaM IDEA | 1.1 | 2.8 | 1.1 | 4.3 | 2.7 | 2.8 | 2.8 | 2.7 | 2.6 | 2.3 | 2.3 | AMaLGaM IDEA [4] | | |
| avg NEWUOA | 1 | 2.6 | 2.5 | 3.3 | 3.2 | 3.1 | 3.1 | 2.9 | 2.8 | 2.4 | 2.4 | avg NEWUOA [31] | | |
| BayEDA-cG | 1 | 2.2 | 2.1 | 8.2 | 7.6 | 26 | <i>16e-2/2e3</i> | | | | | BayEDA-cG [10] | | |
| BFGS | 1.2 | 17 | 4.2 | 4.6 | 7.9 | 7.7 | 7.3 | 7 | 6.6 | 5.8 | 5.8 | BFGS [30] | | |
| Cauchy EDA | 9.1 | 38 | 4.9 | 2.9 | 3.2 | 11 | 14 | 14 | 13 | 12 | 12 | Cauchy EDA [24] | | |
| BIPOP-CMA-ES | 1.2 | 2.9 | 1.1 | 1.8 | 2.1 | 2.2 | 2.2 | 2.1 | 2.1 | 1.9 | 1.9 | BIPOP-CMA-ES [15] | | |
| (1+1)-CMA-ES | 1.2 | 2.8 | 22 | 7.7 | 7.6 | 7.4 | 7.1 | 6.8 | 6.5 | 5.7 | 5.7 | (1+1)-CMA-ES [2] | | |
| DASA | 4.6 | 22 | 64 | 84 | 64 | 62 | 60 | 57 | 54 | 48 | 48 | DASA [19] | | |
| DEPSO | 1.1 | 1.6 | 2.9 | 3.8 | 1.7 | 2.2 | 2.5 | 2.6 | 3 | 6.3 | 6.3 | DEPSO [12] | | |
| DIRECT | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | DIRECT [25] | | |
| EDA-PSO | 1 | 3.3 | 2 | 9.3 | 6.1 | 8.3 | 8.3 | 8.5 | 8.4 | 8.1 | 8.1 | EDA-PSO [6] | | |
| full NEWUOA | 1.2 | 3.1 | 1.5 | 1.4 | 3.5 | 3.4 | 3.3 | 3.1 | 3 | 2.6 | 2.6 | full NEWUOA [31] | | |
| G3-PCX | 1.1 | 2.3 | 7.8 | 13 | 22 | 21 | 20 | 19 | 18 | 16 | 16 | G3-PCX [26] | | |
| simple GA | 1.2 | 2.3 | 4.2 | 18 | 13 | 34 | 96 | 98 | 100 | 120 | 120 | simple GA [22] | | |
| GLOBAL | 1.1 | 2.6 | 3 | 1.6 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 | 2 | 2 | GLOBAL [23] | | |
| iAMaLGaM IDEA | 1.1 | 2.5 | 1 | 4.2 | 5.1 | 5.1 | 5 | 4.8 | 4.6 | 4.1 | 4.1 | iAMaLGaM IDEA [4] | | |
| LSfminbnd | 1.1 | 6.2 | 3.7 | 20 | 36 | 51 | 66 | 210 | <i>71e-2/9e3</i> | | | LSfminbnd [28] | | |
| LSstep | 1.1 | 47 | 170 | 200 | 80 | 79 | 77 | 74 | 71 | 63 | 63 | LSstep [28] | | |
| MA-LS-Chain | 1.1 | 2 | 1.7 | 1.9 | 1.6 | 1.5 | 1.5 | 1.5 | 1.4 | 1.3 | 1.3 | MA-LS-Chain [21] | | |
| MCS (Neum) | 1 | 1 | 2.1 | 3.5 | 1.4 | 1.4 | 1.3 | 1.3 | 1.2 | 1.1 | 1.1 | MCS (Neum) [18] | | |
| NELDER (Han) | 1 | 1.9 | 8.4 | 7.3 | 9.7 | 9.4 | 9 | 8.6 | 8.2 | 7.1 | 7.1 | NELDER (Han) [16] | | |
| NELDER (Doe) | 1 | 3.2 | 1.1 | 4.1 | 3.4 | 3.3 | 3.2 | 3 | 1.2 | 1 | 1 | NELDER (Doe) [5] | | |
| NEWUOA | 1.1 | 11 | 11 | 4.1 | 3.4 | 3.3 | 3.2 | 2.9 | 2.7 | 2.4 | 2.4 | NEWUOA [31] | | |
| (1+1)-ES | 1.4 | 3.7 | 1.1 | 5.3 | 8.4 | 8.2 | 7.9 | 7.5 | 7.1 | 6.3 | 6.3 | (1+1)-ES [1] | | |
| POEMS | 28 | 120 | 16 | 19 | 18 | 20 | 21 | 21 | 22 | 22 | 22 | POEMS [20] | | |
| PSO | 1.1 | 2.4 | 1.9 | 4.1 | 16 | 16 | 16 | 16 | 16 | 15 | 15 | PSO [7] | | |
| PSO-Bounds | 1.2 | 2.3 | 1.7 | 6.6 | 3.9 | 7.3 | 9.2 | 11 | 11 | 12 | 12 | PSO-Bounds [8] | | |
| Monte Carlo | 1.1 | 2.1 | 2.4 | 64 | 150 | 1500 | 5800 | 1.264 | <i>50e-4/1e6</i> | | | Monte Carlo [3] | | |
| Rosenbrock | 1.3 | 19 | 15 | 9.7 | 9.5 | 9.2 | 8.9 | 8.5 | 8 | 7 | 7 | Rosenbrock [27] | | |
| IPOP-SEP-CMA-ES | 1 | 3.8 | 1.5 | 2.9 | 2.1 | 2.2 | 2.2 | 2.1 | 2.1 | 1.9 | 1.9 | IPOP-SEP-CMA-ES [29] | | |
| VNS (Garcia) | 1 | 3.3 | 3.4 | 1.9 | 2.4 | 2.4 | 2.3 | 2.4 | 2.7 | 3.7 | 3.7 | VNS (Garcia) [11] | | |

Table 16: 02-D, running time excess ERT/ERT_{best} on f_{16} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 16 Weierstrass | | | | | | | | | | | | | | | |
|--|-------|------------|------------|------------|------------|------------|------------------|------------|------------------|------------------|--|--|--|--|--|
| Δf_{target} ERT _{best} /D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT _{best} /D | | | | |
| ALPS | 1 | 1.3 | 4.57 | 5.6 | 9.1 | 14 | 19 | 25 | 34 | 37 | ALPS [17] | | | | |
| AMaLGaM IDEA | 1 | 1.2 | 3.2 | 3.4 | 5.1 | 4.6 | 4.5 | 4.2 | 4.1 | 3.3 | AMaLGaM IDEA [4] | | | | |
| avg NEWUOA | 1 | 1.2 | 1.5 | 9.1 | 5.5 | 6.8 | 13 | 21 | 37 | 73 | avg NEWUOA [31] | | | | |
| BayEDAacG | 1 | 1.4 | 1.5 | 9.8 | 24 | 39 | 76 | 71 | 68 | 110 | BayEDAacG [10] | | | | |
| BFGS | 1 | 1.1 | 40 | 150 | 170 | 270 | <i>27e-2/6e3</i> | . | . | . | BFGS [30] | | | | |
| Cauchy EDA | 1 | 4.2 | 4.5 | 4.4 | 6.1 | 15 | 29 | 31 | 35 | 27 | Cauchy EDA [24] | | | | |
| BIPOP-CMA-ES | 1 | 1 | 3.1 | 3.5 | 3.5 | 2.5 | 2.4 | 2.3 | 2.3 | 1.9 | BIPOP-CMA-ES [15] | | | | |
| (1+1)-CMA-ES | 1 | 1.2 | 6 | 2.3 | 2.3 | 5.2 | 8.8 | 12 | 11 | 12 | (1+1)-CMA-ES [2] | | | | |
| DASA | 1 | 9 | 29 | 150 | 180 | 130 | 210 | 250 | 340 | 530 | DASA [19] | | | | |
| DEPSO | 1 | 1.5 | 3.9 | 10 | 10 | 9.6 | 26 | 38 | 72 | <i>16e-4/2e3</i> | DEPSO [12] | | | | |
| DIRECT | 1 | 1.4 | 1.6 | 1 | 1 | 1 | 1 | 1.5 | 2 | 1.9 | DIRECT [25] | | | | |
| EDA-PSO | 1 | 1.8 | 2.6 | 4.8 | 15 | 200 | 290 | 370 | 410 | 320 | EDA-PSO [6] | | | | |
| full NEWUOA | 1 | 2.5 | 8.1 | 5.9 | 3.9 | 3.2 | 5.5 | 7.6 | 10 | 16 | full NEWUOA [31] | | | | |
| G3-PCX | 1 | 1.4 | 2.8 | 8.9 | 3.1 | 4.5 | 4.8 | 5 | 5.3 | 11 | G3-PCX [26] | | | | |
| simple GA | 1 | 1.2 | 2 | 4.1 | 16 | 42 | 180 | 450 | 690 | 690 | simple GA [22] | | | | |
| GLOBAL | 1 | 1.7 | 3.9 | 5.1 | 2.4 | 1.4 | 1.5 | 1.4 | 1.7 | 1.5 | GLOBAL [23] | | | | |
| iAMaLGaM IDEA | 1 | 1.1 | 1 | 6.9 | 7.4 | 9.1 | 9.2 | 8.6 | 8.3 | 7 | iAMaLGaM IDEA [4] | | | | |
| LSfminbd | 1 | 3.6 | 5.6 | 5.7 | 5.4 | 8.3 | 14 | 33 | 38 | 110 | LSfminbd [28] | | | | |
| LSstep | 1 | 1.5 | 1.6 | 11 | 23 | 63 | 70 | 150 | 200 | 150 | LSstep [28] | | | | |
| MA-LS-Chain | 1 | 1.2 | 1.3 | 3.6 | 4.2 | 6.4 | 10 | 11 | 10 | 8.3 | MA-LS-Chain [21] | | | | |
| MCS (Neum) | 1 | 1.1 | 5.1 | 6.7 | 2.7 | 6.8 | 6.8 | 10 | 29 | 120 | MCS (Neum) [18] | | | | |
| NELDER (Han) | 1 | 1.3 | 1.2 | 7.6 | 4.4 | 4.7 | 4.3 | 4 | 3.8 | 2.9 | NELDER (Han) [16] | | | | |
| NELDER (Doe) | 1 | 1.1 | 1.6 | 3.5 | 1.8 | 1.1 | 1.1 | 1 | 1 | 1 | NELDER (Doe) [5] | | | | |
| NEWUOA | 1 | 2.4 | 9 | 10 | 6.8 | 6.9 | 22 | 37 | 44 | 77 | NEWUOA [31] | | | | |
| (1+1)-ES | 1 | 1.7 | 35 | 38 | 35 | 33 | 56 | 73 | 84 | 120 | (1+1)-ES [1] | | | | |
| POEMS | 1 | 98 | 71 | 650 | 200 | 110 | 110 | 110 | 110 | 88 | POEMS [20] | | | | |
| PSO | 1 | 1.7 | 2.5 | 3.8 | 6.1 | 100 | 94 | 88 | 86 | 69 | PSO [7] | | | | |
| PSO.Bounds | 1 | 1.2 | 2.8 | 6.4 | 11 | 110 | 120 | 120 | 120 | 100 | PSO.Bounds [8] | | | | |
| Monte Carlo | 1 | 1.2 | 2.3 | 5 | 20 | 140 | 1200 | 2.4e4 | 7.2e4 | <i>18e-5/1e6</i> | Monte Carlo [3] | | | | |
| Rosenbrock | 1 | 10 | 33 | 36 | 33 | 27 | 79 | 290 | <i>19e-4/8e3</i> | . | Rosenbrock [27] | | | | |
| IPOP-SEF-CMA-ES | 1 | 1.8 | 3.2 | 4.1 | 2.4 | 2.9 | 4 | 3.8 | 3.9 | 3.3 | IPOP-SEF-CMA-ES [29] | | | | |
| VNS (Garcia) | 1 | 1.2 | 4.6 | 5 | 4.8 | 4.9 | 4.7 | 4.7 | 5.6 | 6.8 | VNS (Garcia) [11] | | | | |

Table 17: 02-D, running time excess ERT/ERT_{best} on f_{17} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
|-----------------|---------------------|------------|------------|------------|------------|------------|------------------|------------------|------------------|------------------|------------------|----------------------|
| | ERT_{best}/D | | | | | | | | | | | ERT_{best}/D |
| ALPS | 1 | 0.5 | 1.2 | 1.5 | 2.8 | 16 | 15 | 17 | 12 | 12 | 11 | ALPS [17] |
| AMaLGaM IDEA | 1 | 1.5 | 1.5 | 1.3 | 1.3 | 4.8 | 2.7 | 4.5 | 3.3 | 2.9 | 2.1 | AMaLGaM IDEA [4] |
| avg NEWUOA | 1.1 | 1.3 | 12 | 4.6 | 13 | 8 | 33 | 120 | <i>75e-4/5e3</i> | . | . | avg NEWUOA [31] |
| BayEDAacG | 1 | 1.1 | 1 | 2 | 8 | 7 | 7 | 8.7 | 8.8 | 27 | <i>87e-6/2e3</i> | BayEDAacG [10] |
| BFGS | 1 | 6.4 | 15 | 15 | 16 | 90 | <i>24e-2/2e3</i> | . | . | . | . | BFGS [30] |
| Cauchy EDA | 1 | 7.9 | 18 | 18 | 120 | 56 | 28 | 20 | 11 | 16 | 13 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1 | 1.2 | 4.1 | 1.8 | 1.5 | 1 | 1 | 1 | 1 | 1.3 | 1.1 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1 | 1 | 12 | 3.1 | 3.1 | 5.9 | 14 | 14 | 14 | 16 | 10 | (1+1)-CMA-ES [2] |
| DASA | 1 | 1 | 21 | 29 | 37 | 52 | 33 | 93 | 340 | 220 | 220 | DASA [19] |
| DEPSO | 1 | 1.3 | 2.7 | 1.1 | 4.3 | 3.7 | 3.7 | 3.7 | 2.8 | 2.4 | 2.8 | DEPSO [12] |
| DIRECT | 1 | 1 | 1.4 | 1 | 1 | 1 | 1 | 1.4 | 1.2 | 1 | 1 | DIRECT [25] |
| EDA-PSO | 1.1 | 1.1 | 2.6 | 2 | 3.9 | 7.4 | 7.4 | 9.9 | 8.2 | 8 | 7.1 | EDA-PSO [6] |
| full NEWUOA | 1 | 1.4 | 8.2 | 4.4 | 4.4 | 14 | 21 | 53 | 48 | <i>30e-4/6e3</i> | . | full NEWUOA [31] |
| G3-PCX | 1 | 1.1 | 2.5 | 4.5 | 6.2 | 6.2 | 3.9 | 3.2 | 2.6 | 4.4 | 3 | G3-PCX [26] |
| simple GA | 1 | 1.2 | 2.1 | 5.1 | 47 | 61 | 61 | 91 | 120 | 150 | 150 | simple GA [22] |
| GLOBAL | 1 | 1.2 | 2.6 | 4 | 4.1 | 3.9 | 3.9 | 4.4 | 9.6 | <i>75e-4/500</i> | . | GLOBAL [23] |
| iAMaLGaM IDEA | 1 | 1.2 | 1.3 | 8.8 | 8.8 | 6.2 | 4.2 | 5.1 | 4.2 | 4 | 2.8 | iAMaLGaM IDEA [4] |
| LSfminbnd | 1 | 1.2 | 5.4 | 1.2 | 7.3 | 55 | 55 | <i>16e-3/5e3</i> | . | . | . | LSfminbnd [28] |
| LSstep | 1.1 | 2 | 42 | 40 | 35 | 35 | 44 | 82 | 390 | <i>10e-4/1e4</i> | . | LSstep [28] |
| MA-LS-Chain | 1.1 | 1.3 | 1.3 | 2.2 | 5.3 | 4.3 | 4.3 | 4.8 | 2.8 | 3.1 | 2.9 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1 | 1.3 | 4.3 | 4.8 | 5.4 | 5.4 | 9.2 | 44 | 140 | 130 | MCS (Neum) [18] |
| NELDER (Han) | 1 | 1.5 | 130 | 28 | 20 | 20 | 14 | 11 | 12 | 9.6 | 6.3 | NELDER (Han) [16] |
| NELDER (Doe) | 1 | 1.5 | 1.4 | 1.5 | 3.3 | 3 | 3 | 3.1 | 7 | 5.9 | 4 | NELDER (Doe) [5] |
| NEWUOA | 1 | 1.9 | 7.7 | 6.8 | 18 | 33 | 33 | 120 | <i>75e-4/5e3</i> | . | . | NEWUOA [31] |
| (1+1)-ES | 1 | 1.1 | 2.7 | 5.9 | 6.7 | 4.8 | 4.8 | 8.5 | 13 | 23 | 15 | (1+1)-ES [1] |
| POEMS | 4.5 | 110 | 110 | 18 | 35 | 31 | 31 | 32 | 23 | 24 | 21 | POEMS [20] |
| PSO | 1.1 | 1.2 | 1.9 | 1.6 | 5 | 6.2 | 6.2 | 8.1 | 6.2 | 5.5 | 5.5 | PSO [7] |
| PSO_Bounds | 1 | 1.3 | 1.9 | 1.7 | 5.2 | 220 | 4900 | 22 | 15 | 21 | 30 | PSO_Bounds [8] |
| Monte Carlo | 1 | 1.1 | 1.7 | 5.2 | 83 | 140 | 500 | 7.4e4 | <i>79e-4/1e6</i> | . | . | Monte Carlo [3] |
| Rosenbrock | 1 | 20 | 45 | 83 | 140 | 500 | 500 | 350 | <i>24e-2/5e3</i> | . | . | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1 | 1.9 | 4 | 2.2 | 2.8 | 2.3 | 2.3 | 1.8 | 1.6 | 1.5 | 1.4 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1 | 1 | 2.5 | 5.7 | 4.7 | 4.7 | 2.7 | 2.9 | 2.6 | 6.7 | 32 | VNS (Garcia) [11] |

Table 18: 02-D, running time excess ERT/ERT_{best} on f_{18} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
|-----------------|----------------------------|-------|-------|-------|-------|------------------|------------------|------------------|------------------|------------------|------------------|----------------------------|
| | ERT_{best}/D | | | | | | | | | | | ERT_{best}/D |
| ALPS | 1.1 | 1.3 | 1.6 | 9.5 | 66.9 | 333 | 625 | 854 | 1040 | 1220 | 1430 | ALPS [17] |
| AMaLGaM IDEA | 1.1 | 1.3 | 1.3 | 4.1 | 4.1 | 1 | 1 | 1.1 | 1.2 | 1.1 | 1.1 | AMaLGaM IDEA [4] |
| avg NEWUOA | 1.7 | 7.9 | 5.4 | 9 | 6.1 | 62 | 62 | <i>58e-3/6e3</i> | . | . | . | avg NEWUOA [31] |
| BayEDAacG | 1.4 | 1.5 | 2.3 | 19 | 19 | 48 | 48 | <i>59e-2/2e3</i> | . | . | . | BayEDAacG [10] |
| BFGS | 5.4 | 11 | 14 | 30 | 30 | 110 | <i>74e-2/2e3</i> | . | . | . | . | BFGS [30] |
| Cauchy EDA | 2.6 | 2200 | 380 | 55 | 11 | 6.4 | 5 | 7 | 7 | 7.4 | 6.7 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1.6 | 2.4 | 2.2 | 6.5 | 1.9 | 1.1 | 1.1 | 1 | 1 | 1 | 1 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1 | 22 | 6.6 | 13 | 17 | 38 | 38 | 83 | 140 | <i>32e-3/1e4</i> | . | (1+1)-CMA-ES [2] |
| DASA | 3.3 | 27 | 26 | 91 | 86 | 740 | 740 | 1800 | 4200 | 5900 | 5e3 | DASA [19] |
| DEPSO | 1.3 | 1 | 2.7 | 3.1 | 2.1 | 2.1 | 3.3 | 11 | 9.4 | 8.3 | 75e-4/2e3 | DEPSO [12] |
| DIRECT | 1.4 | 1.9 | 1 | 1 | 1 | 1.1 | 1.2 | 3.4 | 4.8 | 4.9 | 11 | DIRECT [25] |
| EDA-PSO | 1.3 | 1.3 | 2.4 | 5.4 | 7.1 | 9.1 | 9.1 | 11 | 12 | 13 | 15 | EDA-PSO [6] |
| full NEWUOA | 1.2 | 5 | 3 | 16 | 19 | 71 | <i>58e-3/6e3</i> | . | . | . | . | full NEWUOA [31] |
| G3-PCX | 1.9 | 1.1 | 2 | 10 | 21 | 41 | 41 | 48 | 72 | 99 | 85 | G3-PCX [26] |
| simple GA | 1.1 | 1.5 | 4.3 | 15 | 23 | 110 | 680 | 280 | 280 | 1200 | <i>24e-4/1e5</i> | simple GA [22] |
| GLOBAL | 1.3 | 1.2 | 2 | 3.1 | 2.2 | 4.8 | 4.8 | 7.6 | <i>58e-3/1e3</i> | . | . | GLOBAL [23] |
| iAMaLGaM IDEA | 1.2 | 1.8 | 1.4 | 12 | 12 | 1.8 | 1.8 | 2.3 | 2 | 2 | 1.8 | iAMaLGaM IDEA [4] |
| LSfminbnd | 2.1 | 3.6 | 1.3 | 2.1 | 7 | 33 | <i>58e-3/4e3</i> | . | . | . | . | LSfminbnd [28] |
| LSstep | 28 | 18 | 12 | 79 | 60 | 110 | 110 | <i>24e-2/1e4</i> | . | . | . | LSstep [28] |
| MA-LS-Chain | 1.7 | 1.5 | 1.6 | 3.2 | 3.2 | 2.5 | 3.2 | 4 | 3.9 | 5.8 | 7 | MA-LS-Chain [21] |
| MCS (Neum) | 1.4 | 3 | 1.3 | 2.8 | 1.7 | 8.4 | 8.4 | 140 | 350 | <i>30e-4/3e4</i> | . | MCS (Neum) [18] |
| NELDER (Han) | 1.2 | 1.3 | 2.1 | 44 | 18 | 20 | 20 | 38 | 47 | 40 | 34 | NELDER (Han) [16] |
| NELDER (Doe) | 1.3 | 1.3 | 1.2 | 3.1 | 2.4 | 4.3 | 4.3 | 5.8 | 8.7 | 25 | 21 | NELDER (Doe) [5] |
| NEWUOA | 1.3 | 13 | 5.6 | 12 | 14 | 62 | 62 | <i>98e-3/6e3</i> | . | . | . | NEWUOA [31] |
| (1+1)-ES | 1.5 | 2.4 | 63 | 230 | 620 | 1500 | 1500 | 4900 | 1.4e4 | <i>75e-4/1e6</i> | . | (1+1)-ES [1] |
| POEMS | 100 | 72 | 28 | 120 | 29 | 28 | 28 | 23 | 31 | 45 | 42 | POEMS [20] |
| PSO | 1.3 | 1.3 | 1.7 | 3.4 | 2.8 | 3.2 | 3.2 | 3.5 | 5.6 | 6.5 | 7.2 | PSO [7] |
| PSO_Bounds | 1.4 | 1.5 | 1.5 | 5.3 | 6.7 | 8.8 | 8.8 | 10 | 12 | 17 | 23 | PSO_Bounds [8] |
| Monte Carlo | 1.1 | 1.2 | 2.2 | 21 | 270 | 1.1e4 | <i>24e-3/1e6</i> | . | . | . | . | Monte Carlo [3] |
| Rosenbrock | 26 | 54 | 61 | 56 | 200 | <i>53e-2/5e3</i> | . | . | . | . | . | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1.5 | 4.9 | 2.1 | 6.2 | 2.1 | 1.3 | 1.3 | 1.1 | 1 | 1.1 | 1.1 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1 | 1.6 | 3.8 | 16 | 5.4 | 3.6 | 3.6 | 4.8 | 8.1 | 18 | 150 | VNS (Garcia) [11] |

Table 19: 02-D, running time excess ERT/ERT_{best} on f_{19} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 19 Griewank-Rosenbrock F8F2 | | | | | | | | | | | | | | | | | | |
|------------------------------------|---------|------------|------------|---------|------------|------------|------------|------------------|------------------|------------------|----------------------------|--|--|--|--|--|--|--|
| Δf_{target} | $1e+03$ | $1e+02$ | $1e+01$ | $1e+00$ | $1e-01$ | $1e-02$ | $1e-03$ | $1e-04$ | $1e-05$ | $1e-07$ | Δf_{target} | | | | | | | |
| ERT_{best}/D | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 13.2 | 108 | 114 | 120 | 138 | ERT_{best}/D | | | | | | | |
| ALPS | 1 | 1.1 | 5.5 | 5.5 | 17 | 12 | 22 | 30 | 41 | 54 | ALPS [17] | | | | | | | |
| AMaLGaM IDEA | 1 | 1.1 | 6.3 | 40 | 6.2 | 18 | 18 | 17 | 17 | 16 | AMaLGaM IDEA [4] | | | | | | | |
| avg NEWUOA | 1 | 1.3 | 8 | 110 | 13 | 22 | 21 | 20 | 19 | 18 | avg NEWUOA [31] | | | | | | | |
| BayEDAacG | 1 | 1.1 | 3.9 | 44 | 9.9 | 13 | 57 | <i>35e-4/2e3</i> | | | BayEDAacG [10] | | | | | | | |
| BFGS | 1 | 1.1 | 37 | 310 | 61 | 30 | 29 | 27 | 26 | 24 | BFGS [30] | | | | | | | |
| Cauchy EDA | 1 | 1.1 | 16 | 110 | 51 | 170 | 860 | 1300 | 2800 | <i>18e-4/5e4</i> | Cauchy EDA [24] | | | | | | | |
| BIPOP-CMA-ES | 1 | 1 | 6 | 31 | 32 | 31 | 31 | 29 | 28 | 26 | BIPOP-CMA-ES [15] | | | | | | | |
| (1+1)-CMA-ES | 1 | 7.5 | 42 | 760 | 97 | 250 | 250 | 250 | 260 | 270 | (1+1)-CMA-ES [2] | | | | | | | |
| DASA | 1 | 1 | 4.4 | 59 | 17 | 18 | 35 | 36 | 69 | 67 | DASA [19] | | | | | | | |
| DEPSO | 1 | 1 | 1 | 1 | 4.6 | 10 | 9.6 | 9.1 | 8.9 | 59 | DEPSO [12] | | | | | | | |
| DIRECT | 1 | 1 | 5.2 | 37 | 13 | 17 | 30 | 57 | 62 | 72 | DIRECT [25] | | | | | | | |
| EDA-PSO | 1 | 1.1 | 6.7 | 88 | 17 | 17 | 17 | 16 | 15 | 14 | EDA-PSO [6] | | | | | | | |
| full NEWUOA | 1 | 1.3 | 5.3 | 52 | 37 | 49 | 47 | 45 | 43 | 40 | full NEWUOA [31] | | | | | | | |
| G3-PCX | 1 | 1 | 4.5 | 51 | 20 | 21 | 110 | 360 | 640 | 4900 | G3-PCX [26] | | | | | | | |
| simple GA | 1 | 1.2 | 4.3 | 50 | 9.4 | 11 | 10 | 10 | 9.6 | 8.8 | simple GA [22] | | | | | | | |
| GLOBAL | 1 | 1.3 | 5.5 | 25 | 63 | 50 | 48 | 48 | 46 | 42 | GLOBAL [23] | | | | | | | |
| iAMaLGaM IDEA | 1 | 1.1 | 9.4 | 49 | 10 | 29 | 70 | 120 | 310 | <i>59e-5/5e3</i> | iAMaLGaM IDEA [4] | | | | | | | |
| LSfminbd | 1 | 1.1 | 140 | 440 | 27 | 63 | 140 | 580 | <i>11e-4/1e4</i> | | LSfminbd [28] | | | | | | | |
| LSstep | 1 | 1.1 | 6.7 | 60 | 7.2 | 15 | 15 | 14 | 14 | 13 | LSstep [28] | | | | | | | |
| MA-LS-Chain | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MA-LS-Chain [21] | | | | | | | |
| MCS (Neum) | 1 | 1 | 3.1 | 380 | 64 | 32 | 30 | 29 | 27 | 25 | MCS (Neum) [18] | | | | | | | |
| NELDER (Han) | 1 | 1 | 4.6 | 52 | 10 | 8.1 | 7.8 | 7.4 | 27 | 25 | NELDER (Han) [16] | | | | | | | |
| NELDER (Doe) | 1 | 1.5 | 6.2 | 130 | 16 | 27 | 26 | 25 | 24 | 22 | NELDER (Doe) [5] | | | | | | | |
| NEWUOA | 1 | 1.6 | 6.2 | 100 | 22 | 23 | 25 | 27 | 30 | 38 | NEWUOA [31] | | | | | | | |
| (1+1)-ES | 1 | 1.30 | 340 | 550 | 57 | 210 | 200 | 200 | 190 | 190 | (1+1)-ES [1] | | | | | | | |
| POEMS | 1 | 1 | 5.3 | 34 | 9.1 | 4.7 | 6 | 8.7 | 9.9 | 16 | POEMS [20] | | | | | | | |
| PSO | 1 | 1.1 | 5.1 | 40 | 7.8 | 11 | 20 | 36 | 47 | 71 | PSO [7] | | | | | | | |
| PSO.Bounds | 1 | 1.5 | 4.5 | 64 | 16 | 36 | 110 | 310 | 720 | 3.2e4 | PSO.Bounds [8] | | | | | | | |
| Monte Carlo | 1 | 1.2 | 4.2 | 160 | 34 | 30 | 29 | 28 | 26 | 24 | Monte Carlo [3] | | | | | | | |
| Rosenbrock | 1 | 1.5 | 4.3 | 29 | 6.8 | 19 | 20 | 19 | 19 | 18 | Rosenbrock [27] | | | | | | | |
| IPOP-SEP-CMA-ES | 1 | 1.5 | 2.2 | 43 | 12 | 19 | 19 | 20 | 20 | 21 | IPOP-SEP-CMA-ES [29] | | | | | | | |
| VNS (Garcia) | 1 | 1.2 | 4.3 | 29 | 6.8 | 19 | 20 | 20 | 20 | 21 | VNS (Garcia) [11] | | | | | | | |

Table 20: 02-D, running time excess ERT/ERT_{best} on f_{20} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| 20 Schwefel $x^* \sin(x)$ | | | | | | | | | | | |
|---|------------|------------|------------|------------|------------------|------------------|------------|------------|------------------|------------|----------------------------|
| Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
| ERT_{best}/D | 1.1 | 1.6 | 1.87 | 30.3 | 182 | 183 | 183 | 184 | 185 | 188 | ERT_{best}/D |
| ALPS | 2.1 | 2.8 | 3.1 | 14 | 6.2 | 9.2 | 12 | 16 | 20 | 26 | ALPS [17] |
| AMaLGaM IDEA | 2.2 | 2.5 | 2.6 | 26 | 37 | 38 | 38 | 38 | 38 | 38 | AMaLGaM IDEA [4] |
| avg NEWUOA | 3 | 2.2 | 2.1 | 9.8 | 4 | 4 | 4 | 4 | 4 | 3.9 | avg NEWUOA [31] |
| BayEDAacG | 3.2 | 4 | 3.6 | 9.2 | 32 | <i>25e-2/2e3</i> | . | . | . | . | BayEDAacG [10] |
| BFGS | 2.5 | 2.2 | 2.1 | 6 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.6 | BFGS [30] |
| Cauchy EDA | 26 | 20 | 18 | 9.9 | 31 | 150 | 1300 | 2e3 | 2e3 | 1900 | Cauchy EDA [24] |
| BIPOP-CMA-ES | 2.9 | 2.8 | 2.7 | 1.3 | 9.9 | 10 | 11 | 11 | 11 | 11 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 2.2 | 2 | 2.1 | 7.5 | 8.5 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | (1+1)-CMA-ES [2] |
| DASA | 59 | 52 | 49 | 81 | 44 | 45 | 45 | 45 | 45 | 45 | DASA [19] |
| DEPSO | 1.4 | 1 | 1 | 9.9 | 4.9 | 5.6 | 6.4 | 6.8 | 8 | 9.2 | DEPSO [12] |
| DIRECT | 5.7 | 5.9 | 6.1 | 1 | 2.9 | 3 | 3.1 | 3.3 | 3.7 | 3.9 | DIRECT [25] |
| EDA-PSO | 1.7 | 3.3 | 3.2 | 9 | 13 | 21 | 25 | 25 | 26 | 27 | EDA-PSO [6] |
| full NEWUOA | 2.9 | 2.1 | 1.8 | 18 | 8.3 | 8.3 | 8.3 | 8.3 | 8.2 | 8.1 | full NEWUOA [31] |
| G3-PCX | 2.9 | 2.8 | 2.9 | 38 | 7.8 | 7.8 | 8 | 8.1 | 8.1 | 8.2 | G3-PCX [26] |
| simple GA | 2.7 | 2.4 | 2.8 | 14 | 15 | 27 | 45 | 65 | 85 | 130 | simple GA [22] |
| GLOBAL | 1.8 | 1.9 | 2.4 | 11 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | GLOBAL [23] |
| iAMaLGaM IDEA | 2.1 | 2.4 | 2.2 | 51 | 26 | 26 | 27 | 27 | 27 | 27 | iAMaLGaM IDEA [4] |
| LSfminbd | 6.5 | 6.7 | 6.6 | 150 | <i>68e-2/1e4</i> | . | . | . | . | . | LSfminbd [28] |
| LSstep | 94 | 210 | 180 | 120 | 25 | 27 | 30 | 37 | 40 | 50 | LSstep [28] |
| MA-LS-Chain | 1.5 | 1.9 | 2.4 | 4.2 | 1.8 | 2 | 2.1 | 2.2 | 2.3 | 2.4 | MA-LS-Chain [21] |
| MCS (Neum) | 2.9 | 6.2 | 5.7 | 2.2 | 1 | 1 | 1 | 1 | 1 | 1 | MCS (Neum) [18] |
| NELDER (Han) | 1.5 | 1.3 | 1.3 | 36 | 28 | 28 | 28 | 28 | 28 | 27 | NELDER (Han) [16] |
| NELDER (Doe) | 1.6 | 1.7 | 1.5 | 3.9 | 2.8 | 2.8 | 2.9 | 2.9 | 2.9 | 2.9 | NELDER (Doe) [5] |
| NEWUOA | 3 | 2.2 | 2.1 | 7 | 5.9 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | NEWUOA [31] |
| (1+1)-ES | 4.1 | 3.7 | 3.3 | 13 | 9 | 9.1 | 9.2 | 9.2 | 9.2 | 9.2 | (1+1)-ES [1] |
| POEMS | 190 | 140 | 130 | 25 | 30 | 35 | 42 | 46 | 52 | 61 | POEMS [20] |
| PSO | 2.5 | 2.2 | 2.5 | 8.3 | 5 | 6.3 | 8.7 | 10 | 12 | 15 | PSO [7] |
| PSO_Bounds | 2.5 | 2.9 | 3.7 | 11 | 6 | 13 | 20 | 25 | 30 | 36 | PSO_Bounds [8] |
| Monte Carlo | 2.2 | 2.8 | 3.6 | 21 | 67 | 680 | 5800 | 8.2e4 | <i>80e-5/1e6</i> | . | Monte Carlo [3] |
| Rosenbrock | 5 | 4 | 4 | 6.8 | 4.1 | 4.2 | 4.2 | 4.2 | 4.2 | 4.2 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1.6 | 1.8 | 1.8 | 9.4 | 15 | 16 | 17 | 18 | 18 | 18 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1 | 3.8 | 4.3 | 18 | 9.3 | 9.6 | 9.7 | 9.9 | 10 | 13 | VNS (Garcia) [11] |

Table 21: 02-D, running time excess ERT/ERT_{best} on f_{21} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
|-----------------|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------------------------|
| | ERT_{best}/D | 0.5 | 0.5 | 0.833 | 25.3 | 87.2 | 138 | 145 | 153 | 162 | 165 | ERT_{best}/D |
| ALPS | | 1 | 1 | 1.2 | 2.2 | 1.8 | 2.6 | 4.9 | 6.4 | 7.8 | 12 | ALPS [17] |
| AMaLGaM IDEA | | 1 | 1 | 1.3 | 28 | 17 | 11 | 11 | 10 | 10 | 10 | AMaLGaM IDEA [4] |
| avg NEWUOA | | 1 | 1 | 6.1 | 6.5 | 4.6 | 2.9 | 2.8 | 2.7 | 2.6 | 2.7 | avg NEWUOA [31] |
| BayEDAacG | | 1 | 1 | 1.7 | 1.6 | 9.3 | 1.4 | 39 | 57 | 86 | 85 | BayEDAacG [10] |
| BFGS | | 1 | 1 | 2.6 | 4.8 | 3 | 2 | 1.9 | 1.8 | 1.7 | 1.8 | BFGS [30] |
| Cauchy EDA | | 1 | 1 | 6 | 310 | 93 | 62 | 65 | 62 | 81 | 80 | Cauchy EDA [24] |
| BIPOP-CMA-ES | | 1 | 1 | 1.4 | 11 | 10 | 8.2 | 9.7 | 9.3 | 8.9 | 8.9 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | | 1 | 1 | 1.2 | 12 | 9.6 | 6.1 | 5.9 | 5.6 | 5.3 | 5.3 | (1+1)-CMA-ES [2] |
| DASA | | 1 | 1 | 1.3 | 150 | 140 | 88 | 84 | 80 | 77 | 76 | DASA [19] |
| DEPSO | | 1 | 1 | 2.1 | 2.5 | 1.5 | 1.8 | 2.4 | 2.6 | 2.9 | 5.6 | DEPSO [12] |
| DIRECT | | 1 | 1 | 1.3 | 1 | 1 | 1 | 1 | 2 | 2 | 2.3 | DIRECT [25] |
| EDA-PSO | | 1 | 1 | 1 | 1.8 | 83 | 54 | 53 | 52 | 51 | 52 | EDA-PSO [6] |
| full NEWUOA | | 1 | 1 | 2.2 | 3.6 | 3 | 1.9 | 1.8 | 1.7 | 1.7 | 1.7 | full NEWUOA [31] |
| G3-PCX | | 1 | 1 | 1.4 | 2.7 | 2.9 | 1.9 | 1.9 | 1.8 | 1.8 | 1.8 | G3-PCX [26] |
| simple GA | | 1 | 1 | 1.4 | 1 | 1.7 | 4.1 | 7.7 | 18 | 120 | 270 | simple GA [22] |
| GLOBAL | | 1 | 1 | 1.5 | 1.1 | 1.1 | 1 | 1 | 1 | 1 | 1 | GLOBAL [23] |
| iAMaLGaM IDEA | | 1 | 1 | 1.6 | 21 | 12 | 7.9 | 7.8 | 7.5 | 7.2 | 7.1 | iAMaLGaM IDEA [4] |
| LSfminbd | | 1 | 1 | 2.1 | 39 | 20 | 26 | 46 | 60 | 73 | 170 | LSfminbd [28] |
| LSstep | | 1 | 1 | 18 | 370 | 150 | 100 | 100 | 100 | 120 | 190 | LSstep [28] |
| MA-LS-Chain | | 1 | 1 | 1.4 | 1.1 | 1.5 | 1.5 | 1.7 | 1.9 | 1.9 | 2 | MA-LS-Chain [21] |
| MCS (Neum) | | 1 | 1 | 1.6 | 22 | 14 | 8.8 | 8.4 | 8 | 7.6 | 7.5 | MCS (Neum) [18] |
| NELDER (Han) | | 1 | 1 | 1.8 | 19 | 20 | 13 | 12 | 12 | 11 | 11 | NELDER (Han) [16] |
| NELDER (Doe) | | 1 | 1 | 1.4 | 2.6 | 2.6 | 1.7 | 1.6 | 1.5 | 1.5 | 1.5 | NELDER (Doe) [5] |
| NEWUOA | | 1 | 1 | 3.5 | 3.9 | 4 | 2.5 | 2.4 | 2.3 | 2.2 | 2.3 | NEWUOA [31] |
| (1+1)-ES | | 1 | 1 | 2.8 | 14 | 19 | 12 | 11 | 11 | 10 | 10 | (1+1)-ES [1] |
| POEMS | | 1 | 1 | 1.30 | 93 | 890 | 560 | 540 | 520 | 490 | 490 | POEMS [20] |
| PSO | | 1 | 1 | 1.2 | 1.4 | 83 | 53 | 51 | 48 | 46 | 47 | PSO [7] |
| PSO_Bounds | | 1 | 1 | 1.5 | 33 | 300 | 190 | 180 | 170 | 170 | 170 | PSO_Bounds [8] |
| Monte Carlo | | 1 | 1 | 2 | 1.8 | 1.2 | 3.5 | 8.8 | 28 | 42 | 640 | Monte Carlo [3] |
| Rosenbrock | | 1 | 1 | 2.3 | 5.5 | 3.9 | 2.5 | 2.4 | 2.3 | 2.2 | 2.1 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | | 1 | 1 | 1.3 | 9.6 | 6.4 | 6.3 | 8.5 | 8.7 | 8.6 | 9.2 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | | 1 | 1 | 1.1 | 6.1 | 14 | 9.1 | 8.8 | 8.5 | 8.4 | 8.4 | VNS (Garcia) [11] |

21 Gallagher 101 peaks

Table 22: $02-D$, running time excess ERT/ERT_{best} on f_{22} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | | 22 Gallagher 21 peaks | | | | | | | | | | |
|----------------------------|-----------------------|------------------------------|-------|------------|------------|------------|------------|------------|------------|------------|------------------|----------------------------|
| Δf_{target} | ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
| | | 0.5 | 0.5 | 2.53 | 13.4 | 83.9 | 109 | 125 | 142 | 144 | 153 | ERT_{best}/D |
| ALPS | ALPS [17] | 1 | 1 | 1.2 | 1.3 | 1 | 3 | 5.2 | 7.1 | 9.2 | 15 | ALPS [17] |
| AMaLGA | AMaLGA IDEA [4] | 1 | 1 | 1.3 | 51 | 18 | 19 | 17 | 15 | 15 | 15 | AMaLGA IDEA [4] |
| avg NEWUOA | avg NEWUOA [31] | 1 | 1 | 3 | 3.8 | 1.3 | 1.1 | 1.1 | 1.1 | 1.1 | 1.3 | avg NEWUOA [31] |
| BayEDA | BayEDA c G [10] | 1 | 1 | 1.3 | 3.3 | 7.6 | 11 | 34 | 59 | 200 | <i>37e-4/2e3</i> | BayEDA c G [10] |
| BFGS | BFGS [30] | 1 | 1 | 5.4 | 5 | 1.5 | 1.2 | 1.1 | 1 | 1 | 1 | BFGS [30] |
| Cauchy | Cauchy EDA [24] | 1 | 1 | 27 | 610 | 190 | 270 | 390 | 450 | 540 | 510 | Cauchy EDA [24] |
| BIPOP-CMA-ES | BIPOP-CMA-ES [15] | 1 | 1 | 1 | 7.3 | 11 | 8.7 | 10 | 9.2 | 9.1 | 8.7 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | (1+1)-CMA-ES [2] | 1 | 1 | 14 | 26 | 7.2 | 5.7 | 5 | 4.5 | 4.4 | 4.3 | (1+1)-CMA-ES [2] |
| DASA | DASA [19] | 1 | 1 | 11 | 80 | 22 | 21 | 22 | 28 | 40 | 63 | DASA [19] |
| DEPSO | DEPSO [12] | 1 | 1 | 2.3 | 4.7 | 2.4 | 4 | 4.6 | 5 | 6.6 | 9.8 | DEPSO [12] |
| DIRECT | DIRECT [25] | 1 | 1 | 1.5 | 2.1 | 1.3 | 1.3 | 1.4 | 2.2 | 4.8 | 5.1 | DIRECT [25] |
| EDA-PSO | EDA-PSO [6] | 1 | 1 | 1.1 | 4 | 1.7 | 4.2 | 4.9 | 8.4 | 11 | 25 | EDA-PSO [6] |
| full NEWUOA | full NEWUOA [31] | 1 | 1 | 6.5 | 6.8 | 1.5 | 1.2 | 1.1 | 1.1 | 1.1 | 1.2 | full NEWUOA [31] |
| G3-PCX | G3-PCX [26] | 1 | 1 | 2.1 | 2.2 | 1.1 | 1.1 | 1.1 | 1.3 | 1.4 | 1.6 | G3-PCX [26] |
| simple GA | simple GA [22] | 1 | 1 | 1.2 | 3 | 1.3 | 3.3 | 7.1 | 17 | 280 | 1900 | simple GA [22] |
| GLOBAL | GLOBAL [23] | 1 | 1 | 1.7 | 2.9 | 1.3 | 1.5 | 1.5 | 1.3 | 1.4 | 1.3 | GLOBAL [23] |
| iAMaLGA | iAMaLGA IDEA [4] | 1 | 1 | 1.5 | 14 | 9.9 | 8.9 | 8 | 7.2 | 7.1 | 7.3 | iAMaLGA IDEA [4] |
| LSfminbnd | LSfminbnd [28] | 1 | 1 | 1.4 | 4.7 | 5.1 | 53 | 49 | 61 | 69 | 460 | LSfminbnd [28] |
| LSstep | LSstep [28] | 1 | 1 | 1 | 80 | 140 | 140 | 150 | 280 | 970 | 920 | LSstep [28] |
| MA-LS-Chain | MA-LS-Chain [21] | 1 | 1 | 1 | 2.8 | 1.6 | 1.9 | 2.2 | 2.3 | 2.4 | 2.4 | MA-LS-Chain [21] |
| MCS (Neum) | MCS (Neum) [18] | 1 | 1 | 2.4 | 40 | 7.4 | 6 | 5.3 | 4.7 | 4.8 | 5.2 | MCS (Neum) [18] |
| NELDER (Han) | NELDER (Han) [16] | 1 | 1 | 7.7 | 39 | 9.8 | 7.6 | 6.6 | 5.9 | 5.8 | 5.5 | NELDER (Han) [16] |
| NELDER (Doe) | NELDER (Doe) [5] | 1 | 1 | 1.3 | 8.1 | 1.8 | 1.4 | 1.2 | 1.1 | 1.1 | 1.1 | NELDER (Doe) [5] |
| NEWUOA | NEWUOA [31] | 1 | 1 | 1.9 | 6.3 | 1.2 | 1 | 1 | 1 | 1 | 1 | NEWUOA [31] |
| (1+1)-ES | (1+1)-ES [1] | 1 | 1 | 1.6 | 46 | 11 | 9.8 | 9.4 | 9.4 | 10 | 12 | (1+1)-ES [1] |
| POEMS | POEMS [20] | 1 | 1 | 64 | 940 | 230 | 190 | 160 | 150 | 150 | 150 | POEMS [20] |
| PSO | PSO [7] | 1 | 1 | 1.5 | 2.7 | 1 | 1.8 | 1.9 | 2.3 | 3.8 | 6.5 | PSO [7] |
| PSO-Bounds | PSO-Bounds [8] | 1 | 1 | 1.2 | 540 | 87 | 67 | 60 | 56 | 58 | 64 | PSO-Bounds [8] |
| Monte Carlo | Monte Carlo [3] | 1 | 1 | 1.3 | 2.8 | 1.5 | 3.1 | 7.2 | 24 | 93 | 760 | Monte Carlo [3] |
| Rosenbrock | Rosenbrock [27] | 1 | 1 | 12 | 17 | 4.5 | 3.5 | 3.1 | 2.7 | 2.7 | 2.6 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | IPOP-SEP-CMA-ES [29] | 1 | 1 | 1 | 7.7 | 4.4 | 4.1 | 3.9 | 3.6 | 3.8 | 3.8 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | VNS (Garcia) [11] | 1 | 1 | 2 | 1 | 2.8 | 3.8 | 4.8 | 4.7 | 5 | 5.3 | VNS (Garcia) [11] |

Table 23: 02-D, running time excess ERT/ERT_{best} on f_{23} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} |
|-----------------|----------------------------|-------|-------|-------|------------------|-------|------------------|-------|-------------------|------------------|------------------|----------------------------|
| | ERT_{best}/D | 0.5 | 0.5 | 3.9 | 96.5 | 117 | 131 | 150 | 157 | 174 | 190 | ERT_{best}/D |
| ALPS | 1 | 1 | 1.4 | 1.4 | 14 | 86 | 140 | 200 | 640 | 4100 | 2.8e4 | ALPS [17] |
| AMaLGaM IDEA | 1 | 1 | 1.3 | 7.5 | 7.5 | 10 | 9.8 | 9 | 8.9 | 8.4 | 8.1 | AMaLGaM IDEA [4] |
| avg NEWUOA | 1 | 1 | 4.2 | 6.7 | 25 | 25 | 100 | 260 | <i>4.9e-3/6e3</i> | . | . | avg NEWUOA [31] |
| BayEDAacG | 1 | 1 | 2 | 11 | <i>56e-2/2e3</i> | . | . | . | . | . | . | BayEDAacG [10] |
| BFGS | 1 | 1 | 4.8 | 4.9 | 28 | 28 | 120 | 480 | 460 | 410 | <i>73e-3/5e3</i> | BFGS [30] |
| Cauchy EDA | 1 | 1 | 1.8 | 16 | 860 | 860 | <i>14e-2/5e4</i> | . | . | . | . | Cauchy EDA [24] |
| BIPOP-CMA-ES | 1 | 1 | 1.8 | 8.3 | 15 | 14 | 13 | 13 | 13 | 12 | 12 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES | 1 | 1 | 2.1 | 5.1 | 8.4 | 8.4 | 8.6 | 7.7 | 7.6 | 6.9 | 6.6 | (1+1)-CMA-ES [2] |
| DASA | 1 | 1 | 5.7 | 17 | 170 | 170 | 1800 | 8600 | 9600 | 8700 | 7900 | DASA [19] |
| DEPSO | 1 | 1 | 2.2 | 24 | <i>96e-2/2e3</i> | . | . | . | . | . | . | DEPSO [12] |
| DIRECT | 1 | 1 | 1.5 | 4.2 | 290 | 290 | 270 | 240 | 230 | 210 | 200 | DIRECT [25] |
| EDA-PSO | 1 | 1 | 2.3 | 18 | 1400 | 1400 | <i>13e-2/1e5</i> | . | . | . | . | EDA-PSO [6] |
| full NEWUOA | 1 | 1 | 6 | 1.5 | 24 | 46 | 81 | 81 | 79 | 71 | 65 | full NEWUOA [31] |
| G3-PCX | 1 | 1 | 1.9 | 1.6 | 6.1 | 6.1 | 6 | 5.8 | 5.8 | 5.5 | 7.4 | G3-PCX [26] |
| simple GA | 1 | 1 | 1.4 | 6.6 | 330 | 330 | 840 | 3300 | <i>41e-4/1e5</i> | . | . | simple GA [22] |
| GLOBAL | 1 | 1 | 1 | 2.6 | 97 | 97 | <i>21e-2/2e3</i> | . | . | . | . | GLOBAL [23] |
| iAMaLGaM IDEA | 1 | 1 | 1.3 | 5.3 | 5.5 | 5.5 | 5.3 | 4.9 | 5 | 4.7 | 4.6 | iAMaLGaM IDEA [4] |
| LSfminbnd | 1 | 1 | 1.3 | 2.1 | 30 | 30 | 120 | 200 | 190 | <i>25e-3/7e3</i> | . | LSfminbnd [28] |
| LSstep | 1 | 1 | 2.6 | 18 | 1300 | 1300 | <i>24e-2/1e4</i> | . | . | . | . | LSstep [28] |
| MA-LS-Chain | 1 | 1 | 1.8 | 5.5 | 7.4 | 7.4 | 7.1 | 6.6 | 6.7 | 6.4 | 7 | MA-LS-Chain [21] |
| MCS (Neum) | 1 | 1 | 3.4 | 2.8 | 6.3 | 6.3 | 23 | 210 | 500 | 1e3 | 1900 | MCS (Neum) [18] |
| NELDER (Han) | 1 | 1 | 1.3 | 1.6 | 2.2 | 2.2 | 2.2 | 2 | 1.9 | 1.8 | 1.7 | NELDER (Han) [16] |
| NELDER (Doe) | 1 | 1 | 4.7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | NELDER (Doe) [5] |
| NEWUOA | 1 | 1 | 7.8 | 3.2 | 32 | 32 | 89 | 130 | 170 | 500 | 460 | NEWUOA [31] |
| (1+1)-ES | 1 | 1 | 2.6 | 3.7 | 19 | 19 | 55 | 240 | 1e3 | 2100 | 6700 | (1+1)-ES [1] |
| POEMS | 1 | 1 | 1.4 | 28 | 42 | 42 | 59 | 73 | 79 | 180 | 190 | POEMS [20] |
| PSO | 1 | 1 | 1.3 | 9 | 9 | 9 | 88 | 88 | 79 | 88 | 95 | PSO [7] |
| PSO_Bounds | 1 | 1 | 1.7 | 9.4 | 260 | 260 | 460 | 500 | 690 | 660 | 860 | PSO_Bounds [8] |
| Monte Carlo | 1 | 1 | 1.5 | 8 | 1900 | 1900 | <i>46e-3/1e6</i> | . | . | . | . | Monte Carlo [3] |
| Rosenbrock | 1 | 1 | 1.9 | 2.2 | 9.9 | 9.9 | 15 | 17 | 23 | 29 | <i>66e-7/5e3</i> | Rosenbrock [27] |
| IPOP-SEP-CMA-ES | 1 | 1 | 2.6 | 8.1 | 14 | 14 | 16 | 14 | 14 | 13 | 12 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) | 1 | 1 | 1.8 | 8.3 | 38 | 38 | 67 | 65 | 62 | 56 | 52 | VNS (Garcia) [11] |

Table 24: 02-D, running time excess ERT/ERT_{best} on f_{24} , in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

| | Δf_{target} ERT_{best}/D | 1e+03 | 1e+02 | 1e+01 | 1e+00 | 1e-01 | 1e-02 | 1e-03 | 1e-04 | 1e-05 | 1e-07 | Δf_{target} ERT_{best}/D |
|----------------------|---------------------------------------|-------|-------|------------|------------|------------------|------------------|------------------|------------------|------------|------------|---------------------------------------|
| ALPS [17] | | 0.5 | 1 | 1 | 4 | 4 | 2.8 | 2.9 | 2.9 | 3 | 3.2 | ALPS [17] |
| AMaLGaM IDEA [4] | | 1 | 1 | 1.2 | 35 | 11 | 6.7 | 6.7 | 6.6 | 6.6 | 6.7 | AMaLGaM IDEA [4] |
| avg NEWUOA [31] | | 1 | 1 | 3.3 | 1.9 | 1.4 | 6.2 | 6 | 5.9 | 5.9 | 5.9 | avg NEWUOA [31] |
| BayEDAeG [10] | | 1 | 1 | 1.9 | 68 | <i>22e-1/2e3</i> | | | | | | BayEDAeG [10] |
| BFGS [30] | | 1 | 1 | 3.4 | 5.1 | 2.9 | <i>42e-2/3e3</i> | | | | | BFGS [30] |
| Cauchy EDA [24] | | 1 | 1 | 3.9 | 33 | 170 | <i>49e-2/5e4</i> | | | | | Cauchy EDA [24] |
| BIPOP-CMA-ES [15] | | 1 | 1 | 4.6 | 19 | 17 | 13 | 22 | 22 | 22 | 22 | BIPOP-CMA-ES [15] |
| (1+1)-CMA-ES [2] | | 1 | 1 | 2.7 | 6.1 | 4.8 | 2.9 | 2.8 | 2.7 | 2.7 | 3.6 | (1+1)-CMA-ES [2] |
| DASA [19] | | 1 | 1 | 10 | 140 | 110 | 61 | 59 | 58 | 58 | 58 | DASA [19] |
| DEPSO [12] | | 1 | 1 | 3.3 | 67 | <i>24e-1/2e3</i> | | | | | | DEPSO [12] |
| DIRECT [25] | | 1 | 1 | 1.9 | 79 | 8.7 | 5 | 4.9 | 4.7 | 4.7 | 4.8 | DIRECT [25] |
| EDA-PSO [6] | | 1 | 1 | 1.6 | 100 | 12 | 9 | 9 | 8.8 | 8.8 | 8.9 | EDA-PSO [6] |
| full NEWUOA [31] | | 1 | 1 | 2.8 | 1 | 1 | 1.1 | 1 | 1 | 1 | 1 | full NEWUOA [31] |
| G3-PCX [26] | | 1 | 1 | 1.2 | 37 | 20 | <i>10e-2/5e4</i> | | | | | G3-PCX [26] |
| simple GA [22] | | 1 | 1 | 1.6 | 67 | <i>79e-2/1e5</i> | | | | | | simple GA [22] |
| GLOBAL [23] | | 1 | 1 | 2.7 | 3.3 | 7 | <i>51e-2/2e3</i> | | | | | GLOBAL [23] |
| iAMaLGaM IDEA [4] | | 1 | 1 | 1.4 | 28 | 9.1 | 5.4 | 5.3 | 5.2 | 5.3 | 5.3 | iAMaLGaM IDEA [4] |
| LSfminbnd [28] | | 1 | 1 | 2.8 | 8.3 | <i>37e-2/8e3</i> | | | | | | LSfminbnd [28] |
| LStep [28] | | 3 | 3 | 4.8 | 29 | 33 | 12 | 12 | <i>11e-1/1e4</i> | | | LStep [28] |
| MA-LS-Chain [21] | | 1 | 1 | 2.5 | 31 | 34 | <i>11e-1/1e4</i> | | | | | MA-LS-Chain [21] |
| MCS (Neum) [18] | | 1 | 1 | 2.5 | 5.7 | 1.6 | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | MCS (Neum) [18] |
| NELDER (Han) [16] | | 1 | 1 | 16 | 7.4 | 5 | 6.6 | 6.4 | 6.2 | 6.2 | 6.2 | NELDER (Han) [16] |
| NELDER (Doe) [5] | | 1 | 1 | 1.5 | 1.9 | 1.5 | 3.2 | 3.1 | 3 | 3 | 3 | NELDER (Doe) [5] |
| NEWUOA [31] | | 1 | 1 | 3.1 | 2.8 | 1.9 | 2 | 1.9 | 1.9 | 1.9 | 1.9 | NEWUOA [31] |
| (1+1)-ES [1] | | 1 | 1 | 8 | 12 | 11 | 21 | 20 | 19 | 19 | 19 | (1+1)-ES [1] |
| POEMS [20] | | 1 | 1 | 28 | 1500 | 170 | <i>20e-1/1e5</i> | | | | | POEMS [20] |
| PSO [7] | | 1 | 1 | 2.4 | 470 | 49 | 18 | 17 | 17 | 17 | 17 | PSO [7] |
| PSO_Bounds [8] | | 1 | 1 | 1.3 | 1500 | 150 | 57 | 55 | 54 | 54 | 54 | PSO_Bounds [8] |
| Monte Carlo [3] | | 1 | 1 | 2.5 | 14 | 150 | 570 | <i>49e-3/1e6</i> | | | | Monte Carlo [3] |
| Rosenbrock [27] | | 1 | 1 | 19 | 35 | 15 | 11 | 11 | 11 | 11 | 11 | Rosenbrock [27] |
| IPOP-SEP-CMA-ES [29] | | 1 | 1 | 1.7 | 7.2 | 3.9 | 3.7 | 3.7 | 3.6 | 3.6 | 3.6 | IPOP-SEP-CMA-ES [29] |
| VNS (Garcia) [11] | | 1 | 1 | 1.2 | 5.3 | 1.7 | 1 | 1 | 1.1 | 1.9 | 4.7 | VNS (Garcia) [11] |

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