Comparison tables: BBOB 2012 testbed in 2-D

The BBOBies

August 16, 2012

Abstract

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking at GECCO 2012, see `http://coco.gforge.inria.fr/doku.php?id=bbob-2012`. More than 27 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 [4, 2]. The experimental set-up is described in [3].

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 in BBOB-2009 (see [1]) if an algorithm from BBOB-2009 reached the given target function value. The ERT value is given otherwise ($\mathrm{ERT}_{\mathrm{best}}$ is noted as infinite). See [3] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values. Table 1 gives an overview on all algorithms submitted to the noise-free testbed in 2012.

Table 1: Names and references of all algorithms submitted for the noise-free testbed

algorithm short name	paper	reference
ACOR	An ACO Algorithm Benchmarked on the BBOB Noiseless Function Testbed (Page 159)	[5]
BIPOPaCMA	Black-Box Optimization Benchmarking of IPOP-SaACM-ES and BIPOP-SaACM-ES on the BBOB-2012 Noiseless Testbed (Page 175)	[12]
BIPOPsaACM	Black-box Optimization Benchmarking of IPOP-SaACM-ES and BIPOP-SaACM-ES on the BBOB-2012 Noiseless Testbed (Page 175)	[12]
CMA	Comparing Mirrored Mutations and Active Covariance Matrix Adaptation in the IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 297)	[14]
CMAES	Benchmarking the Differential Evolution with Adaptive Encoding on Noiseless Functions (Page 189)	[9]
CMAa	Comparing Mirrored Mutations and Active Covariance Matrix Adaptation in the IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 297)	[14]
CMAm	Comparing Mirrored Mutations and Active Covariance Matrix Adaptation in the IPOP-CMA-ES on the Noiseless BBOB Testbed (Page 297)	[14]
CMAma	On the Impact of a Small Initial Population Size in the IPOP Active CMA-ES with Mirrored Mutations on the Noiseless BBOB Testbed (Page 285)	[19]
CMAmah	On the Impact of a Small Initial Population Size in the IPOP Active CMA-ES with Mirrored Mutations on the Noiseless BBOB Testbed (Page 285)	[19]
CMAmh	On the Impact of Active Covariance Matrix Adaptation in the CMA-ES With Mirrored Mutations and Small Initial Population Size on the Noiseless BBOB Testbed (Page 291)	[20]
DBRCGA	Black-Box Optimization Benchmarking for Noiseless Function Testbed Using A Direction-Based RCGA (Page 167)	[11]
DE	Benchmarking the Differential Evolution with Adaptive Encoding on Noiseless Functions (Page 189)	[9]
DE-AUTO	MEMPSODE: An Empirical Assessment of Local Search Algorithm Impact on a Memetic Algorithm Using Noiseless Testbed (Page 245)	[17]
DE-BFGS	MEMPSODE: Comparing Particle Swarm Optimization and Differential Evolution Within a Hybrid Memetic Global Optimization Framework (Page 253)	[18]
DE-ROLL	MEMPSODE: An Empirical Assessment of Local Search Algorithm Impact on a Memetic Algorithm Using Noiseless Testbed (Page 245)	[17]
DE-SIMPLEX	MEMPSODE: An Empirical Assessment of Local Search Algorithm Impact on a Memetic Algorithm Using Noiseless Testbed (Page 245)	[17]
DEctpb	JADE, an Adaptive Differential Evolution Algorithm, Benchmarked on the BBOB Noiseless Testbed (Page 197)	[16]
IPOPsaACM	Black-box Optimization Benchmarking of NIPOP-aCMA-ES and NBIPOP-aCMA-ES on the BBOB-2012 Noiseless Testbed (Page 269)	[14]
JADEctpb	JADE, an Adaptive Differential Evolution Algorithm, Benchmarked on the BBOB Noiseless Testbed (Page 197)	[16]
MVDE	Benchmarking the Multi-View Differential Evolution on the Noiseless BBOB-2012 Function Testbed (Page 183)	[10]
NBIPOPaCMA	Black-box Optimization Benchmarking of NIPOP-aCMA-ES and NBIPOP-aCMA-ES on the BBOB-2012 Noiseless Testbed (Page 269)	[13]
NIPOPaCMA	Black-box Optimization Benchmarking of NIPOP-aCMA-ES and NBIPOP-aCMA-ES on the BBOB-2012 Noiseless Testbed (Page 269)	[13]
PSO-BFGS	MEMPSODE: Comparing Particle Swarm Optimization and Differential Evolution Within a Hybrid Memetic Global Optimization Framework (Page 253)	[18]
SNES	Benchmarking Separable Natural Evolution Strategies on the Noiseless and Noisy Black-box Optimization Testbeds (Page 205)	[8]
xNES	Benchmarking Exponential Natural Evolution Strategies on the Noiseless and Noisy Black-Box Optimization Testbeds (Page 213)	[6]
xNESas	Benchmarking Natural Evolution Strategies with Adaptation Sampling on the Noiseless and Noisy Black-Box Optimization Testbeds (Page 229)	[7]
xNESas	Investigating the Impact of Adaptation Sampling in Natural Evolution Strategies on Black-Box Optimization Testbeds (Page 221)	[15]

Table 2: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f1	1.8	5.7	5.7	6.2	6.2	6.2	15/15
ACOR	**1.4**(1)	4.4(5)	11(9)	31(8)	50(4)	72(9)	15/15
BIPOPaCMA	3.3(5)	3.9(3)	7.8(6)	18(6)	26(7)	36(5)	15/15
BIPOPsaACM	5.4(6)	5.1(5)	8.3(4)	12(1)	16(3)	19(2)	15/15
CMA	**2.9**(2)	4.3(3)	10(3)	18(4)	27(7)	36(6)	15/15
CMAES	3.7(5)	4.9(4)	9.5(6)	19(5)	29(5)	40(5)	15/15
CMAa	3.4(6)	**3.2**(3)	8.2(5)	18(6)	26(6)	38(8)	15/15
CMAm	3.1(4)	3.3(3)	**6.4**(5)	15(4)	22(4)	30(5)	15/15
CMAma	3.0(5)	3.8(3)	7.8(4)	14(5)	22(7)	29(7)	15/15
CMAmah	3.4(4)	**3.3**(2)	**6.1**(3)	13(4)	19(4)	27(5)	15/15
CMAmh	4.1(6)	**2.6**(3)	**6.3**(3)	**11**(4)	21(5)	28(3)	15/15
DBRCGA	**1.8**(1)	4.8(4)	15(10)	36(6)	54(10)	77(13)	15/15
DE	**1.9**(2)	3.6(4)	12(7)	32(10)	49(13)	67(20)	15/15
DE-AUTO	**1.6**(1)	3.3(4)	8.8(4)	**10**(0.2)	**10**(0.2)	**10**(0.2)	15/15
DE-BFGS	**2.9**(3)	4.1(2)	9.2(2)	**9.1**(0.2)	**9.1**(0.2)	**9.1**(0.2)	15/15
DE-ROLL	**2.1**(1)	**2.5**(3)	12(4)	13(1)	**13**(1)	**13**(1)	15/15
DE-SIMPLEX	**2.9**(2)	5.2(4)	10(6)	13(1)	16(2)	18(2)	15/15
DEctpb	**2.6**(2)	4.7(5)	13(7)	35(8)	52(7)	72(7)	15/15
IPOPsaACM	3.1(2)	3.6(3)	**7.0**(5)	12(1)	15(2)	19(1)	15/15
JADEctpb	**2.3**(2)	4.0(4)	9.2(5)	22(7)	36(6)	51(7)	15/15
MVDE	**2.3**(3)	3.7(3)	20(17)	78(22)	129(29)	175(40)	15/15
NBIPOPaCMA	4.8(6)	4.0(4)	7.6(5)	16(7)	27(5)	37(5)	15/15
NIPOPaCMA	**2.6**(3)	3.8(4)	7.6(5)	16(5)	26(4)	34(7)	15/15
PSO-BFGS	**1.9**(3)	5.3(4)	9.1(3)	**9.2**(0.2)	**9.2**(0.2)	**9.2**(0.2)	15/15
SNES	6.5(6)	4.5(3)	7.1(6)	19(9)	39(6)	51(12)	15/15
xNES	4.2(5)	4.2(4)	7.4(6)	18(8)	32(7)	44(7)	15/15
xNESas	6.6(9)	4.3(5)	8.0(7)	18(8)	28(9)	40(10)	15/15

Table 3: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f2	16	19	25	26	28	29	15/15
ACOR	13(3)	14(2)	13(2)	17(3)	20(2)	24(3)	15/15
BIPOPaCMA	14(10)	16(9)	14(5)	16(3)	17(3)	19(3)	15/15
BIPOPsaACM	6.3(2)	7.0(2)	5.7(2)	6.4(1)	6.8(1)	7.4(1.0)	15/15
CMA	12(10)	18(10)	17(4)	20(3)	21(3)	22(2)	15/15
CMAES	17(12)	22(7)	20(3)	21(4)	23(3)	24(3)	15/15
CMAa	12(8)	16(6)	14(2)	16(3)	16(2)	18(2)	15/15
CMAm	12(12)	20(10)	17(8)	19(5)	20(4)	21(3)	15/15
CMAma	13(9)	19(4)	16(2)	17(3)	17(2)	19(2)	15/15
CMAmah	19(14)	23(12)	20(3)	21(3)	21(3)	22(3)	15/15
CMAmh	22(15)	27(15)	26(3)	27(3)	27(2)	28(3)	15/15
DBRCGA	11(8)	15(8)	16(6)	20(6)	23(4)	29(6)	15/15
DE	11(3)	12(2)	11(3)	15(3)	18(3)	21(4)	15/15
DE-AUTO	**4.3**(0.3)	**3.8**(0.2)	**3.1**(0.2)	**3.2**(0.3)	**3.3**(0.3)	**3.4**(0.5)	15/15
DE-BFGS	**4.0**(0.3)	**3.7**(0.3)	**3.0**(0.2)	**3.2**(0.4)	**3.2**(0.3)	**3.3**(0.3)	15/15
DE-ROLL	**5.0**(4)	**4.5**(3)	**3.6**(2)	**3.7**(2)	**3.8**(2)	**4.1**(2)	15/15
DE-SIMPLEX	5.1(1)	5.3(1)	4.3(1)	4.7(0.9)	4.9(0.9)	5.2(0.8)	15/15
DEctpb	10(4)	12(4)	12(3)	17(3)	19(4)	23(5)	15/15
IPOPsaACM	5.1(3)	5.7(2)	5.4(1)	5.9(0.8)	6.1(0.9)	6.8(0.9)	15/15
JADEb	6.4(1)	7.6(3)	7.2(2)	9.1(2)	11(2)	13(2)	15/15
JADEctpb	7.5(3)	9.5(2)	9.4(2)	12(2)	15(3)	17(2)	15/15
MVDE	23(8)	28(10)	29(7)	40(6)	50(7)	60(5)	15/15
NBIPOPaCMA	14(10)	18(6)	15(3)	17(3)	17(4)	19(3)	15/15
NIPOPaCMA	11(8)	15(7)	14(4)	16(2)	17(2)	19(2)	15/15
PSO-BFGS	**4.2**(0.3)	**3.8**(0.4)	**3.1**(0.4)	**3.2**(0.4)	**3.1**(0.4)	**3.3**(0.4)	15/15
SNES	11(7)	12(6)	11(3)	14(3)	17(2)	20(2)	15/15
xNES	6.6(6)	11(7)	11(4)	13(3)	15(4)	18(4)	15/15
xNESas	8.9(8)	19(20)	17(18)	28(22)	38(19)	43(22)	15/15

Table 4: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f3	15	271	445	450	454	464	15/15
ACOR	5.2(4)	**1.8**(2)	17(58)	18(58)	18(57)	18(56)	15/15
BIPOPaCMA	3.3(2)	3.9(3)	7.6(9)	7.9(9)	8.1(9)	8.2(8)	15/15
BIPOPsaACM	6.2(3)	**1.9**(2)	5.0(6)	6.8(6)	6.8(6)	7.1(6)	15/15
CMA	4.0(5)	5.5(5)	8.0(7)	8.5(8)	8.8(8)	9.0(8)	15/15
CMAES	3.9(4)	4.2(4)	10(11)	10(11)	10(11)	10(11)	15/15
CMAa	**2.6**(3)	3.2(3)	5.2(4)	5.7(5)	5.9(5)	6.0(5)	15/15
CMAm	**2.8**(2)	3.3(3)	5.9(8)	6.6(9)	6.9(9)	7.0(9)	15/15
CMAma	**2.5**(2)	**2.8**(3)	6.0(7)	10(10)	10(10)	11(10)	15/15
CMAmah	5.6(5)	5.2(4)	6.1(4)	6.7(4)	6.9(4)	7.1(4)	15/15
CMAmh	6.8(16)	3.9(4)	6.4(7)	7.8(8)	8.2(8)	8.3(8)	15/15
DBRCGA	**2.8**(2)	**2.0**(0.7)	**2.4**(2)	**2.8**(2)	3.1(2)	3.7(2)	15/15
DE	3.9(3)	**0.96**(0.3)	**1.9**(3)	**2.1**(3)	**2.3**(3)	**2.5**(3)	15/15
DE-AUTO	3.6(2)	3.7(5)	5.8(6)	5.9(6)	5.8(6)	5.7(6)	15/15
DE-BFGS	6.5(8)	**1.6**(1)	**1.7**(0.8)	**1.7**(0.9)	**1.7**(0.9)	**1.7**(0.9)	15/15
DE-ROLL	4.5(3)	**0.50**(0.4)	**1.5**(2)	**1.5**(2)	**1.5**(2)	**1.5**(2)	15/15
DE-SIMPLEX	8.9(8)	**2.8**(2)	**2.6**(2)	**2.7**(2)	**2.7**(2)	**2.7**(2)	15/15
DEctpb	4.1(3)	**1.3**(0.7)	**1.4**(0.7)	**1.9**(0.8)	**2.3**(0.7)	**2.6**(0.6)	15/15
IPOPsaACM	3.1(3)	**3.0**(3)	5.2(3)	7.0(7)	7.2(9)	7.2(9)	15/15
JADEb	4.0(2)	**1.3**(2)	3.4(3)	3.5(3)	3.7(3)	3.7(3)	15/15
JADEctpb	3.2(2)	**0.96**(0.6)	**0.76**(0.4)	**1.3**(0.4)	**1.5**(0.3)	**1.7**(0.3)	15/15
MVDE	6.3(4)	**1.9**(0.8)	**1.7**(0.6)	**2.4**(0.3)	3.3(0.3)	4.0(0.5)	15/15
NBIPOPaCMA	5.9(3)	**2.4**(4)	8.8(9)	10(9)	10(9)	10(9)	15/15
NIPOPaCMA	3.4(2)	3.1(4)	10(12)	16(26)	16(27)	17(27)	15/15
PSO-BFGS	7.0(6)	**1.6**(2)	**3.0**(3)	**3.0**(3)	**2.9**(3)	**2.9**(3)	15/15
SNES	13(7)	5.8(8)	21(29)	34(47)	34(47)	33(46)	15/15
xNES	13(2)	13(15)	23(27)	24(27)	24(27)	23(26)	15/15
xNESas	13(38)	6.6(7)	20(28)	20(28)	20(27)	20(27)	15/15

Table 5: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f4	22	344	459	523	544	566	15/15
ACOR	4.4(2)	22(75)	92(110)	82(97)	79(93)	76(89)	15/15
BIPOPaCMA	4.0(2)	8.1(15)	41(48)	39(50)	39(51)	38(51)	15/15
BIPOPsaACM	3.8(2)	6.3(7)	34(46)	92(93)	230(387)	224(369)	15/15
CMA	**2.6**(2)	6.7(9)	50(44)	95(110)	104(119)	105(121)	15/15
CMAES	4.5(2)	4.4(5)	42(30)	42(39)	40(38)	39(36)	15/15
CMAa	**2.1**(1)	11(10)	66(50)	140(231)	151(257)	154(262)	15/15
CMAm	**2.1**(1)	8.2(10)	74(80)	164(130)	175(134)	178(135)	15/15
CMAma	**2.1**(2)	10(11)	112(91)	218(210)	241(232)	243(234)	15/15
CMAmah	6.6(13)	7.3(12)	56(53)	133(246)	144(262)	144(261)	15/15
CMAmh	3.7(3)	7.0(11)	71(93)	144(210)	162(261)	162(259)	15/15
DBRCGA	3.6(3)	**1.8**(1)	**2.7**(2)	**2.7**(2)	**2.9**(2)	3.1(2)	15/15
DE	3.2(2)	**2.1**(2)	3.8(5)	3.6(4)	4.0(4)	4.0(4)	15/15
DE-AUTO	**2.6**(0.7)	4.0(8)	8.4(7)	7.4(7)	7.1(6)	6.8(6)	15/15
DE-BFGS	3.5(3)	**1.6**(1)	**2.7**(4)	**2.4**(3)	**2.4**(3)	**2.3**(3)	15/15
DE-ROLL	**2.3**(2)	**1.1**(1)	**2.4**(2)	**2.2**(2)	**2.1**(2)	**2.0**(2)	15/15
DE-SIMPLEX	4.7(3)	**1.9**(1)	4.2(7)	3.7(6)	3.6(6)	3.5(6)	15/15
DEctpb	4.2(1)	**1.2**(0.7)	**2.2**(3)	**2.3**(2)	**2.6**(3)	**2.8**(2)	15/15
IPOPsaACM	**2.5**(2)	4.5(4)	69(84)	283(189)	1074(1460)	1130(1399)	14/15
JADEb	4.4(2)	**2.6**(4)	6.9(6)	6.2(5)	6.1(5)	6.0(5)	15/15
JADEctpb	**2.6**(2)	**1.1**(0.5)	**1.4**(2)	**1.5**(1)	**1.7**(1)	**1.8**(1)	15/15
MVDE	5.7(4)	**1.7**(0.7)	**1.7**(0.5)	**2.4**(0.5)	3.0(0.3)	3.5(0.4)	15/15
NBIPOPaCMA	**2.4**(2)	8.0(6)	67(64)	71(71)	71(85)	69(84)	15/15
NIPOPaCMA	3.8(2)	5.7(7)	120(231)	177(271)	178(264)	175(255)	15/15
PSO-BFGS	4.5(5)	**2.1**(2)	4.4(4)	4.0(4)	3.8(4)	4.4(6)	15/15
SNES	8.4(2)	12(20)	47(49)	44(43)	42(41)	41(39)	15/15
xNES	8.6(2)	20(20)	64(58)	57(51)	55(49)	53(47)	15/15
xNESas	11(30)	11(12)	46(72)	44(63)	42(61)	41(58)	15/15

Table 6: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f5	3.7	4.4	4.4	4.4	4.4	4.4	15/15
ACOR	4.0(1)	14(0.9)	15(1)	15(1)	15(1)	15(1)	15/15
BIPOPaCMA	**2.9**(2)	5.3(4)	5.7(5)	5.7(5)	5.7(5)	5.7(5)	15/15
BIPOPsaACM	3.9(3)	5.8(4)	6.5(4)	6.5(4)	6.5(4)	6.5(4)	15/15
CMA	3.8(4)	7.8(7)	8.4(7)	8.4(7)	8.4(7)	8.4(7)	15/15
CMAES	3.1(2)	5.8(3)	6.1(3)	6.2(3)	6.2(3)	6.2(3)	15/15
CMAa	4.7(5)	6.1(5)	6.2(4)	6.3(4)	6.3(4)	6.3(4)	15/15
CMAm	**2.7**(2)	**4.2**(2)	**4.6**(2)	**4.6**(2)	**4.6**(2)	**4.6**(2)	15/15
CMAma	**3.0**(2)	**4.3**(2)	**4.5**(2)	**4.7**(2)	**4.7**(2)	**4.7**(2)	15/15
CMAmah	3.3(2)	**4.7**(3)	**5.1**(4)	**5.1**(4)	**5.1**(4)	**5.1**(4)	15/15
CMAmh	**2.2**(2)	**3.2**(2)	**3.5**(2)	**3.5**(2)	**3.5**(2)	**3.5**(2)	15/15
DBRCGA	3.4(3)	8.7(5)	11(5)	11(5)	11(5)	11(5)	15/15
DE	3.4(3)	7.6(5)	8.1(7)	8.1(7)	8.1(7)	8.1(7)	15/15
DE-AUTO	3.6(2)	8.8(3)	10(4)	10(4)	10(4)	10(4)	15/15
DE-BFGS	5.9(2)	12(3)	13(1)	13(1)	13(1)	13(1)	15/15
DE-ROLL	3.6(3)	8.8(2)	11(3)	11(3)	12(3)	12(3)	15/15
DE-SIMPLEX	4.9(2)	8.2(2)	11(6)	12(7)	14(10)	36(61)	15/15
DEctpb	4.5(4)	9.4(8)	10(8)	11(7)	11(7)	11(7)	15/15
IPOPsaACM	**3.0**(3)	6.1(6)	6.8(6)	6.8(6)	6.8(6)	6.8(6)	15/15
JADEb	3.5(4)	6.4(5)	7.7(6)	7.8(6)	7.8(6)	7.8(6)	15/15
JADEctpb	3.1(3)	9.3(8)	11(8)	11(8)	11(8)	11(8)	15/15
MVDE	5.2(6)	34(11)	44(15)	45(15)	45(15)	45(15)	15/15
NBIPOPaCMA	4.1(3)	5.9(4)	6.3(3)	6.3(3)	6.3(3)	6.3(3)	15/15
NIPOPaCMA	3.2(2)	4.9(3)	5.4(3)	5.4(3)	5.4(3)	5.4(3)	15/15
PSO-BFGS	6.3(7)	13(0.3)	13(0.3)	13(0.3)	13(0.3)	13(0.3)	15/15
SNES	5.3(3)	10(6)	11(7)	11(7)	11(7)	11(7)	15/15
xNES	6.9(4)	14(12)	14(12)	14(12)	14(12)	14(12)	15/15
xNESas	5.9(5)	19(29)	20(29)	20(30)	20(30)	20(30)	15/15

Table 7: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f6	13	23	41	67	95	124	15/15
ACOR	**2.1**(3)	6.1(3)	6.0(3)	8.1(2)	8.4(2)	8.9(2)	15/15
BIPOPaCMA	**2.0**(2)	3.5(3)	3.1(1)	3.5(1)	3.8(1.0)	3.8(0.9)	15/15
BIPOPsaACM	**2.3**(2)	**3.1**(1)	3.1(0.7)	4.0(2)	4.0(2)	4.2(2)	15/15
CMA	**2.2**(3)	3.8(3)	4.1(2)	3.9(0.9)	4.1(0.9)	4.1(0.9)	15/15
CMAES	**2.7**(2)	4.0(4)	4.3(2)	4.3(1)	4.2(1)	4.3(0.9)	15/15
CMAa	**3.0**(4)	4.3(3)	3.2(3)	3.9(1)	3.9(1)	3.9(0.7)	15/15
CMAm	4.0(6)	5.5(2)	4.3(2)	4.4(1.0)	4.5(2)	4.6(1)	15/15
CMAma	**2.0**(3)	3.8(4)	4.0(2)	4.0(2)	4.2(0.8)	4.3(0.7)	15/15
CMAmah	**2.4**(3)	3.6(2)	**2.8**(1)	**3.0**(0.6)	**2.9**(0.5)	**2.9**(0.4)	15/15
CMAmh	**2.5**(2)	3.3(3)	3.2(2)	3.4(1)	3.2(1)	3.3(0.8)	15/15
DBRCGA	**2.0**(2)	6.4(3)	6.7(3)	7.4(2)	7.5(2)	8.1(2)	15/15
DE	**2.8**(3)	4.7(3)	6.2(2)	7.5(2)	8.0(2)	8.3(2)	15/15
DE-AUTO	**1.6**(2)	**3.1**(1)	**2.3**(1)	**1.9**(0.7)	**1.7**(0.7)	**1.5**(0.5)	15/15
DE-BFGS	**1.9**(2)	3.1(2)	**2.4**(0.8)	**1.8**(0.5)	**1.5**(0.3)	**1.6**(0.6)	15/15
DE-ROLL	**1.4**(1)	9.5(7)	22(49)	18(36)	51(52)	135(305)	14/15
DE-SIMPLEX	**2.1**(2)	**3.0**(1)	**2.2**(0.4)	**1.9**(0.8)	**1.6**(0.5)	**1.6**(0.7)	15/15
DEctpb	3.5(3)	6.0(3)	6.3(3)	8.9(2)	8.9(1)	9.3(2)	15/15
IPOPsaACM	**2.6**(2)	3.3(2)	4.2(4)	3.8(2)	3.9(2)	3.9(1)	15/15
JADEb	**2.4**(3)	**3.0**(2)	3.2(2)	3.8(1)	4.3(1)	4.4(1)	15/15
JADEctpb	**1.7**(1)	3.6(2)	3.4(2)	4.5(1)	4.9(0.9)	5.1(0.6)	15/15
MVDE	**1.9**(2)	8.6(8)	12(5)	22(9)	28(6)	30(8)	15/15
NBIPOPaCMA	**2.8**(4)	3.8(3)	3.5(2)	3.9(1)	4.0(1)	4.0(0.8)	15/15
NIPOPaCMA	4.0(4)	3.9(3)	3.2(2)	3.8(0.9)	3.9(0.6)	3.9(0.4)	15/15
PSO-BFGS	3.2(3)	3.8(1)	**2.7**(0.7)	**2.1**(0.5)	**1.7**(0.3)	**1.6**(0.4)	15/15
SNES	**2.6**(3)	3.3(2)	3.4(2)	4.8(2)	5.0(1)	5.3(1)	15/15
xNES	5.2(4)	4.6(2)	4.5(4)	5.8(3)	5.5(4)	5.2(3)	15/15
xNESas	5.6(6)	6.2(4)	14(2)	11(3)	9.3(2)	8.5(2)	15/15

Table 8: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f7	3.2	21	60	217	217	241	15/15
ACOR	4.7(5)	4.1(4)	3.7(2)	**2.0**(1)	**2.0**(1)	**2.5**(2)	15/15
BIPOPaCMA	6.2(6)	5.5(6)	3.2(2)	**1.9**(1)	**1.9**(1)	**1.9**(1)	15/15
BIPOPsaACM	4.4(4)	**2.8**(3)	**2.5**(2)	**1.2**(1.0)	**1.2**(1.0)	**1.2**(0.9)	15/15
CMA	**3.2**(2)	**2.2**(3)	**1.7**(2)	**1.4**(1)	**1.4**(1)	**1.8**(2)	15/15
CMAES	5.2(5)	**2.7**(4)	**2.5**(2)	**1.6**(3)	**1.6**(3)	**2.2**(2)	15/15
CMAa	5.0(6)	**2.6**(2)	**2.1**(2)	**1.3**(0.9)	**1.3**(0.9)	**1.3**(0.8)	15/15
CMAm	5.3(9)	3.6(5)	**2.1**(2)	**1.1**(1)	**1.1**(1)	**1.2**(1)	15/15
CMAma	6.4(8)	3.6(3)	3.1(3)	**1.2**(1)	**1.2**(1)	**1.4**(1.0)	15/15
CMAmah	**3.2**(3)	**2.0**(2)	**2.7**(3)	**1.7**(1)	**1.7**(1)	**1.9**(1)	15/15
CMAmh	**2.5**(2)	**2.3**(3)	4.5(4)	**1.7**(1)	**1.7**(1)	**2.0**(2)	15/15
DBRCGA	4.3(4)	3.1(3)	**2.9**(3)	**2.9**(2)	**2.9**(2)	3.7(4)	15/15
DE	5.2(7)	**2.9**(3)	**2.9**(1)	**1.7**(1)	**1.7**(1)	**1.9**(1)	15/15
DE-AUTO	**3.1**(4)	4.4(10)	12(13)	9.3(7)	9.3(7)	8.4(7)	15/15
DE-BFGS	3.4(3)	11(4)	5.9(2)	**2.3**(0.8)	**2.3**(0.8)	5.4(5)	15/15
DE-ROLL	5.1(7)	6.9(7)	6.5(8)	3.7(3)	3.7(3)	4.1(3)	15/15
DE-SIMPLEX	4.7(5)	**2.6**(2)	**2.2**(1)	**1.1**(1.0)	**1.1**(1.0)	**1.2**(0.9)	15/15
DEctpb	8.6(10)	3.7(3)	3.4(1.0)	**1.7**(0.8)	**1.7**(0.8)	**2.1**(0.9)	15/15
IPOPsaACM	4.5(3)	5.0(6)	3.7(3)	**1.3**(0.8)	**1.3**(0.8)	**1.6**(0.8)	15/15
JADEb	**2.5**(3)	**1.8**(2)	4.1(0.6)	34(6)	34(6)	31(5)	14/15
JADEctpb	5.8(8)	**2.6**(2)	**2.0**(1.0)	**0.97**(0.2)	**0.97**(0.2)	**1.1**(0.3)	15/15
MVDE	6.2(5)	4.2(4)	5.6(4)	4.0(2)	4.0(2)	5.1(2)	15/15
NBIPOPaCMA	5.9(3)	3.5(3)	3.2(3)	**1.7**(1)	**1.7**(1)	**1.8**(2)	15/15
NIPOPaCMA	4.5(5)	**3.0**(3)	3.6(3)	**1.6**(1)	**1.6**(1)	**1.6**(1)	15/15
PSO-BFGS	18(28)	53(111)	78(102)	27(29)	27(29)	90(116)	12/15
SNES	6.5(6)	33(93)	21(34)	11(19)	11(19)	22(36)	13/15
xNES	48(7)	39(49)	28(33)	12(16)	12(16)	11(17)	15/15
xNESas	5.1(4)	37(94)	25(34)	7.4(9)	7.4(9)	7.8(8)	15/15

Table 9: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f8	5.4	12	37	86	94	112	15/15
ACOR	6.0(6)	12(8)	12(3)	17(4)	32(7)	39(6)	15/15
BIPOPaCMA	4.3(3)	8.9(8)	8.1(5)	5.2(2)	5.6(2)	5.2(2)	15/15
BIPOPsaACM	4.8(5)	**6.2**(8)	**3.9**(3)	**2.5**(1)	**2.6**(1)	**2.4**(1)	15/15
CMA	6.2(6)	12(17)	7.5(7)	5.4(3)	5.8(3)	5.4(2)	15/15
CMAES	6.6(6)	12(19)	10(6)	6.1(4)	6.5(3)	6.0(2)	15/15
CMAa	7.0(3)	13(14)	8.2(9)	5.1(4)	5.5(3)	5.2(3)	15/15
CMAm	4.8(4)	8.0(12)	10(8)	6.1(3)	6.5(3)	5.9(2)	15/15
CMAma	6.7(7)	8.4(10)	5.7(6)	4.4(3)	4.7(3)	4.5(2)	15/15
CMAmah	**3.7**(4)	**6.4**(10)	7.3(6)	5.3(2)	5.4(2)	5.1(2)	15/15
CMAmh	4.1(3)	14(22)	9.5(11)	7.1(4)	7.3(4)	6.6(3)	15/15
DBRCGA	4.4(4)	7.1(5)	13(22)	15(14)	18(15)	19(14)	15/15
DE	6.9(6)	9.5(8)	7.4(4)	6.2(2)	8.7(3)	9.4(3)	15/15
DE-AUTO	5.4(5)	**6.5**(4)	**3.0**(1)	**1.6**(0.5)	**1.5**(0.5)	**1.3**(0.4)	15/15
DE-BFGS	5.4(6)	8.6(3)	**3.7**(0.9)	**1.8**(0.4)	**1.7**(0.3)	**1.5**(0.3)	15/15
DE-ROLL	30(5)	49(86)	105(143)	208(116)	312(117)	1189(1102)	6/15
DE-SIMPLEX	5.0(5)	**6.3**(6)	**3.3**(2)	**1.7**(0.7)	**1.7**(0.6)	**1.5**(0.5)	15/15
DEctpb	11(13)	18(22)	12(12)	8.7(7)	12(5)	13(4)	15/15
IPOPsaACM	5.7(5)	11(14)	6.5(6)	3.8(2)	3.8(2)	3.4(2)	15/15
JADEb	4.8(4)	11(16)	7.9(8)	5.4(4)	6.0(3)	6.1(3)	15/15
JADEctpb	**3.9**(4)	7.0(6)	6.8(5)	6.0(3)	7.1(3)	7.2(2)	15/15
MVDE	9.2(7)	20(13)	20(20)	22(8)	32(10)	36(9)	15/15
NBIPOPaCMA	**4.0**(4)	11(13)	7.7(7)	5.2(3)	5.5(3)	5.1(3)	15/15
NIPOPaCMA	5.0(4)	10(8)	7.6(7)	5.2(3)	5.4(2)	5.0(2)	15/15
PSO-BFGS	8.1(6)	10(2)	4.1(0.9)	**2.0**(0.4)	**1.9**(0.3)	**1.6**(0.3)	15/15
SNES	6.4(5)	881(1273)	578(1260)	728(704)	1282(1071)	1523(919)	13/15
xNES	6.4(7)	15(18)	21(14)	13(10)	13(10)	12(8)	15/15
xNESas	**3.7**(3)	17(20)	17(32)	10(14)	11(14)	10(12)	15/15

Table 10: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f9	1	18	30	68	81	92	15/15
ACOR	28(18)	5.0(4)	7.8(5)	12(8)	21(12)	26(18)	15/15
BIPOPaCMA	28(30)	**3.3**(2)	7.1(4)	5.3(2)	5.3(1)	5.4(1)	15/15
BIPOPsaACM	19(14)	6.0(6)	7.5(5)	4.6(3)	4.2(2)	3.9(2)	15/15
CMA	40(24)	7.9(5)	11(8)	7.6(4)	7.4(3)	7.2(2)	15/15
CMAES	21(20)	5.8(10)	9.0(8)	6.6(4)	6.6(3)	6.5(3)	15/15
CMAa	26(28)	6.9(9)	10(8)	6.8(3)	6.5(3)	6.3(3)	15/15
CMAm	25(20)	6.6(11)	10(10)	6.9(5)	6.7(4)	6.4(3)	15/15
CMAma	**19**(21)	5.0(5)	8.4(8)	5.8(4)	5.6(3)	5.5(2)	15/15
CMAmah	39(24)	5.7(2)	8.8(6)	6.4(2)	6.2(2)	6.2(2)	15/15
CMAmh	44(15)	10(15)	13(11)	9.3(5)	8.6(4)	8.2(4)	15/15
DBRCGA	31(28)	6.2(4)	12(12)	18(15)	18(12)	18(13)	15/15
DE	45(42)	7.7(6)	10(7)	8.4(6)	10(3)	12(3)	15/15
DE-AUTO	35(27)	5.9(2)	**4.8**(2)	**2.5**(0.7)	**2.1**(0.6)	**1.9**(0.5)	15/15
DE-BFGS	22(28)	4.9(2)	**3.8**(2)	**2.1**(0.7)	**1.9**(0.6)	**1.7**(0.5)	15/15
DE-ROLL	23(23)	33(66)	95(135)	207(150)	295(171)	1536(1712)	9/15
DE-SIMPLEX	37(21)	**4.1**(2)	**3.4**(2)	**1.9**(0.8)	**1.8**(0.7)	**1.7**(0.6)	15/15
DEctpb	38(27)	8.6(6)	15(8)	12(5)	14(5)	16(4)	15/15
IPOPsaACM	**19**(20)	6.4(7)	7.8(6)	4.6(3)	4.2(2)	3.8(2)	15/15
JADEb	26(27)	5.6(8)	8.3(11)	6.2(5)	6.3(4)	6.4(3)	15/15
JADEctpb	31(21)	**4.0**(2)	6.3(3)	5.7(2)	6.8(2)	7.3(1)	15/15
MVDE	30(41)	11(8)	22(13)	28(14)	37(15)	44(16)	15/15
NBIPOPaCMA	25(25)	7.2(7)	9.0(7)	6.6(3)	6.4(3)	6.1(3)	15/15
NIPOPaCMA	27(14)	6.7(11)	8.8(8)	5.9(3)	5.9(3)	5.8(3)	15/15
PSO-BFGS	42(30)	**4.3**(2)	**3.6**(1)	**2.0**(0.4)	**1.8**(0.3)	**1.6**(0.3)	15/15
SNES	**16**(15)	14(18)	175(126)	445(430)	735(787)	1047(1004)	13/15
xNES	**18**(16)	10(14)	16(17)	16(21)	15(23)	14(20)	15/15
xNESas	27(31)	4.7(5)	14(20)	12(17)	11(15)	10(13)	15/15

Table 11: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f10	30	46	54	68	82	98	15/15
ACOR	79(126)	140(185)	282(346)	554(395)	761(519)	875(633)	15/15
BIPOPaCMA	7.0(6)	6.6(3)	6.6(2)	6.0(1)	5.7(1)	5.4(0.9)	15/15
BIPOPsaACM	3.6(1)	**2.6**(0.7)	**2.4**(0.6)	**2.3**(0.5)	**2.2**(0.3)	**2.0**(0.3)	15/15
CMA	8.8(7)	8.2(3)	7.9(2)	7.2(1)	6.8(1)	6.3(1)	15/15
CMAES	10(6)	8.1(3)	7.6(2)	7.3(2)	6.9(1)	6.5(1)	15/15
CMAa	5.9(5)	5.8(3)	6.2(2)	5.9(1)	5.6(1)	5.4(0.8)	15/15
CMAm	7.1(6)	7.3(4)	8.3(2)	7.6(1)	7.1(1)	6.4(0.9)	15/15
CMAma	6.4(4)	6.2(3)	6.3(1)	5.7(1)	5.5(0.9)	5.0(1)	15/15
CMAmah	10(8)	10(2)	9.1(2)	8.2(2)	7.4(1)	6.7(1)	15/15
CMAmh	13(10)	11(7)	12(1)	10(2)	9.3(1)	8.5(1.0)	15/15
DBRCGA	7.8(3)	17(16)	23(32)	28(25)	27(21)	28(18)	15/15
DE	11(9)	11(6)	12(4)	15(6)	16(5)	17(4)	15/15
DE-AUTO	**2.3**(0.1)	**1.6**(0.1)	**1.4**(0.1)	**1.2**(0.2)	**1.1**(0.1)	**1.9**(0.2)	15/15
DE-BFGS	**2.3**(0.3)	**1.6**(0.2)	**1.4**(0.2)	**1.2**(0.3)	**1.1**(0.3)	**1.1**(0.4)	15/15
DE-ROLL	29(34)	83(102)	235(150)	341(207)	440(136)	1265(666)	5/15
DE-SIMPLEX	**2.8**(0.7)	**2.1**(0.4)	**1.9**(0.4)	**1.7**(0.2)	**1.7**(0.2)	**1.5**(0.1)	15/15
DEctpb	11(8)	11(4)	12(3)	13(3)	15(3)	16(2)	15/15
IPOPsaACM	3.3(1)	**2.6**(1)	**2.9**(1)	**2.7**(0.9)	**2.5**(0.7)	**2.4**(0.6)	15/15
JADEb	5.8(3)	6.8(6)	7.5(5)	8.0(4)	7.9(3)	7.4(3)	15/15
JADEctpb	4.9(3)	5.4(3)	5.7(2)	6.7(2)	7.2(1)	7.4(1)	15/15
MVDE	21(18)	27(13)	33(13)	44(5)	53(9)	56(8)	15/15
NBIPOPaCMA	6.4(5)	5.6(4)	5.7(2)	5.5(1)	5.4(0.9)	5.3(1.0)	15/15
NIPOPaCMA	7.7(6)	7.0(3)	7.0(2)	6.4(0.8)	6.2(1)	5.8(0.8)	15/15
PSO-BFGS	**2.4**(0.4)	**1.6**(0.2)	**1.4**(0.2)	**1.2**(0.3)	**1.1**(0.3)	**1.2**(0.6)	15/15
SNES	275(68)	365(243)	1554(1472)	1.4e4(1e4)	∞	∞ *2e5*	0/15
xNES	5.8(3)	5.7(2)	5.6(2)	6.1(1)	5.9(1)	5.8(0.9)	15/15
xNESas	3.5(2)	4.8(2)	5.0(1)	5.7(4)	8.3(3)	7.7(3)	15/15

Table 12: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f11	35	45	50	67	81	97	15/15
ACOR	82(102)	196(216)	317(296)	600(472)	806(445)	882(502)	15/15
BIPOPaCMA	6.6(4)	6.5(3)	7.2(1)	6.3(1.0)	5.9(0.8)	5.5(0.8)	15/15
BIPOPsaACM	**2.6**(0.8)	**2.5**(0.5)	**2.5**(0.3)	**2.2**(0.3)	**2.0**(0.2)	**1.9**(0.2)	15/15
CMA	7.2(6)	9.2(3)	9.1(2)	7.7(1)	7.1(1)	6.4(1)	15/15
CMAES	6.7(6)	7.8(3)	8.3(2)	7.4(1)	6.9(0.6)	6.5(0.7)	15/15
CMAa	4.3(3)	5.9(3)	6.8(0.9)	6.1(0.8)	5.9(0.8)	5.6(0.6)	15/15
CMAm	7.2(6)	8.6(5)	8.8(2)	7.6(2)	6.8(1)	6.3(1)	15/15
CMAma	4.5(4)	6.7(3)	6.8(2)	5.8(1)	5.4(1)	5.1(0.9)	15/15
CMAmah	8.2(6)	9.3(5)	10(2)	8.5(1)	7.6(1)	6.9(0.9)	15/15
CMAmh	7.1(8)	8.8(7)	12(2)	11(1)	9.4(0.8)	8.4(0.7)	15/15
DBRCGA	7.9(4)	10(11)	13(11)	15(8)	17(8)	20(9)	15/15
DE	7.1(3)	9.4(4)	11(4)	13(7)	15(6)	15(4)	15/15
DE-AUTO	**2.0**(0.2)	**1.6**(0.2)	**1.5**(0.2)	**1.2**(0.1)	**1.1**(0.1)	**1.4**(0.2)	15/15
DE-BFGS	**1.9**(0.2)	**1.5**(0.1)	**1.4**(0.1)	**1.1**(0.1)	**1.0**(0.1)	**0.92**(0.1)	15/15
DE-ROLL	193(317)	207(316)	310(264)	414(253)	482(311)	1584(1643)	7/15
DE-SIMPLEX	**2.4**(0.6)	**2.2**(0.5)	**2.1**(0.3)	**1.8**(0.2)	**1.7**(0.2)	**1.6**(0.1)	15/15
DEctpb	8.5(4)	9.5(3)	12(4)	13(2)	15(2)	15(2)	15/15
IPOPsaACM	**2.8**(1)	**2.9**(0.8)	**2.9**(0.9)	**2.5**(0.6)	**2.2**(0.5)	**2.2**(0.5)	15/15
JADEb	4.6(4)	7.2(6)	7.8(6)	7.4(5)	7.5(4)	7.5(3)	15/15
JADEctpb	4.3(2)	5.4(2)	6.1(1)	6.5(1)	7.0(1)	6.9(1)	15/15
MVDE	16(12)	28(15)	34(12)	41(7)	49(9)	53(10)	15/15
NBIPOPaCMA	5.7(5)	6.7(4)	7.1(2)	6.3(1)	5.9(1)	5.4(1)	15/15
NIPOPaCMA	5.2(4)	6.8(3)	6.7(3)	6.2(2)	5.8(1)	5.4(1)	15/15
PSO-BFGS	**1.9**(0.2)	**1.6**(0.1)	**1.5**(0.1)	**1.2**(0.1)	**1.1**(0.1)	**1.0**(0.1)	15/15
SNES	28(29)	808(1635)	1470(1816)	5275(5526)	1.7e4(2e4)	2.9e4(4e4)	1/15
xNES	4.7(4)	6.3(5)	7.1(4)	6.5(3)	6.5(3)	6.3(2)	15/15
xNESas	6.6(7)	6.9(6)	7.5(5)	7.4(3)	7.3(3)	6.9(3)	15/15

Table 13: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f12	35	46	75	105	153	195	15/15
ACOR	12(4)	47(84)	54(106)	140(256)	177(312)	184(277)	15/15
BIPOPaCMA	4.7(4)	6.7(5)	6.9(5)	7.2(7)	6.4(7)	6.0(6)	15/15
BIPOPsaACM	**3.1**(1)	**3.2**(2)	6.2(1)	6.2(7)	5.1(5)	4.3(4)	15/15
CMA	9.0(9)	15(16)	15(16)	14(16)	11(13)	10(12)	15/15
CMAES	7.1(4)	6.9(3)	5.4(3)	5.6(1)	4.9(1.0)	4.6(1)	15/15
CMAa	4.9(4)	12(19)	11(18)	11(15)	10(12)	8.5(11)	15/15
CMAm	4.8(5)	7.1(4)	7.8(4)	7.5(5)	7.3(7)	6.9(7)	15/15
CMAma	7.6(8)	12(18)	10(14)	9.3(12)	7.6(9)	6.8(8)	15/15
CMAmah	13(15)	21(23)	17(19)	15(17)	12(14)	11(13)	15/15
CMAmh	10(8)	11(7)	8.8(4)	8.6(2)	7.7(5)	7.2(7)	15/15
DBRCGA	5.6(3)	30(11)	33(28)	41(44)	41(57)	39(54)	15/15
DE	10(8)	18(28)	19(30)	21(32)	19(25)	18(21)	15/15
DE-AUTO	**1.7**(0.7)	**1.6**(0.3)	**1.2**(0.3)	**1.1**(0.7)	**1.1**(0.9)	**1.0**(1.0)	15/15
DE-BFGS	**1.9**(0.4)	**1.8**(0.3)	**1.4**(0.8)	**1.3**(0.9)	**1.1**(0.8)	**1.0**(0.7)	15/15
DE-ROLL	16(31)	47(65)	48(65)	68(80)	110(124)	311(504)	12/15
DE-SIMPLEX	**2.4**(0.6)	**3.0**(2)	**2.6**(3)	**2.5**(3)	**2.1**(2)	**1.9**(2)	15/15
DEctpb	16(5)	24(7)	22(13)	25(17)	23(18)	23(16)	15/15
IPOPsaACM	5.1(4)	6.1(6)	4.7(5)	4.2(4)	3.4(3)	3.2(3)	15/15
JADEb	12(21)	19(37)	19(34)	20(30)	16(23)	15(19)	15/15
JADEctpb	5.2(3)	5.9(2)	5.0(2)	7.5(5)	7.9(5)	7.6(6)	15/15
MVDE	17(12)	29(18)	25(18)	713(21)	506(38)	409(55)	14/15
NBIPOPaCMA	5.8(4)	7.7(3)	5.6(2)	5.0(1)	4.1(1)	3.6(0.9)	15/15
NIPOPaCMA	9.3(5)	13(20)	11(20)	10(15)	8.6(11)	7.7(8)	15/15
PSO-BFGS	3.1(3)	4.0(5)	**3.4**(4)	**2.9**(4)	**2.4**(3)	**2.1**(3)	15/15
SNES	22(29)	128(135)	503(1041)	2206(2916)	2633(3284)	2065(2575)	5/15
xNES	5.8(5)	17(28)	24(75)	29(76)	24(56)	22(46)	15/15
xNESas	3.7(2)	9.2(12)	14(17)	19(41)	21(44)	27(51)	15/15

Table 14: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f13	23	35	46	71	95	122	15/15
ACOR	4.9(5)	16(15)	53(52)	278(267)	1.4e4(2e4)	3.3e5(4e5)	1/15
BIPOPaCMA	4.6(3)	4.9(3)	5.1(2)	5.8(2)	5.7(1)	5.5(0.9)	15/15
BIPOPsaACM	**2.4**(2)	**2.8**(1.0)	**2.9**(1)	**2.8**(1.0)	**2.7**(0.9)	**2.7**(0.7)	15/15
CMA	5.3(5)	6.1(3)	5.9(2)	6.6(2)	7.1(1)	6.7(1)	15/15
CMAES	3.9(4)	7.1(5)	7.3(3)	7.3(2)	7.7(2)	7.5(1)	15/15
CMAa	4.5(3)	5.1(3)	5.7(2)	5.6(1)	5.5(0.6)	5.4(0.7)	15/15
CMAm	7.2(6)	9.0(4)	9.1(5)	8.3(2)	8.0(2)	7.9(1)	15/15
CMAma	4.6(5)	5.0(4)	6.5(3)	6.4(2)	6.1(1)	5.9(1)	15/15
CMAmah	7.9(10)	10(6)	10(4)	9.3(3)	9.0(2)	8.4(2)	15/15
CMAmh	6.6(9)	9.2(8)	10(7)	11(7)	12(6)	13(5)	15/15
DBRCGA	4.1(2)	6.5(2)	9.4(2)	14(7)	25(24)	42(34)	15/15
DE	5.9(3)	7.4(3)	9.3(3)	20(24)	20(18)	23(16)	15/15
DE-AUTO	**2.7**(1)	**2.2**(0.2)	**1.8**(0.1)	**1.3**(0.1)	**1.1**(0.1)	**1.6**(2)	15/15
DE-BFGS	**2.8**(0.3)	**2.0**(0.2)	**1.7**(0.2)	**1.3**(0.2)	**1.1**(0.1)	**1.4**(1)	15/15
DE-ROLL	10(11)	30(31)	43(29)	54(24)	57(18)	175(116)	14/15
DE-SIMPLEX	**2.2**(1)	**2.3**(0.6)	**2.1**(0.5)	**1.7**(0.3)	**1.5**(0.3)	**1.4**(0.2)	15/15
DEctpb	4.4(5)	8.5(3)	11(2)	14(2)	15(3)	15(3)	15/15
IPOPsaACM	**2.9**(1)	**2.9**(0.9)	3.3(1)	**2.8**(0.9)	**2.7**(0.5)	**2.5**(0.6)	15/15
JADEb	3.7(2)	4.8(4)	5.3(4)	6.3(3)	8.3(6)	9.1(6)	15/15
JADEctpb	**2.7**(1)	4.2(2)	5.2(2)	6.5(0.9)	7.0(1.0)	6.8(0.7)	15/15
MVDE	7.9(6)	19(6)	26(13)	43(9)	49(13)	55(9)	15/15
NBIPOPaCMA	3.8(2)	4.5(2)	4.6(2)	5.7(1)	5.7(1)	5.4(0.9)	15/15
NIPOPaCMA	3.9(5)	5.4(3)	5.8(3)	5.4(1)	5.8(1.0)	5.6(0.7)	15/15
PSO-BFGS	3.0(0.2)	**2.2**(0.3)	**1.9**(0.3)	**1.4**(0.2)	**1.2**(0.3)	**1.3**(0.6)	15/15
SNES	21(46)	71(196)	320(456)	1602(1271)	5289(5788)	2.4e4(2e4)	0/15
xNES	7.6(4)	7.4(8)	7.3(5)	7.1(3)	6.9(4)	6.6(3)	15/15
xNESas	3.5(2)	4.6(2)	5.6(4)	6.8(5)	7.1(4)	8.5(3)	15/15

Table 15: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f14	1.4	7.4	16	38	67	90	15/15
ACOR	**0.95**(0.4)	**2.6**(3)	6.9(2)	10(2)	49(50)	868(885)	15/15
BIPOPaCMA	**2.6**(5)	**2.2**(2)	3.1(2)	4.3(2)	5.3(0.9)	5.6(1)	15/15
BIPOPsaACM	**2.1**(3)	**2.8**(3)	3.1(2)	3.5(0.8)	**2.7**(0.7)	**3.0**(0.9)	15/15
CMA	**2.3**(5)	3.6(3)	3.6(2)	4.9(2)	6.3(2)	6.7(1)	15/15
CMAES	**2.1**(2)	**2.5**(3)	3.5(2)	4.7(2)	6.4(2)	7.5(1)	15/15
CMAa	3.1(2)	3.5(2)	4.0(2)	4.8(2)	5.4(1)	5.7(2)	15/15
CMAm	**2.5**(2)	**2.9**(4)	3.2(2)	4.1(2)	5.9(2)	7.2(1)	15/15
CMAma	**2.1**(3)	3.2(2)	4.2(2)	5.5(2)	5.5(1)	6.1(0.8)	15/15
CMAmah	**2.0**(2)	**1.7**(2)	**2.3**(0.9)	4.2(2)	6.4(1)	8.0(0.8)	15/15
CMAmh	**2.0**(2)	**2.4**(2)	**2.7**(1)	5.8(3)	8.9(3)	10(4)	15/15
DBRCGA	**1.2**(0.4)	**3.0**(3)	6.7(5)	8.8(2)	12(6)	21(15)	15/15
DE	**1.5**(1)	**2.9**(3)	5.0(4)	9.1(2)	10(4)	12(3)	15/15
DE-AUTO	**1.7**(1)	3.7(4)	3.4(1)	**2.0**(0.3)	**1.4**(0.2)	6.1(5)	15/15
DE-BFGS	**2.3**(2)	**2.9**(2)	3.7(0.3)	**2.0**(0.2)	**1.4**(0.1)	**2.7**(3)	15/15
DE-ROLL	**1.3**(1)	**2.7**(2)	5.2(2)	59(79)	147(97)	445(669)	14/15
DE-SIMPLEX	**1.1**(0.7)	3.8(3)	3.7(0.3)	**2.3**(0.3)	**1.7**(0.3)	**1.5**(0.2)	15/15
DEctpb	**1.9**(1)	4.0(3)	7.3(4)	9.1(3)	11(3)	12(3)	15/15
IPOPsaACM	5.0(7)	4.7(4)	3.5(2)	3.8(1)	3.1(0.9)	**3.0**(0.7)	15/15
JADEb	**2.5**(2)	4.3(4)	3.8(1)	5.0(2)	5.1(1)	6.0(3)	15/15
JADEctpb	**2.0**(2)	**2.2**(2)	4.1(2)	5.6(2)	6.2(2)	6.7(2)	15/15
MVDE	**1.6**(1)	4.9(4)	13(5)	21(6)	31(7)	41(12)	15/15
NBIPOPaCMA	3.0(3)	**2.3**(2)	3.3(3)	4.5(2)	5.6(0.9)	6.1(1.0)	15/15
NIPOPaCMA	**2.6**(3)	**2.9**(3)	3.1(3)	4.7(2)	5.0(0.9)	5.6(1)	15/15
PSO-BFGS	**1.8**(1)	4.6(4)	4.0(0.4)	**2.2**(0.2)	**1.5**(0.1)	13(1)	15/15
SNES	4.1(6)	3.3(4)	**2.9**(2)	19(25)	1962(1526)	7540(6895)	1/15
xNES	3.8(6)	3.3(2)	3.7(2)	5.8(3)	5.8(2)	6.2(2)	15/15
xNESas	**1.3**(1)	**2.3**(4)	**2.6**(2)	4.6(1)	5.1(1)	5.3(2)	15/15

Table 16: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f15	37	291	1033	1113	1231	1412	15/15
ACOR	**2.1**(2)	**2.3**(1)	11(26)	11(24)	10(22)	9.0(19)	15/15
BIPOPaCMA	**1.3**(1)	**1.8**(2)	**2.7**(2)	**2.6**(2)	**2.5**(2)	**2.2**(2)	15/15
BIPOPsaACM	**2.4**(5)	**2.0**(1)	**2.8**(3)	**2.7**(3)	**2.5**(2)	**2.2**(2)	15/15
CMA	**0.93**(0.7)	**2.5**(4)	**2.9**(1)	**2.9**(1)	**2.8**(1)	**2.5**(1)	15/15
CMAES	**1.1**(1.0)	**2.6**(3)	3.8(4)	3.6(4)	3.3(4)	**2.9**(3)	15/15
CMAa	**1.4**(0.8)	**2.0**(2)	**2.0**(3)	**2.0**(3)	**1.9**(3)	**1.7**(2)	15/15
CMAm	**1.2**(1.0)	**1.8**(1)	**1.9**(2)	**2.4**(2)	**2.3**(2)	**2.1**(2)	15/15
CMAma	**1.3**(1.0)	3.1(4)	**2.4**(2)	**2.6**(2)	**2.5**(2)	**2.2**(2)	15/15
CMAmah	**1.2**(1)	**2.9**(4)	**2.7**(2)	**2.7**(2)	**2.6**(2)	**2.4**(2)	15/15
CMAmh	**2.6**(7)	3.8(4)	**2.6**(2)	**2.7**(2)	**2.6**(2)	**2.4**(2)	15/15
DBRCGA	**1.8**(2)	**2.4**(3)	**1.8**(2)	**1.8**(2)	**1.8**(2)	**1.6**(1)	15/15
DE	**2.5**(2)	**1.9**(1)	**1.8**(3)	**1.9**(3)	**1.8**(2)	**1.7**(2)	15/15
DE-AUTO	7.4(12)	10(9)	6.9(6)	6.4(6)	5.8(5)	5.1(4)	15/15
DE-BFGS	**1.4**(0.7)	**0.71**(0.7)	**0.46**(0.4)	**0.44**(0.4)	**0.41**(0.4)	**0.36**(0.3)$_{\downarrow}$	15/15
DE-ROLL	3.4(1.0)	4.5(7)	7.3(6)	6.9(6)	6.3(5)	5.6(5)	15/15
DE-SIMPLEX	**2.7**(5)	**1.7**(1)	**2.8**(4)	**2.6**(3)	**2.4**(3)	**2.1**(3)	15/15
DEctpb	**2.3**(2)	**2.6**(1)	**1.2**(0.7)	**1.6**(0.4)	**1.7**(0.7)	**1.7**(0.5)	15/15
IPOPsaACM	**1.3**(1)	**2.6**(3)	**1.4**(1)	**1.8**(2)	**1.7**(2)	**1.5**(2)	15/15
JADEb	**1.3**(0.9)	3.4(4)	3.4(3)	3.3(3)	3.0(3)	**2.7**(2)	15/15
JADEctpb	**1.1**(0.7)	**1.4**(0.5)	**0.95**(0.8)	**1.1**(0.8)	**1.1**(0.7)	**1.1**(0.6)	15/15
MVDE	**2.7**(2)	4.9(2)	244(484)	227(450)	206(407)	180(355)	12/15
NBIPOPaCMA	**1.4**(0.9)	**2.6**(4)	**2.8**(4)	3.0(4)	**2.8**(3)	**2.6**(3)	15/15
NIPOPaCMA	**1.7**(1)	3.7(3)	**2.8**(3)	**2.9**(3)	**2.7**(3)	**2.5**(3)	15/15
PSO-BFGS	**2.0**(1)	**2.8**(2)	**2.0**(2)	**1.9**(2)	**1.7**(1)	**1.5**(1)	15/15
SNES	**1.5**(2)	5.9(7)	10(13)	10(12)	8.9(11)	7.8(9)	15/15
xNES	13(28)	9.5(10)	15(17)	17(20)	15(18)	13(16)	15/15
xNESas	**0.81**(0.7)	4.0(4)	4.4(4)	4.4(4)	4.0(3)	3.6(3)	15/15

Table 17: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f16	9.1	50	174	358	409	538	15/15
ACOR	**2.7**(4)	4.6(4)	5.1(5)	36(29)	43(26)	33(20)	15/15
BIPOPaCMA	**1.4**(2)	**2.6**(0.9)	**2.8**(3)	**2.8**(2)	**2.7**(2)	**2.2**(1)	15/15
BIPOPsaACM	3.2(2)	4.4(7)	5.1(3)	4.4(5)	4.7(4)	3.8(3)	15/15
CMA	5.1(8)	8.5(13)	4.2(4)	3.5(3)	3.3(3)	**2.6**(2)	15/15
CMAES	4.6(7)	7.4(11)	**3.6**(6)	**2.6**(3)	**2.4**(2)	**1.9**(2)	15/15
CMAa	4.6(4)	11(13)	6.3(8)	3.8(4)	4.0(4)	3.2(3)	15/15
CMAm	**2.4**(2)	5.8(9)	4.5(7)	3.4(4)	3.5(3)	**2.8**(3)	15/15
CMAma	8.8(9)	10(10)	4.4(3)	4.2(3)	4.1(3)	3.3(2)	15/15
CMAmah	3.9(4)	6.5(11)	5.6(8)	11(6)	10(5)	8.2(4)	15/15
CMAmh	10(4)	13(11)	6.9(6)	4.6(4)	4.6(4)	3.7(3)	15/15
DBRCGA	**2.3**(3)	**2.4**(3)	5.4(7)	6.2(6)	8.4(9)	6.7(7)	15/15
DE	4.0(4)	4.8(4)	5.4(7)	3.5(4)	3.5(3)	3.4(3)	15/15
DE-AUTO	3.2(3)	33(53)	31(39)	25(32)	38(33)	34(63)	15/15
DE-BFGS	**2.6**(1)	6.1(10)	4.5(4)	5.4(2)	6.5(1)	14(8)	14/15
DE-ROLL	3.2(3)	26(35)	32(45)	41(39)	47(49)	115(194)	12/15
DE-SIMPLEX	**1.3**(1)	5.4(7)	**2.8**(4)	**2.1**(2)	**2.2**(2)	**1.8**(2)	15/15
DEctpb	3.4(3)	3.8(3)	5.1(3)	13(8)	19(7)	16(6)	15/15
IPOPsaACM	3.8(6)	6.6(8)	4.3(4)	**3.0**(3)	3.1(2)	**2.9**(2)	15/15
JADEb	**2.1**(3)	4.3(4)	**2.7**(5)	**2.0**(2)	**2.0**(2)	**1.7**(2)	15/15
JADEctpb	**2.8**(2)	**3.8**(3)	3.8(2)	**2.8**(2)	3.2(2)	**2.8**(1)	15/15
MVDE	**2.4**(2)	**2.4**(2)	6.1(6)	207(4)	183(4)	141(3)	14/15
NBIPOPaCMA	3.3(3)	6.8(11)	4.0(6)	3.5(4)	3.3(4)	**2.6**(3)	15/15
NIPOPaCMA	3.3(4)	6.2(8)	4.0(5)	**2.5**(3)	**2.4**(3)	**2.0**(2)	15/15
PSO-BFGS	5.2(7)	9.4(12)	7.7(8)	14(13)	22(29)	106(131)	12/15
SNES	**1.8**(2)	5.1(5)	4.7(7)	6.7(8)	12(19)	12(20)	14/15
xNES	3.4(4)	13(23)	6.5(12)	5.4(6)	5.0(5)	3.9(4)	15/15
xNESas	3.1(4)	5.4(11)	3.8(4)	3.7(4)	4.4(6)	4.6(5)	15/15

Table 18: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f17	2.7	61	133	396	1086	1657	15/15
ACOR	**1.4**(1)	**0.94**(0.8)	**2.1**(0.7)	**1.8**(0.3)	**1.1**(0.2)	**0.98**(0.2)	15/15
BIPOPaCMA	19(14)	3.4(5)	**2.8**(3)	**1.6**(1)	**1.6**(1)	**1.4**(0.8)	15/15
BIPOPsaACM	3.2(4)	**1.2**(0.7)	**2.1**(2)	**2.2**(1)	**2.4**(1)	**1.7**(1)	15/15
CMA	3.4(3)	**1.8**(1)	**1.9**(3)	**2.1**(1)	**1.6**(1)	**1.3**(0.6)	15/15
CMAES	**2.4**(2)	**1.5**(1)	**2.3**(3)	**2.0**(4)	**2.9**(3)	**2.7**(3)	15/15
CMAa	**2.0**(3)	**0.78**(0.6)	**1.7**(2)	**1.7**(1)	**1.4**(0.6)	**1.1**(0.5)	15/15
CMAm	4.3(5)	**1.4**(1)	**3.0**(3)	**1.7**(1)	**1.3**(0.9)	**0.99**(0.7)	15/15
CMAma	**1.9**(2)	**1.3**(0.6)	**1.6**(2)	**1.3**(0.9)	**1.1**(0.9)	**0.82**(0.7)	15/15
CMAmah	**2.1**(2)	3.9(5)	**2.8**(4)	**2.0**(2)	**1.7**(1)	**1.3**(0.8)	15/15
CMAmh	3.6(3)	5.2(9)	3.1(4)	**2.3**(2)	**1.8**(1)	**1.6**(0.8)	15/15
DBRCGA	**1.7**(2)	**2.1**(1)	**2.6**(1)	3.2(4)	5.0(7)	3.5(4)	15/15
DE	3.0(4)	**1.5**(1)	3.1(0.9)	**2.5**(0.5)	**2.1**(2)	**1.6**(1)	15/15
DE-AUTO	**1.4**(1)	7.0(9)	9.0(11)	10(12)	7.6(5)	5.0(3)	15/15
DE-BFGS	**2.0**(2)	**2.2**(2)	3.9(2)	4.1(0.8)	**2.5**(0.5)	4.1(3)	15/15
DE-ROLL	**2.3**(2)	3.7(5)	6.2(4)	5.4(3)	4.4(1)	3.0(1)	15/15
DE-SIMPLEX	**1.8**(2)	6.5(6)	6.7(5)	3.9(3)	**2.1**(1)	337(423)	3/15
DEctpb	**1.8**(2)	**2.1**(1)	**2.6**(1.0)	**2.3**(0.6)	**1.6**(0.4)	**1.4**(0.4)	15/15
IPOPsaACM	4.2(8)	**1.5**(0.7)	**2.0**(2)	**2.1**(1)	**2.0**(0.9)	**1.7**(1)	15/15
JADEb	**1.7**(2)	**1.0**(0.7)	**1.0**(0.3)	19(1)	8.7(2)	5.8(2)	14/15
JADEctpb	**2.7**(2)	**1.2**(0.6)	**1.5**(0.5)	**1.3**(0.2)	**1.2**(0.8)	**0.95**(0.6)	15/15
MVDE	**1.5**(0.9)	**2.1**(2)	5.4(2)	5.7(1)	69(1.0)	47(0.9)	14/15
NBIPOPaCMA	4.2(4)	**1.7**(0.5)	**1.4**(0.4)	**1.2**(1)	**1.4**(1)	**1.1**(0.8)	15/15
NIPOPaCMA	**1.9**(2)	**1.7**(0.8)	**1.4**(0.5)	**1.4**(1)	**1.2**(0.6)	**1.1**(0.9)	15/15
PSO-BFGS	**1.7**(1)	10(8)	12(7)	9.0(3)	5.8(1)	16(18)	12/15
SNES	7.3(15)	3.6(2)	3.4(7)	**2.5**(3)	5.9(10)	6.4(8)	15/15
xNES	12(31)	8.0(17)	6.2(8)	6.7(8)	15(23)	13(14)	15/15
xNESas	4.2(6)	7.9(17)	4.3(8)	12(20)	26(17)	25(22)	15/15

Table 19: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f18	19	134	666	1708	2438	2858	15/15
ACOR	**1.6**(2)	**2.6**(2)	**1.5**(1)	**1.9**(1)	**2.4**(1)	**3.0**(2)	15/15
BIPOPaCMA	**2.1**(2)	4.4(6)	**2.2**(3)	**1.3**(0.8)	**1.1**(0.6)	**1.2**(1)	15/15
BIPOPsaACM	3.3(2)	**1.8**(2)	**0.84**(0.7)	**0.71**(0.7)	**1.4**(1)	**1.7**(2)	15/15
CMA	**1.4**(2)	3.8(4)	**1.6**(1)	**0.84**(0.6)	**0.91**(0.4)	**0.91**(0.4)	15/15
CMAES	**1.5**(1)	5.1(7)	**2.0**(2)	**1.5**(1)	9.1(12)	10(10)	14/15
CMAa	**1.3**(1)	**2.7**(3)	**1.4**(1)	**0.93**(0.6)	**0.92**(0.4)	**0.91**(0.3)	15/15
CMAm	3.2(1)	6.4(7)	**2.1**(1)	**1.3**(0.5)	**1.4**(0.9)	**1.3**(0.8)	15/15
CMAma	3.3(1)	5.3(7)	**1.6**(1)	**0.98**(0.5)	**1.0**(0.4)	**1.00**(0.4)	15/15
CMAmah	**1.3**(1)	5.3(5)	**1.9**(2)	**1.4**(0.4)	**1.2**(0.4)	**1.1**(0.3)	15/15
CMAmh	**1.2**(1)	7.7(8)	**2.6**(2)	**1.6**(0.6)	**1.3**(0.3)	**1.2**(0.3)	15/15
DBRCGA	**1.5**(2)	**1.8**(1)	**1.7**(2)	7.7(18)	18(20)	16(17)	15/15
DE	3.1(3)	3.1(2)	**1.4**(1)	**2.3**(2)	3.8(4)	3.5(4)	15/15
DE-AUTO	**1.8**(1)	12(23)	6.6(8)	5.6(4)	5.7(2)	4.9(2)	15/15
DE-BFGS	**2.5**(5)	5.8(4)	**1.9**(0.7)	**1.6**(0.5)	**1.8**(0.4)	8.6(11)	4/15
DE-ROLL	**2.3**(1)	4.6(5)	**2.7**(2)	**2.9**(1)	5.1(2)	24(36)	11/15
DE-SIMPLEX	3.2(5)	9.2(7)	**2.9**(1)	**1.9**(0.7)	**1.8**(0.8)	103(108)	1/15
DEctpb	**1.9**(2)	**1.7**(1.0)	**0.93**(0.2)	**0.85**(0.2)	**1.1**(0.2)	**1.2**(0.6)	15/15
IPOPsaACM	**2.0**(2)	**3.0**(3)	**1.4**(1)	**0.83**(0.6)	**1.1**(0.6)	**1.4**(1)	15/15
JADEb	**1.5**(1)	**1.4**(0.7)	11(0.7)	5.0(0.9)	18(23)	15(20)	11/15
JADEctpb	**2.1**(1)	**1.5**(0.4)	**0.63**(0.3)	**0.47**(0.1)	**0.68**(0.5)	**0.69**(0.4)	15/15
MVDE	3.3(3)	3.7(3)	**2.1**(0.6)	44(0.9)	32(1)	28(0.8)	14/15
NBIPOPaCMA	4.9(3)	4.6(3)	**2.6**(2)	**1.4**(1)	**1.3**(0.8)	**1.3**(0.7)	15/15
NIPOPaCMA	**1.8**(1)	**2.6**(3)	**0.72**(0.6)	**0.88**(0.7)	**0.84**(0.4)	**0.82**(0.3)	15/15
PSO-BFGS	6.8(11)	11(12)	4.5(3)	3.8(2)	5.0(1)	24(19)	2/15
SNES	**1.5**(2)	11(15)	18(24)	81(114)	181(216)	156(182)	5/15
xNES	**1.7**(1)	13(16)	4.9(4)	3.9(4)	12(13)	18(17)	14/15
xNESas	28(82)	13(15)	5.3(6)	7.0(5)	12(12)	17(14)	14/15

Table 20: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f19	1	1	26	227	252	276	15/15
ACOR	3.6(4)	38(28)	6.9(9)	72(246)	70(229)	68(210)	15/15
BIPOPaCMA	5.3(6)	**21**(23)	7.5(6)	21(22)	21(20)	20(19)	15/15
BIPOPsaACM	5.0(4)	**24**(16)	11(17)	16(22)	23(24)	22(22)	15/15
CMA	5.4(6)	58(41)	**5.1**(6)	12(13)	**11**(12)	**11**(12)	15/15
CMAES	5.6(6)	198(508)	25(22)	22(21)	20(19)	19(17)	15/15
CMAa	10(11)	42(31)	11(8)	**10**(15)	**11**(13)	**11**(12)	15/15
CMAm	4.5(4)	77(44)	14(21)	**12**(12)	15(14)	**14**(14)	15/15
CMAma	4.5(6)	137(380)	15(24)	25(35)	24(33)	24(30)	15/15
CMAmah	**3.5**(2)	48(46)	8.2(16)	22(28)	30(26)	29(24)	15/15
CMAmh	7.1(6)	78(48)	17(21)	**9.0**(11)	**8.5**(10)	**8.1**(9)	15/15
DBRCGA	3.9(2)	33(33)	**6.2**(5)	15(18)	15(17)	15(16)	15/15
DE	**3.4**(2)	55(38)	10(8)	120(224)	109(202)	100(185)	12/15
DE-AUTO	**3.3**(2)	86(34)	53(57)	81(102)	76(92)	70(74)	15/15
DE-BFGS	4.3(4)	61(80)	11(9)	24(50)	21(45)	31(41)	15/15
DE-ROLL	**2.9**(2)	76(127)	12(9)	65(117)	66(104)	160(174)	11/15
DE-SIMPLEX	4.3(4)	77(104)	17(18)	41(126)	37(114)	34(104)	15/15
DEctpb	4.0(4)	73(86)	9.2(9)	75(221)	69(198)	66(182)	13/15
IPOPsaACM	4.7(7)	33(34)	7.8(4)	**10**(9)	17(13)	16(13)	15/15
JADEb	4.3(4)	**25**(30)	**5.4**(4)	116(223)	105(201)	97(183)	12/15
JADEctpb	3.6(4)	34(26)	**6.6**(5)	115(221)	104(199)	96(182)	12/15
MVDE	8.6(11)	68(70)	12(14)	3432(4406)	3093(3968)	3188(3631)	8/15
NBIPOPaCMA	5.7(5)	32(43)	25(31)	31(43)	31(39)	28(36)	15/15
NIPOPaCMA	7.0(7)	93(45)	14(22)	34(26)	36(24)	34(22)	15/15
PSO-BFGS	7.2(8)	91(76)	21(27)	13(11)	**12**(10)	27(26)	15/15
SNES	5.7(8)	**24**(20)	7.4(6)	16(36)	51(101)	168(262)	14/15
xNES	4.1(4)	31(37)	11(9)	33(32)	40(59)	37(54)	15/15
xNESas	5.9(8)	38(40)	15(17)	65(81)	69(75)	64(67)	15/15

Table 21: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f20	3.7	61	365	366	370	375	15/15
ACOR	**1.1**(2)	**3.7**(3)	57(70)	58(70)	58(69)	57(69)	15/15
BIPOPaCMA	4.0(6)	6.9(6)	7.8(8)	13(15)	13(15)	13(15)	15/15
BIPOPsaACM	3.9(3)	7.1(8)	5.3(5)	5.9(6)	5.9(6)	6.0(6)	15/15
CMA	4.4(4)	11(14)	8.2(6)	11(19)	12(21)	12(21)	15/15
CMAES	**2.5**(2)	17(19)	21(24)	23(24)	23(24)	23(23)	15/15
CMAa	**2.6**(3)	10(7)	10(11)	13(23)	14(24)	14(24)	15/15
CMAm	**2.3**(2)	19(19)	16(17)	17(18)	18(19)	19(19)	15/15
CMAma	4.2(5)	14(18)	9.3(11)	12(12)	12(12)	13(12)	15/15
CMAmah	**2.5**(3)	14(13)	9.1(6)	14(11)	14(11)	15(11)	15/15
CMAmh	**2.4**(2)	12(18)	11(11)	13(12)	13(12)	13(12)	15/15
DBRCGA	**2.3**(3)	6.8(6)	**4.8**(5)	5.2(5)	5.5(5)	5.8(5)	15/15
DE	**2.4**(3)	5.1(3)	7.3(7)	7.6(7)	8.0(7)	8.2(7)	15/15
DE-AUTO	**1.8**(1)	14(26)	42(68)	42(67)	42(67)	41(66)	15/15
DE-BFGS	3.6(2)	**5.0**(3)	12(23)	12(23)	12(22)	12(22)	15/15
DE-ROLL	**1.7**(3)	13(19)	30(77)	30(76)	30(75)	30(75)	15/15
DE-SIMPLEX	3.1(2)	5.0(6)	21(15)	21(15)	21(15)	21(15)	15/15
DEctpb	**1.6**(3)	**2.7**(2)	**2.2**(3)	**3.1**(3)	**3.6**(3)	**4.1**(3)	15/15
IPOPsaACM	**2.6**(3)	8.2(11)	6.9(8)	13(15)	13(15)	13(15)	15/15
JADEb	**2.9**(4)	7.7(9)	**3.1**(3)	**3.3**(3)	**3.5**(3)	**3.7**(3)	15/15
JADEctpb	3.1(3)	**3.8**(2)	**2.6**(4)	**3.2**(4)	**3.6**(4)	**3.8**(4)	15/15
MVDE	3.7(5)	7.3(7)	916(1372)	998(1367)	988(1351)	976(1335)	11/15
NBIPOPaCMA	**2.8**(3)	8.2(13)	5.6(6)	7.5(9)	7.6(9)	7.7(9)	15/15
NIPOPaCMA	3.2(4)	12(15)	10(9)	11(10)	13(10)	14(10)	15/15
PSO-BFGS	6.5(8)	8.7(9)	4.9(7)	**4.9**(7)	**4.9**(7)	**4.8**(7)	15/15
SNES	5.7(5)	35(50)	18(19)	29(26)	29(26)	29(25)	15/15
xNES	6.5(4)	28(34)	22(24)	22(24)	22(23)	22(23)	15/15
xNESas	3.8(3)	27(32)	21(26)	23(26)	23(26)	23(25)	15/15

Table 22: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f21	1.7	51	174	290	324	330	15/15
ACOR	**1.6**(1)	**1.1**(1)	**0.93**(0.7)	**1.4**(0.6)	**1.6**(0.4)	**1.8**(0.5)	15/15
BIPOPaCMA	**2.0**(2)	5.5(6)	8.4(11)	21(7)	22(6)	27(6)	15/15
BIPOPsaACM	**1.7**(2)	3.9(4)	5.1(6)	3.6(4)	5.1(5)	5.1(5)	15/15
CMA	**1.2**(2)	6.1(7)	7.2(7)	4.8(5)	4.7(4)	4.9(4)	15/15
CMAES	**0.96**(0.6)	10(13)	8.3(12)	5.1(7)	4.8(6)	4.7(6)	15/15
CMAa	**0.92**(0.3)	5.1(7)	3.8(8)	**2.6**(5)	**2.5**(5)	**2.6**(5)	15/15
CMAm	**2.4**(2)	7.2(7)	5.8(9)	3.9(5)	3.7(5)	3.8(5)	15/15
CMAma	**1.5**(0.9)	8.6(15)	7.9(13)	7.7(16)	10(15)	21(16)	15/15
CMAmah	**2.1**(3)	7.2(8)	6.9(9)	4.4(5)	4.2(5)	4.2(5)	15/15
CMAmh	**1.4**(0.9)	6.0(10)	3.5(4)	**2.2**(2)	**2.1**(2)	**3.0**(2)	15/15
DBRCGA	**1.6**(2)	**1.3**(2)	**0.84**(0.8)	**0.97**(0.4)	**1.2**(0.3)	**1.5**(0.4)	15/15
DE	**1.1**(0.9)	3.9(2)	4.4(6)	**3.0**(4)	3.0(3)	3.2(3)	15/15
DE-AUTO	**1.2**(0.6)	19(41)	19(19)	12(11)	11(10)	11(10)	15/15
DE-BFGS	**1.3**(0.9)	**2.3**(4)	10(11)	5.9(7)	5.4(6)	5.9(6)	15/15
DE-ROLL	**1.3**(0.9)	15(26)	24(55)	15(33)	14(30)	18(30)	15/15
DE-SIMPLEX	**1.3**(0.9)	3.9(6)	19(41)	11(24)	10(22)	10(22)	15/15
DEctpb	**1.4**(1)	4.3(6)	**2.8**(5)	**2.3**(3)	**2.4**(3)	**2.8**(3)	15/15
IPOPsaACM	**1.3**(1)	6.8(9)	5.6(8)	10(6)	10(6)	11(6)	15/15
JADEb	**1.4**(0.9)	**2.4**(2)	3.6(5)	**2.3**(3)	**2.2**(3)	**2.3**(3)	15/15
JADEctpb	**1.1**(0.6)	**1.1**(1)	4.0(8)	**2.8**(5)	**2.9**(4)	3.1(4)	15/15
MVDE	**1.4**(1)	**1.8**(2)	383(2)	248(2)	224(2)	221(3)	14/15
NBIPOPaCMA	**1.2**(0.6)	22(39)	10(11)	8.6(11)	7.8(10)	7.8(10)	15/15
NIPOPaCMA	**0.76**(0.3)	13(13)	68(34)	43(21)	39(19)	38(20)	15/15
PSO-BFGS	**1.2**(0.9)	3.3(4)	**2.6**(4)	**1.6**(2)	**1.5**(2)	16(28)	15/15
SNES	**1.1**(0.6)	44(59)	23(40)	14(24)	13(22)	13(21)	15/15
xNES	**1.4**(1)	29(43)	21(28)	14(17)	14(15)	14(15)	15/15
xNESas	**1.4**(1)	19(37)	17(37)	10(23)	9.4(20)	9.4(20)	15/15

Table 23: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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.

Δf_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f22	5.1	27	168	249	289	306	15/15
ACOR	**1.3**(1)	**2.2**(2)	42(151)	30(105)	28(90)	28(89)	15/15
BIPOPaCMA	3.2(4)	16(12)	5.3(10)	5.7(7)	5.2(6)	5.1(6)	15/15
BIPOPsaACM	5.2(2)	10(15)	5.4(8)	6.3(6)	6.8(9)	6.5(8)	15/15
CMA	**1.8**(2)	6.4(12)	6.8(12)	14(22)	62(109)	108(228)	14/15
CMAES	**1.6**(2)	8.3(12)	4.9(4)	4.9(6)	4.4(5)	4.3(5)	15/15
CMAa	**1.4**(2)	11(12)	7.5(16)	7.9(17)	8.8(16)	11(17)	14/15
CMAm	**1.7**(2)	19(45)	11(8)	8.3(6)	8.9(9)	9.0(9)	15/15
CMAma	8.3(2)	14(21)	6.7(8)	7.9(12)	12(16)	12(17)	15/15
CMAmah	6.5(1)	8.7(17)	11(14)	7.9(10)	26(31)	129(346)	14/15
CMAmh	**1.6**(1)	14(17)	10(16)	40(27)	49(81)	104(211)	15/15
DBRCGA	**0.92**(0.8)	**2.3**(3)	**0.96**(0.9)	**1.3**(0.9)	**1.4**(0.9)	**1.9**(1)	15/15
DE	**1.1**(1)	6.4(5)	4.5(7)	3.7(4)	3.6(4)	3.8(4)	15/15
DE-AUTO	**1.3**(1)	8.7(20)	15(7)	10(5)	8.6(4)	9.3(4)	15/15
DE-BFGS	**1.4**(1)	**2.2**(2)	**0.63**(0.6)	**0.58**(0.3)	**0.53**(0.3)	**1.7**(2)	15/15
DE-ROLL	**0.88**(1)	8.2(15)	15(24)	14(18)	23(26)	55(56)	15/15
DE-SIMPLEX	**1.5**(1)	**2.4**(4)	**2.8**(2)	**2.1**(1)	**1.9**(1)	**1.8**(1)	15/15
DEctpb	**1.4**(1)	3.5(3)	**2.1**(5)	**2.1**(3)	**2.5**(3)	**2.8**(3)	15/15
IPOPsaACM	**1.5**(2)	10(16)	3.0(5)	3.4(4)	6.3(4)	16(3)	15/15
JADEb	**1.1**(1)	**2.0**(2)	5.7(6)	4.3(4)	3.9(3)	3.9(3)	15/15
JADEctpb	**1.2**(0.9)	**2.0**(2)	**1.7**(3)	**1.5**(2)	**1.6**(2)	**1.9**(2)	15/15
MVDE	**1.1**(1)	3.4(3)	**2.0**(1)	3.3(3)	5.0(3)	5.8(3)	15/15
NBIPOPaCMA	**1.3**(0.7)	10(11)	11(11)	9.1(8)	8.2(7)	8.0(6)	15/15
NIPOPaCMA	**2.3**(2)	55(123)	12(20)	13(29)	12(25)	11(24)	15/15
PSO-BFGS	**1.3**(1)	**2.5**(2)	**1.1**(1)	**0.85**(0.9)	**0.80**(0.8)	17(25)	15/15
SNES	**2.5**(3)	71(95)	40(79)	105(142)	107(132)	141(172)	15/15
xNES	**1.9**(2)	71(111)	27(32)	20(22)	23(27)	21(25)	15/15
xNESas	4.4(3)	45(87)	21(27)	21(21)	18(18)	17(17)	15/15

Table 24: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f23	7.8	193	234	299	348	379	15/15
ACOR	**1.5**(2)	10(9)	1019(808)	∞	∞	∞ *1e7*	0/15
BIPOPaCMA	3.5(3)	5.6(4)	8.7(11)	7.4(9)	**6.8**(8)	**6.7**(7)	15/15
BIPOPsaACM	**2.4**(2)	7.9(12)	12(14)	10(11)	11(12)	10(11)	15/15
CMA	**1.5**(1)	4.1(4)	10(9)	8.8(7)	**8.2**(6)	**8.0**(6)	15/15
CMAES	4.0(4)	6.3(7)	14(10)	12(10)	11(8)	10(8)	15/15
CMAa	**1.5**(2)	5.5(7)	22(20)	20(15)	18(14)	17(13)	15/15
CMAm	**2.6**(2)	7.5(8)	60(23)	109(18)	94(16)	87(15)	14/15
CMAma	**2.5**(3)	5.0(6)	15(21)	12(17)	11(15)	11(14)	15/15
CMAmah	**2.5**(3)	5.9(7)	13(13)	11(10)	10(9)	10(8)	15/15
CMAmh	**2.5**(3)	5.6(6)	17(19)	14(16)	12(14)	12(13)	15/15
DBRCGA	**1.6**(2)	9.4(6)	58(68)	61(61)	53(53)	50(48)	15/15
DE	**2.9**(3)	9.5(12)	30(23)	26(18)	24(16)	24(22)	15/15
DE-AUTO	**2.1**(3)	**1.4**(1)	**3.1**(3)	**3.1**(2)	**2.9**(2)	**2.8**(1)	15/15
DE-BFGS	**1.9**(2)	**2.4**(2)	**4.0**(4)	**5.8**(5)	12(3)	348(411)	2/15
DE-ROLL	**1.6**(2)	5.2(4)	22(22)	34(25)	36(32)	265(317)	10/15
DE-SIMPLEX	**1.4**(1)	**0.84**(0.6)	**0.78**(0.5)	**0.72**(0.4)*	9.4(3)	500(623)	3/15
DEctpb	**2.2**(3)	18(23)	229(230)	1502(1534)	2019(2301)	1858(1882)	1/15
IPOPsaACM	**2.2**(3)	7.4(8)	9.0(9)	8.6(9)	**8.5**(8)	**8.0**(7)	15/15
JADEb	**2.1**(2)	4.9(5)	18(15)	23(11)	21(10)	20(9)	15/15
JADEctpb	**2.3**(2)	5.1(6)	48(79)	50(67)	43(58)	40(53)	15/15
MVDE	**0.99**(0.8)	6.3(4)	2167(4276)	6718(8353)	5794(7196)	5312(6594)	5/15
NBIPOPaCMA	**1.8**(2)	6.2(8)	12(9)	11(11)	10(9)	9.2(9)	15/15
NIPOPaCMA	**2.4**(2)	9.0(8)	16(10)	15(8)	14(7)	13(7)	15/15
PSO-BFGS	3.5(4)	**1.9**(2)	**3.3**(4)	**4.2**(4)	44(40)	∞ *2e5*	0/15
SNES	**2.1**(3)	11(12)	305(416)	460(635)	399(560)	476(543)	8/15
xNES	**1.4**(2)	18(19)	95(91)	79(69)	82(73)	79(67)	15/15
xNESas	**2.6**(4)	15(16)	95(128)	100(88)	87(76)	159(160)	0/15

Table 25: 02-D, running time excess ERT/ERT$_{\text{best 2009}}$ 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_{opt}	1e1	1e0	1e-1	1e-3	1e-5	1e-7	#succ
f24	18	857	8515	24113	24721	24721	5/15
ACOR	**2.1**(2)	546(779)	59(79)	21(28)	21(27)	21(27)	15/15
BIPOPaCMA	**1.3**(2)	12(13)	28(44)	15(17)	18(17)	18(17)	15/15
BIPOPsaACM	**1.5**(1)	23(39)	10(12)	19(33)	34(35)	34(35)	14/15
CMA	4.2(1)	52(71)	130(165)	233(295)	227(276)	227(260)	1/15
CMAES	**1.9**(1)	6.9(9)	5.9(7)	8.4(9)	8.2(8)	8.2(8)	6/15
CMAa	**1.0**(1.0)	119(234)	132(141)	110(140)	107(128)	107(122)	2/15
CMAm	**1.7**(3)	106(234)	95(118)	46(58)	45(57)	45(57)	4/15
CMAma	**1.9**(2)	73(172)	307(353)	∞	∞	∞ *4e5*	0/15
CMAmah	**1.6**(1)	56(137)	130(165)	109(124)	106(122)	106(129)	2/15
CMAmh	**1.2**(0.8)	98(178)	133(167)	113(125)	110(122)	110(122)	2/15
DBRCGA	**1.2**(2)	**4.8**(5)	4.2(6)	5.0(5)	4.9(5)	4.9(5)	12/15
DE	**2.0**(2)	18(16)	**3.1**(3)	**2.4**(2)	**2.3**(3)	**2.3**(2)	13/15
DE-AUTO	**1.4**(2)	79(117)	10(12)	4.0(5)	3.9(4)	3.9(4)	11/15
DE-BFGS	**1.6**(2)	41(57)	4.2(6)	**1.5**(2)	**1.5**(2)	**1.5**(2)	15/15
DE-ROLL	8.5(1)	314(359)	33(36)	12(13)	12(12)	12(12)	7/15
DE-SIMPLEX	**1.1**(0.9)	79(64)	8.1(6)	**2.9**(2)	**2.8**(2)	**2.8**(2)	15/15
DEctpb	**1.5**(2)	124(137)	15(17)	5.3(5)	5.2(6)	5.2(6)	8/15
IPOPsaACM	**1.7**(2)	58(96)	258(329)	573(631)	559(648)	559(615)	2/15
JADEb	**2.2**(2)	5.7(4)	**2.9**(4)	**3.0**(2)	**2.9**(3)	**2.9**(3)	12/15
JADEctpb	**2.1**(2)	**5.3**(12)	**1.9**(2)	**0.80**(0.7)	**0.78**(0.7)	**0.79**(0.7)	15/15
MVDE	**1.7**(1)	4669(5836)	470(587)	270(311)	263(324)	263(303)	2/15
NBIPOPaCMA	4.8(2)	6.9(10)	14(28)	7.9(10)	7.8(9)	7.8(9)	15/15
NIPOPaCMA	**1.7**(1)	38(27)	23(28)	22(38)	22(37)	22(37)	14/15
PSO-BFGS	**1.4**(2)	**3.2**(2)	**0.97**(0.8)	**0.53**(0.5)	**0.52**(0.5)	**0.52**(0.5)	15/15
SNES	16(0.8)	**4.5**(7)	4.9(7)	13(14)	15(16)	15(18)	6/15
xNES	3.7(2)	5.8(7)	10(10)	20(21)	19(23)	19(23)	4/15
xNESas	**2.2**(1)	7.7(16)	13(12)	28(27)	27(30)	27(28)	4/15

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