

Black-Box Optimization Benchmarking Template for Noiseless Function Testbed

Draft version *

Forename Name

ABSTRACT

to be written

Categories and Subject Descriptors

G.1.6 [Numerical Analysis]: Optimization—*global optimization, unconstrained optimization*; F.2.1 [Analysis of Algorithms and Problem Complexity]: Numerical Algorithms and Problems

General Terms

Algorithms

Keywords

Benchmarking, Black-box optimization

1. CPU TIMING

In order to evaluate the CPU timing of the algorithm, we have run the **MY-ALGORITHM-NAME** on the function f_8 with restarts for at least 30 seconds and until a maximum budget equal to $400(D+2)$ is reached. The code was run on a **Mac Intel(R) Core(TM) i5-2400S CPU @ 2.50GHz** with **1** processor and **4** cores. The time per function evaluation for dimensions 2, 3, 5, 10, 20, **40** equals $1.8 \cdot e^{-8}$, $1.8 \cdot e^{-7}$, $6.0 \cdot e^{-3}$, $1.9 \cdot e$, $2.1 \cdot e^2$, $4.4 \cdot e^3$, $1.1 \cdot e^5$ milliseconds respectively.

2. RESULTS

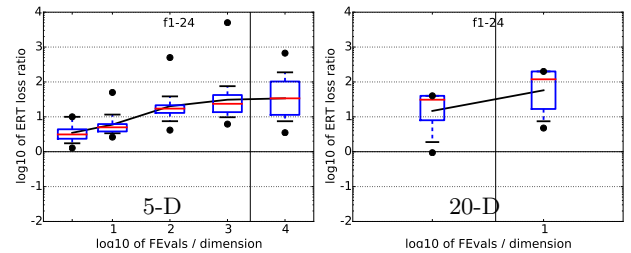
Results of Experimental Data from experiments according to [?] on the benchmark functions given in [?, ?] are presented in Figures ??, ??, ??, and ?? and in Tables ??.

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f_1-f_{24} in 5-D, maxFE/D=2493						
#FEs/D	best	10%	25%	med	75%	90%
2	1.3	1.5	2.3	3.1	4.6	10
10	2.6	3.3	3.8	5.0	6.4	16
100	4.2	6.9	13	17	22	88
1e3	6.2	8.2	13	24	42	1.1e2
1e4	3.5	6.6	11	34	1.1e2	2.0e2
RL _{US} /D	2e3	2e3	2e3	2e3	2e3	2e3
f_1-f_{24} in 20-D, maxFE/D=5						
#FEs/D	best	10%	25%	med	75%	90%
2	0.94	1.2	7.3	31	40	40
10	4.8	7.4	15	1.2e2	2.0e2	2.0e2
RL _{US} /D	5	5	5	5	5	5

Figure 3: ERT loss ratio versus the budget in number of f -evaluations divided by dimension. For each given budget FEvals, the target value f_t is computed as the best target f -value reached within the budget by the given algorithm. Shown is then the ERT to reach f_t for the given algorithm or the budget, if the GECCO-BBOB-2009 best algorithm reached a better target within the budget, divided by the best ERT seen in GECCO-BBOB-2009 to reach f_t . Line: geometric mean. Box-Whisker error bar: 25-75%-ile with median (box), 10-90%-ile (caps), and minimum and maximum ERT loss ratio (points). The vertical line gives the maximal number of function evaluations in a single trial in this function subset. See also Figure ?? for results on each function subgroup.

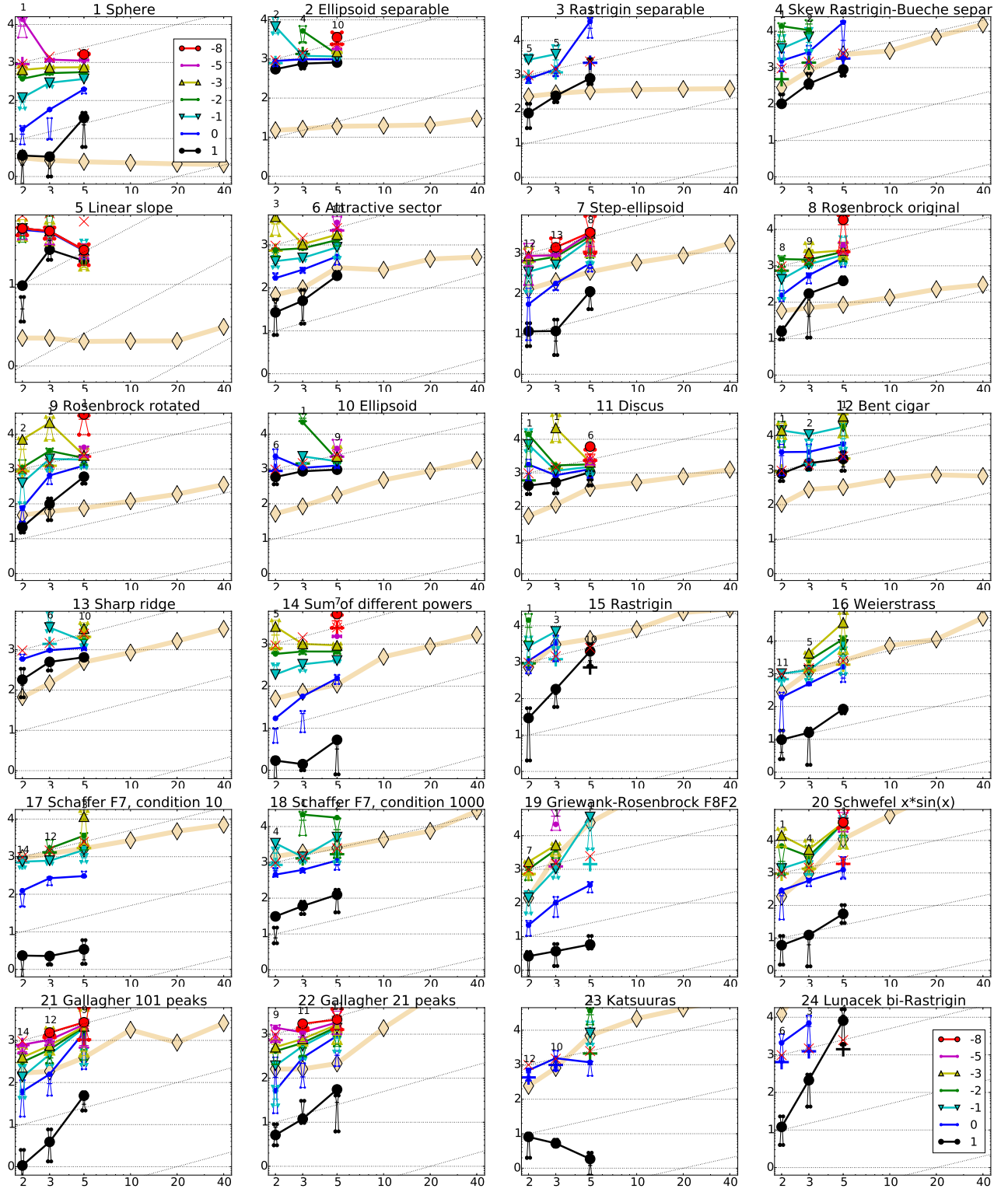


Figure 1: Expected number of f -evaluations (ERT, lines) to reach $f_{\text{opt}} + \Delta f$; median number of f -evaluations (+) to reach the most difficult target that was reached not always but at least once; maximum number of f -evaluations in any trial (\times); interquartile range with median (notched boxes) of simulated runlengths to reach $f_{\text{opt}} + \Delta f$; all values are divided by dimension and plotted as \log_{10} values versus dimension. Shown are $\Delta f = 10^{\{-8, -5, -3, -2, -1, 0, 1\}}$. Numbers above ERT-symbols (if appearing) indicate the number of trials reaching the respective target. The light thick line with diamonds indicates the respective best result from BBOB-2009 for $\Delta f = 10^{-8}$. Horizontal lines mean linear scaling, slanted grid lines depict quadratic scaling.

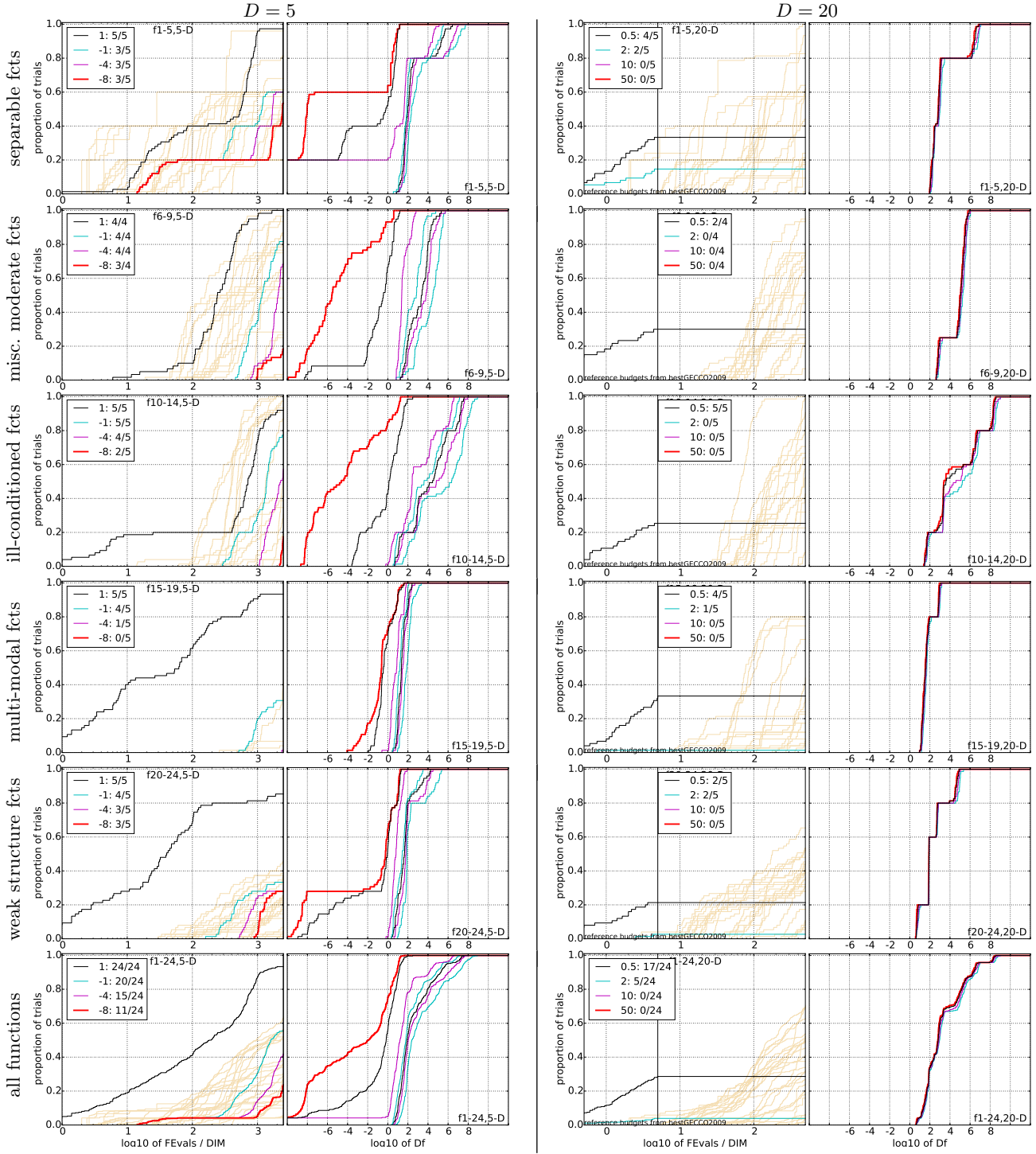


Figure 2: Empirical cumulative distribution functions (ECDF), plotting the fraction of trials with an outcome not larger than the respective value on the x -axis. Left subplots: ECDF of the number of function evaluations (FEvals) divided by search space dimension D , to fall below $f_{\text{opt}} + \Delta f$ with $\Delta f = 10^k$, where k is the first value in the legend. The thick red line represents the most difficult target value $f_{\text{opt}} + 10^{-8}$. Legends indicate for each target the number of functions that were solved in at least one trial within the displayed budget. Right subplots: ECDF of the best achieved Δf for running times of $0.5D, 1.2D, 3D, 10D, 100D, 1000D, \dots$ function evaluations (from right to left cycling cyan-magenta-black...) and final Δf -value (red), where Δf and Df denote the difference to the optimal function value. Light brown lines in the background show ECDFs for the most difficult target of all algorithms benchmarked during BBOB-2009.

Δf	5-D							#succ
	1e+1	1e+0	1e-1	1e-2	1e-3	1e-5	1e-7	
f₁	11	12	12	12	12	12	12	15/15
	16(19)	81(24)	151(27)	229(31)	308(31)	457(27)	603(47)	15/15
f₂	83	87	88	89	90	92	94	15/15
	49(8)	56(6)	65(11)	74(5)	84(4)	102(6)	119(6)	10/15
f₃	716	1622	1637	1642	1646	1650	1654	15/15
	5.5(10)	112(246)	∞	∞	∞	∞	$\infty 1.2e4$	0/15
f₄	809	1633	1688	1758	1817	1886	1903	15/15
	5.5(1)	54(71)	∞	∞	∞	∞	$\infty 1.2e4$	0/15
f₅	10	10	10	10	10	10	10	15/15
	10(6)	13(3)	13(5)	13(5)	13(8)	13(8)	13(5)	15/15
f₆	114	214	281	404	580	1038	1332	15/15
	8.4(2)	13(3)	16(4)	16(16)	15(10)	16(10)	$\infty 1.2e4$	0/15
f₇	24	324	1171	1451	1572	1572	1597	15/15
	24(22)	8.7(10)	10(18)	9.0(9)	10(20)	10(10)	10(12)	8/15
f₈	73	273	336	372	391	410	422	15/15
	26(8)	31(37)	29(19)	32(27)	34(17)	45(39)	108(88)	2/15
f₉	35	127	214	263	300	335	369	15/15
	87(49)	49(27)	43(34)	39(12)	41(27)	62(73)	122(74)	1/15
f₁₀	349	500	574	607	626	829	880	15/15
	14(2)	13(2)	14(7)	15(4)	18(2)	23(12)	211(159)	0/15
f₁₁	143	202	763	977	1177	1467	1673	15/15
	37(16)	32(18)	10(5)	9.2(13)	8.8(6)	8.5(3)	13(8)	6/15
f₁₂	108	268	371	413	461	1303	1494	15/15
	97(86)	107(181)	243(233)	221(217)	398(435)	∞	$\infty 1.2e4$	0/15
f₁₃	132	195	250	319	1310	1752	2255	15/15
	25(3)	29(12)	33(6)	47(21)	13(7)	∞	$\infty 1.2e4$	0/15
f₁₄	10	41	58	90	139	251	476	15/15
	2.7(6)	19(7)	35(8)	37(4)	34(3)	30(3)	22(2)	7/15
f₁₅	511	9310	19369	19743	20073	20769	21359	14/15
	20(30)	∞	∞	∞	∞	∞	$\infty 1.2e4$	0/15
f₁₆	120	612	2662	10163	10449	11644	12095	15/15
	3.5(2)	13(17)	15(7)	5.6(5)	17(19)	∞	$\infty 1.2e4$	0/15
f₁₇	5.2	215	899	2861	3669	6351	7934	15/15
	3.3(3)	7.1(2)	8.3(8)	6.3(4)	16(9)	∞	$\infty 1.2e4$	0/15
f₁₈	103	378	3968	8451	9280	10905	12469	15/15
	6.0(4)	15(19)	6.4(11)	10(19)	∞	∞	$\infty 1.2e4$	0/15
f₁₉	1	1	242	1.0e5	1.2e5	1.2e5	1.2e5	15/15
	29(20)	1707(1575)	741(1029)	∞	∞	∞	$\infty 1.2e4$	0/15
f₂₀	16	851	38111	51362	54470	54861	55313	14/15
	17(14)	7.3(5)	4.6(6)	3.4(3)	3.2(7)	3.2(4)	3.3(4)	1/15
f₂₁	41	1157	1674	1692	1705	1729	1757	14/15
	5.9(6)	6.7(15)	5.9(10)	6.2(4)	6.4(6)	6.9(14)	7.3(4)	9/15
f₂₂	71	386	938	980	1008	1040	1068	14/15
	3.9(3)	12(16)	7.3(7)	7.5(6)	8.2(7)	8.9(9)	10(6)	11/15
f₂₃	3.0	518	14249	27890	31654	33030	34256	15/15
	3.1(1)	11(3)	2.9(2)	6.6(6)	∞	∞	$\infty 1.2e4$	0/15
f₂₄	1622	2.2e5	6.4e6	9.6e6	9.6e6	1.3e7	1.3e7	3/15
	25(31)	∞	∞	∞	∞	∞	$\infty 1.2e4$	0/15

#FEs/D	20-D					#succ
	0.5	1.2	3	10	50	
f₁	6.3e+1:24	4.0e+1:42	1.0e-8:43	1.0e-8:43	1.0e-8:43	15/15
	∞	∞	∞	∞	$\infty 100$	0/15
f₂	4.0e+6:29	2.5e+6:42	1.0e+5:65	1.0e+4:207	1.0e-8:412	15/15
	1.2(0.9)	2.1(3)	∞	∞	$\infty 100$	0/15
f₃	6.3e+2:33	4.0e+2:44	1.6e+2:109	1.0e+2:255	2.5e+1:3277	15/15
	14(15)	33(51)	∞	∞	$\infty 100$	0/15
f₄	6.3e+2:22	4.0e+2:91	2.5e+2:250	1.6e+2:332	6.3e+1:1927	15/15
	66(75)	∞	∞	∞	$\infty 100$	0/15
f₅	2.5e+2:19	1.6e+2:34	1.0e-8:41	1.0e-8:41	1.0e-8:41	15/15
	7.9(10)	∞	∞	∞	$\infty 100$	0/15
f₆	2.5e+5:16	6.3e+4:43	1.6e+4:62	1.6e+2:353	1.6e+1:1078	15/15
	28(46)	∞	∞	∞	$\infty 100$	0/15
f₇	1.0e+3:11	4.0e+2:39	2.5e+2:74	6.3e+1:319	1.0e+1:1351	15/15
	1.7(1)	∞	∞	∞	$\infty 100$	0/15
f₈	4.0e+4:19	2.5e+4:35	4.0e+3:67	2.5e+2:231	1.6e+1:1470	15/15
	∞	∞	∞	∞	$\infty 100$	0/15
f₉	1.0e+2:357	6.3e+1:560	4.0e+1:684	2.5e+1:756	1.0e+1:1716	15/15
	∞	∞	∞	∞	$\infty 100$	0/15
f₁₀	1.6e+6:15	1.0e+6:27	4.0e+5:70	6.3e+4:231	4.0e+3:1015	15/15
	48(88)	∞	∞	∞	$\infty 100$	0/15
f₁₁	4.0e+4:11	2.5e+3:27	1.6e+2:313	1.0e+2:481	1.0e+1:1002	15/15
	3.0(4)	6.0(8)	∞	∞	$\infty 100$	0/15
f₁₂	1.0e+8:23	6.3e+7:39	2.5e+7:76	4.0e+6:209	1.0e+1:1042	15/15
	61(69)	∞	∞	∞	$\infty 100$	0/15
f₁₃	1.6e+3:28	1.0e+3:64	6.3e+2:79	4.0e+1:211	2.5e+0:1724	15/15
	52(51)	∞	∞	∞	$\infty 100$	0/15
f₁₄	2.5e+1:15	1.6e+1:42	1.0e+1:75	1.6e+0:219	6.3e-4:1106	15/15
	100(79)	∞	∞	∞	$\infty 100$	0/15
f₁₅	6.3e+2:15	4.0e+2:67	2.5e+2:292	1.6e+2:846	1.0e+2:1671	15/15
	92(112)	∞	∞	∞	$\infty 100$	0/15
f₁₆	4.0e+1:26	2.5e+1:127	1.6e+1:540	1.6e+1:540	1.0e+1:1384	15/15
	3.8(5)	∞	∞	∞	$\infty 100$	0/15
f₁₇	1.6e+1:11	1.0e+1:63	6.3e+0:305	4.0e+0:468	1.0e+0:1030	15/15
	5.6(4)	22(43)	∞	∞	$\infty 100$	0/15
f₁₈	4.0e+1:116	2.5e+1:252	1.6e+1:430	1.0e+1:621	4.0e+0:1090	15/15
	6.1(4)	∞	∞	∞	$\infty 100$	0/15
f₁₉	1.6e-1:2.5e5	1.0e-1:3.4e5	6.3e-2:3.4e5	4.0e-2:3.4e5	2.5e-2:3.4e5	3/15
	∞	∞	∞	∞	$\infty 100$	0/15
f₂₀	1.6e+4:38	1.0e+4:42	2.5e+2:62	2.5e+0:250	1.6e+0:2536	15/15
	38(42)	34(41)	∞	∞	$\infty 100$	0/15
f₂₁	6.3e+1:36	4.0e+1:77	4.0e+1:77	1.6e+1:456	4.0e+0:1094	15/15
	∞	∞	∞	∞	$\infty 100$	0/15
f₂₂	6.3e+1:45	4.0e+1:68	4.0e+1:68	1.6e+1:231	6.3e+0:1219	15/15
	∞	∞	∞	∞	$\infty 100$	0/15
f₂₃	6.3e+0:29	4.0e+0:118	2.5e+0:306	2.5e+0:306	1.0e+0:1614	15/15
	0.94(0.8)	13(8)	∞	∞	$\infty 100$	0/15
f₂₄	2.5e+2:208	1.6e+2:918	1.0e+2:6628	6.3e+1:9885	4.0e+1:31629	15/15
	∞	∞	∞	∞	$\infty 100$	0/15

Table 1: Expected running time (ERT in number of function evaluations) divided by the best ERT measured during BBOB-2009. The ERT and in braces, as dispersion measure, the half difference between 90 and 10%-tile of bootstrapped run lengths appear in the second row of each cell, the best ERT in the first. The different target Δf -values are shown in the top row. #succ is the number of trials that reached the (final) target $f_{\text{opt}} + 10^{-8}$. The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Bold entries are statistically significantly better (according to the rank-sum test) compared to the best algorithm in BBOB-2009, with $p = 0.05$ or $p = 10^{-k}$ when the number $k > 1$ is following the \downarrow symbol, with Bonferroni correction by the number of functions.

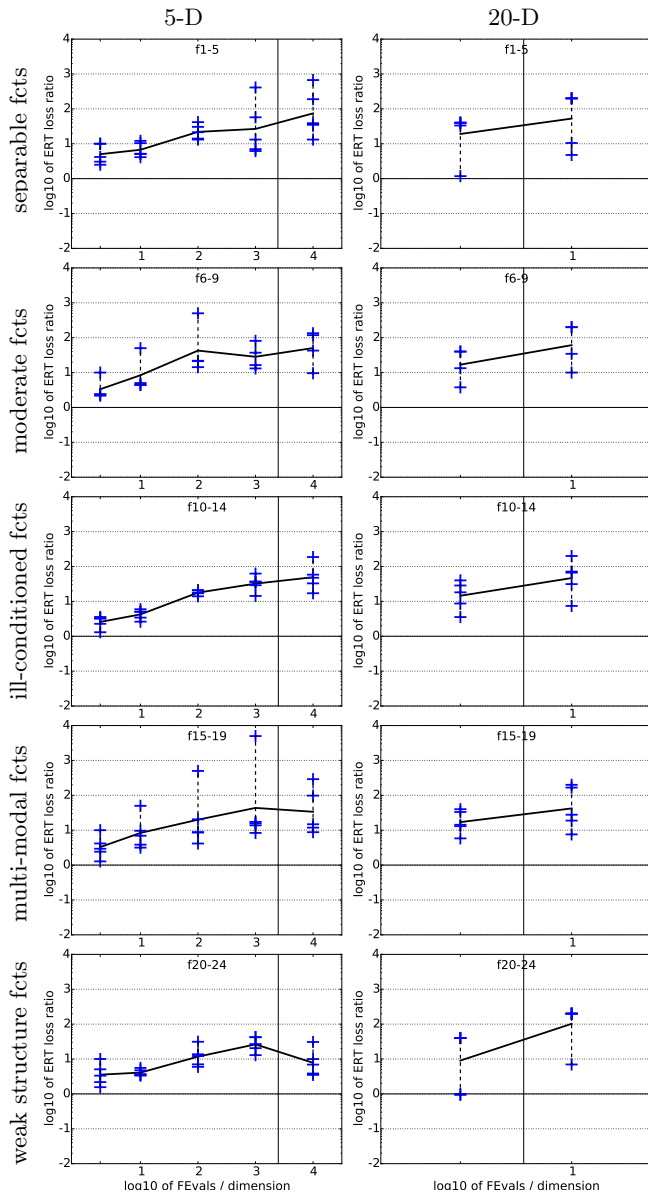


Figure 4: ERT loss ratios (see Figure ?? for details). Each cross (+) represents a single function, the line is the geometric mean.