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## ► To cite this version:

Anne Auger. Benchmarking the (1+1)-ES with One-Fifth Success rule on the BBOB-2009 Noisy Testbed. ACM-GECCO Genetic and Evolutionary Computation Conference, Jul 2009, Montreal, Canada. inria-00430516

HAL Id: inria-00430516

<https://inria.hal.science/inria-00430516>

Submitted on 8 Nov 2009

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# Benchmarking the (1+1)-ES with One-Fifth Success rule on the BBOB-2009 Noisy Testbed

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## ABSTRACT

The (1+1)-ES with one-fifth success rule is one of the first and simplest stochastic algorithm proposed for optimization on a continuous search space in a black-box scenario. In this paper, we benchmark an independent-restart (1+1)-ES with one-fifth success rule on the BBOB-2009 noisy testbed. The maximum number of function evaluations used equals  $10^6$  times the dimension of the search space. The algorithm could only solve 3 functions with moderate noise in 5-D and 2 functions in 20-D.

## 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, Evolutionary computation

## 1. INTRODUCTION

The (1+1)-ES with one-fifth success rule is one of the earliest and simplest adaptive stochastic search algorithm [8, 7, 3]. This paper complements [1] where an independent-restart implementation of the (1+1)-ES with one-fifth success rule is benchmarked on the BBOB-2009 noise-free testbed. Indeed, we test exactly the same algorithm, using the same settings on the BBOB-2009 noisy testbed. For the description of the algorithm and the settings we refer to [1].

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GECCO'09, July 8–12, 2009, Montréal Québec, Canada.  
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## 2. RESULTS AND DISCUSSION

Results from experiments according to [5] on the benchmark functions given in [4, 6] are presented in Figures 1 and 2 and in Tables 1 and 2.

We observe that globally the algorithm performs poorly. In 5-D, only  $f_{101}$ ,  $f_{102}$ ,  $f_{103}$  are solved and in 20-D only  $f_{101}$  and  $f_{102}$  are solved. The functions solved belong to the class of functions with moderate noise.

## Acknowledgments

The author would like to acknowledge Nikolaus Hansen, Steffen Finck and Raymond Ros for their great and hard work on the BBOB project.

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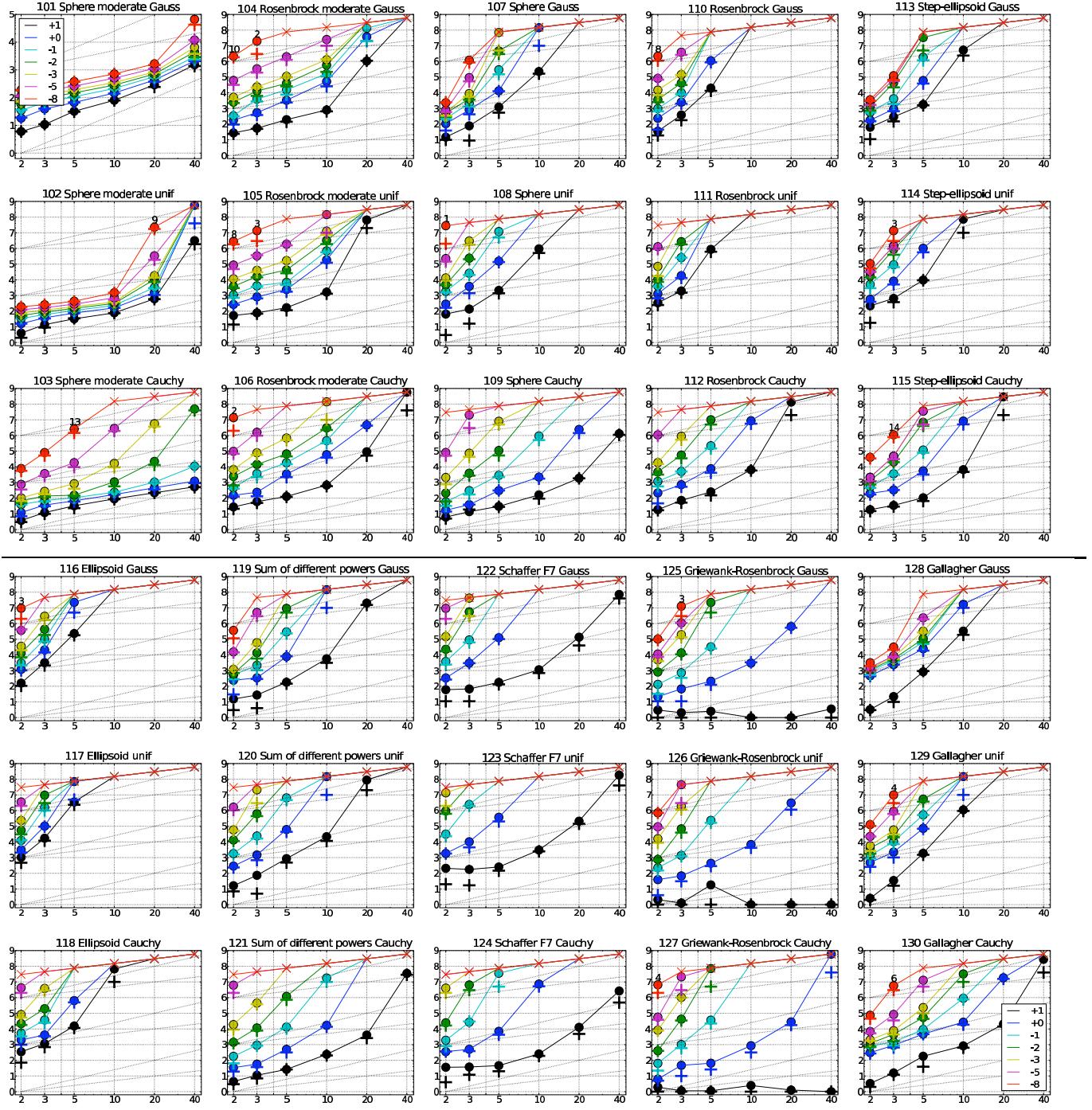


Figure 1: Expected Running Time (ERT, ●) to reach  $f_{\text{opt}} + \Delta f$  and median number of function evaluations of successful trials (+), shown for  $\Delta f = 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-5}, 10^{-8}$  (the exponent is given in the legend of  $f_{101}$  and  $f_{130}$ ) versus dimension in log-log presentation. The ERT( $\Delta f$ ) equals to  $\#FEs(\Delta f)$  divided by the number of successful trials, where a trial is successful if  $f_{\text{opt}} + \Delta f$  was surpassed during the trial. The  $\#FEs(\Delta f)$  are the total number of function evaluations while  $f_{\text{opt}} + \Delta f$  was not surpassed during the trial from all respective trials (successful and unsuccessful), and  $f_{\text{opt}}$  denotes the optimal function value. Crosses (×) indicate the total number of function evaluations  $\#FEs(-\infty)$ . Numbers above ERT-symbols indicate the number of successful trials. Annotated numbers on the ordinate are decimal logarithms. Additional grid lines show linear and quadratic scaling.

$\Delta f$	<i>f101</i> in 5-D, N=15, mFE=438				<i>f101</i> in 20-D, N=15, mFE=2971				$\Delta f$	<i>f102</i> in 5-D, N=15, mFE=886				<i>f102</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	3.2e1	2.7e1	3.8e1	3.2e1	15	2.9e2	2.4e2	3.5e2	2.9e2	15	3.2e1	2.7e1	3.7e1	3.2e1		
1	15	6.7e1	5.9e1	7.4e1	6.7e1	15	4.3e2	3.7e2	4.9e2	4.3e2	15	6.1e2	5.0e2	7.2e2	6.1e2		
le-1	15	1.1e2	9.9e1	1.2e2	1.1e2	15	5.7e2	5.2e2	6.3e2	5.7e2	15	1.1e3	1.2e3	2.0e3	1.6e3		
le-3	15	1.9e2	1.8e2	2.0e2	1.9e2	15	8.4e2	7.9e2	9.0e2	8.4e2	15	1.8e4	1.4e4	2.3e4	1.8e4		
le-5	15	2.6e2	2.5e2	2.7e2	2.6e2	15	1.1e3	1.1e3	1.2e3	1.1e3	15	3.4e5	2.4e5	4.4e5	3.4e5		
le-8	15	3.8e2	3.7e2	3.9e2	3.8e2	15	1.6e3	1.5e3	1.8e3	1.6e3	9	2.3e7	1.7e7	3.3e7	1.3e7		
	<i>f103</i> in 5-D, N=15, mFE=5.00e6				<i>f103</i> in 20-D, N=15, mFE=2.00e7					<i>f104</i> in 5-D, N=15, mFE=5.00e6				<i>f104</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	3.3e1	2.5e1	4.1e1	3.3e1	15	2.2e2	2.1e2	2.3e2	2.2e2	10	1.9e2	1.4e2	2.5e2	1.9e2		
1	15	6.8e1	6.1e1	7.5e1	6.8e1	15	4.6e2	3.9e2	5.3e2	4.6e2	1	3.3e3	2.3e3	4.4e3	3.3e3		
le-1	15	1.1e2	9.9e1	1.1e2	1.1e2	15	1.0e3	8.5e2	1.3e3	1.0e3	le-1	1.5e4	1.1e4	2.0e4	1.5e4		
le-3	15	4.8e2	5.2e2	1.2e3	8.4e2	14	5.7e6	4.0e6	7.5e6	5.5e6	le-3	1.1e5	7.7e4	1.5e5	1.1e5		
le-5	15	1.8e4	9.3e3	2.9e4	1.8e4	0	4.2e-5	3.2e-5	7.4e-5	7.9e6	le-5	2.0e6	1.5e6	2.6e6	2.0e6		
le-8	13	2.6e6	1.9e6	3.3e6	2.4e6	.	.	.	.	le-8	2.5e-8	1.5e-9	7.3e-7	1.8e6			
	<i>f105</i> in 5-D, N=15, mFE=5.00e6				<i>f105</i> in 20-D, N=15, mFE=2.00e7					<i>f106</i> in 5-D, N=15, mFE=5.00e6				<i>f106</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	1.7e2	1.2e2	2.2e2	1.7e2	4	6.6e7	4.0e7	1.4e8	1.5e7	10	1.3e2	1.1e2	1.4e2	1.3e2		
1	15	2.4e3	1.9e3	2.9e3	2.4e3	0	1.3e+0	3.7e-1	1.5e+0	1.1e7	1	3.5e3	2.4e3	4.6e3	3.5e3		
le-1	15	6.9e3	5.0e3	8.9e3	6.9e3	.	.	.	.	le-1	1.8e4	1.3e4	2.4e4	1.8e4			
le-3	15	1.7e5	1.2e5	2.2e5	1.7e5	.	.	.	.	le-3	6.9e5	4.6e5	9.4e5	6.9e5			
le-5	14	1.9e6	1.4e6	2.4e6	1.8e6	.	.	.	.	le-5	0	1e-5	3.5e-6	2.8e-5			
le-8	0	4.2e-8	1.3e-8	3.8e-7	2.8e6	.	.	.	.	le-8	.	.	.	.			
	<i>f107</i> in 5-D, N=15, mFE=5.00e6				<i>f107</i> in 20-D, N=15, mFE=2.00e7					<i>f108</i> in 5-D, N=15, mFE=5.00e6				<i>f108</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	1.2e3	8.3e2	1.6e3	1.2e3	0	3.4e+0	2.8e+0	4.8e+0	1.0e7	10	1.2e3	1.4e3	2.8e3	2.1e3		
1	15	3.1e4	1.1e4	1.6e4	1.3e4	.	.	.	.	1	1.6e5	1.1e5	2.0e5	1.6e5			
le-1	15	2.9e5	1.9e5	4.0e5	2.9e5	.	.	.	.	le-1	5	1.2e7	7.7e6	2.3e7	3.3e6		
le-3	1	7.1e7	3.3e7	>7e7	5.9e5	.	.	.	.	le-3	0	1.2e-2	4.1e-3	2.4e-2	2.2e6		
le-5	5	5.0e-4	1.3e-4	1.6e-3	2.8e6	.	.	.	.	le-5	.	.	.	.			
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.			
	<i>f109</i> in 5-D, N=15, mFE=5.00e6				<i>f109</i> in 20-D, N=15, mFE=2.00e7					<i>f110</i> in 5-D, N=15, mFE=5.00e6				<i>f110</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	3.0e1	2.4e1	3.6e1	3.0e1	15	1.9e3	1.4e3	2.4e3	1.9e3	10	2.0e4	1.4e4	2.5e4	2.0e4		
1	15	3.1e2	2.3e2	3.8e2	3.1e2	15	2.4e6	1.6e6	3.3e6	2.4e6	1	1.1e6	7.8e5	1.4e6	1.1e6		
le-1	15	2.9e3	2.1e3	3.7e3	2.9e3	0	7.2e-2	5.8e-2	8.2e-2	1.4e7	le-1	0	2.9e-2	1.5e-2	4.9e-2		
le-3	7	8.1e6	5.6e6	1.3e7	3.6e6	.	.	.	.	le-3	.	.	.	.			
le-5	0	1.3e-4	2.3e-5	2.2e-4	3.2e6	.	.	.	.	le-5	.	.	.	.			
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.			
	<i>f111</i> in 5-D, N=15, mFE=5.00e6				<i>f111</i> in 20-D, N=15, mFE=2.00e7					<i>f112</i> in 5-D, N=15, mFE=5.00e6				<i>f112</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	8.8e5	6.1e5	1.1e6	8.8e5	0	1.5e+3	1.1e+3	2.0e+3	1.1e7	10	2.5e2	1.9e2	3.1e2	2.5e2		
1	0	4.5e-1	2.2e-1	6.6e-1	2.8e6	.	.	.	.	1	7.6e3	5.3e3	1.0e4	7.6e3			
le-1	.	.	.	.	.	.	.	.	.	le-1	1.2e5	1.5e5	3.0e5	2.2e5			
le-3	.	.	.	.	.	.	.	.	.	le-3	0	1.4e-3	4.3e-4	2.9e-3	2.8e6		
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.			
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.			
	<i>f113</i> in 5-D, N=15, mFE=5.00e6				<i>f113</i> in 20-D, N=15, mFE=2.00e7					<i>f114</i> in 5-D, N=15, mFE=5.00e6				<i>f114</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	1.8e3	1.4e3	2.2e3	1.8e3	0	1.3e+1	1.0e+1	1.7e+1	1.0e7	10	9.7e3	7.2e3	1.2e4	9.7e3		
1	15	6.1e4	4.1e4	8.0e4	6.1e4	.	.	.	.	1	1.0e6	6.9e5	1.4e6	1.0e6			
le-1	13	1.9e6	1.2e6	2.7e6	1.4e6	.	.	.	.	le-1	0	2.9e-2	2.0e-2	5.3e-2	3.2e6		
le-3	0	2.3e-3	9.6e-4	1.1e-2	2.2e6	.	.	.	.	le-3	.	.	.	.			
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.			
le-8	0	9.6e-4	3.0e-8	1.4e-3	2.2e6	.	.	.	.	le-8	.	.	.	.			
	<i>f115</i> in 5-D, N=15, mFE=5.00e6				<i>f115</i> in 20-D, N=15, mFE=2.00e7					<i>f116</i> in 5-D, N=15, mFE=5.00e6				<i>f116</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	1.1e2	7.8e1	1.4e2	1.1e2	1	2.9e8	1.4e8	>3e8	2.0e7	10	2.3e5	1.6e5	3.1e5	2.3e5		
1	15	5.6e3	3.7e3	7.6e3	5.6e3	0	1.4e+0	1.1e+0	1.7e+0	1.1e7	1	3	2.2e7	1.3e7	6.6e7		
le-1	15	1.2e5	7.5e4	1.6e5	1.2e5	.	.	.	.	le-1	0	1.7e-1	8.0e-2	3.3e-1	2.8e6		
le-3	2	3.6e7	1.9e7	>7e7	5.0e6	.	.	.	.	le-3	.	.	.	.			
le-5	2	3.6e7	1.9e7	>7e7	5.0e6	.	.	.	.	le-5	.	.	.	.			
le-8	0	9.6e-4	3.0e-8	1.4e-3	2.2e6	.	.	.	.	le-8	.	.	.	.			
	<i>f117</i> in 5-D, N=15, mFE=5.00e6				<i>f117</i> in 20-D, N=15, mFE=2.00e7					<i>f118</i> in 5-D, N=15, mFE=5.00e6				<i>f118</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	12	3.5e6	2.7e6	4.4e6	3.0e6	0	6.9e+2	5.3e+2	9.7e+2	1.3e7	10	1.5e4	1.1e4	2.1e4	1.5e4		
1	1	7.1e7	3.3e7	>7e7	5.0e6	.	.	.	.	1	15	6.4e5	4.5e5	8.4e5	6.4e5		
le-1	0	6.7e-1	1.4e-1	1.2e+0	2.5e6	.	.	.	.	le-1	0	2.2e-2	1.2e-2	5.6e-2	2.8e6		
le-3	.	.	.	.	.	.	.	.	.	le-3	.	.	.	.			
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.			
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.			
	<i>f119</i> in 5-D, N=15, mFE=5.00e6				<i>f119</i> in 20-D, N=15, mFE=2.00e7					<i>f120</i> in 5-D, N=15, mFE=5.00e6				<i>f120</i> in 20-D, N=15, mFE=2.00e7			
	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>		
10	15	1.8e2	1.3e2	2.4e2	1.8e2	9	2.0e7	1.6e7	2.6e7	1.6e7	10	8.6e2	5.3e2	1.2e3	8.6e2		
1	15	7.7e3	5.6e3	1.0e4	7.7e3	0	9.7e-1	8.4e-1	1.1e+								

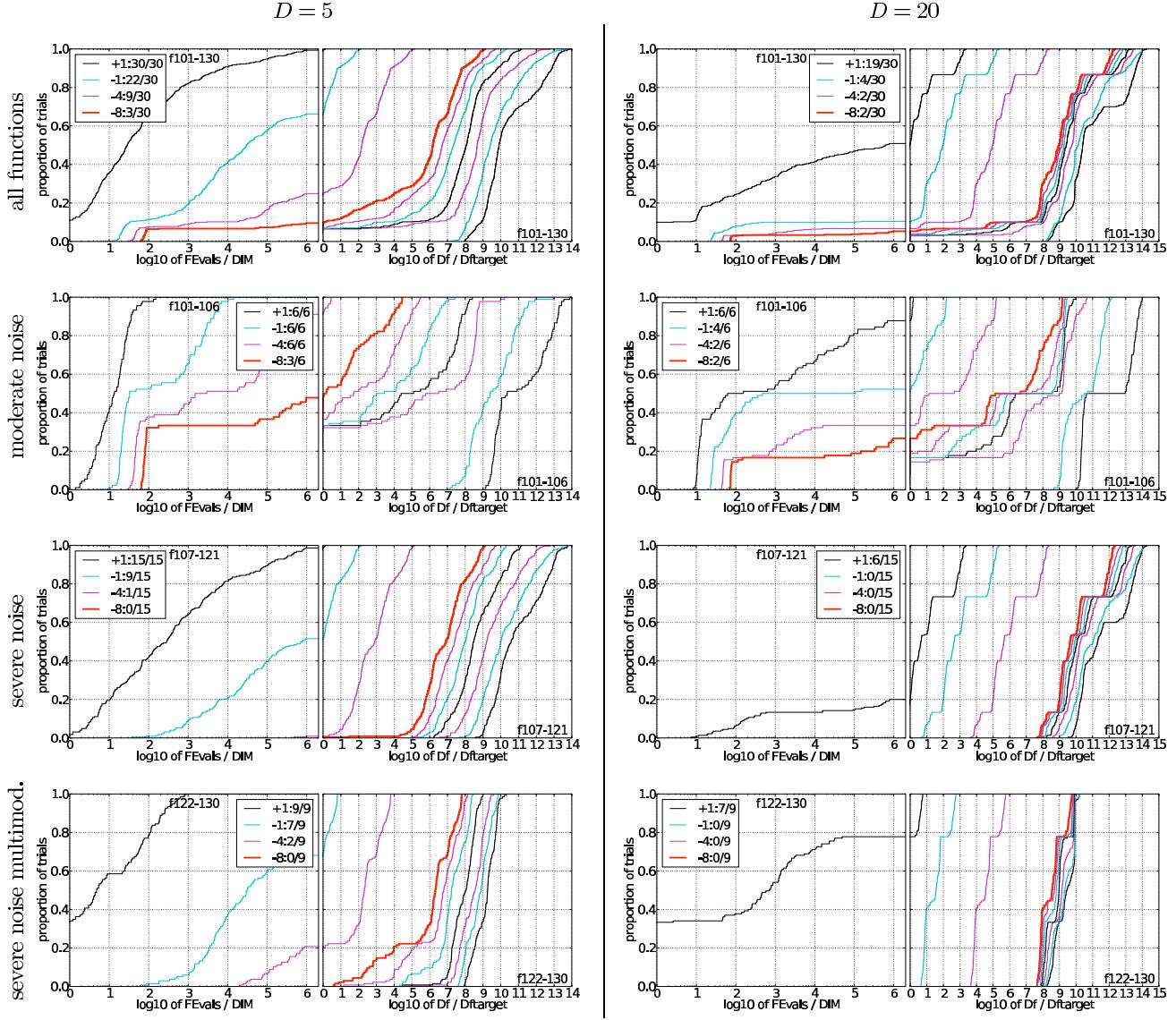


Figure 2: Empirical cumulative distribution functions (ECDFs), plotting the fraction of trials versus running time (left subplots) or versus  $\Delta f$  (right subplots). The thick red line represents the best achieved results. Left subplots: ECDF of the running time (number of function evaluations), 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. Right subplots: ECDF of the best achieved  $\Delta f$  divided by  $10^k$  (upper left lines in continuation of the left subplot), and best achieved  $\Delta f$  divided by  $10^{-8}$  for running times of  $D, 10D, 100D, \dots$  function evaluations (from right to left cycling black-cyan-magenta). Top row: all results from all functions; second row: moderate noise functions; third row: severe noise functions; fourth row: severe noise and highly-multimodal functions. The legends indicate the number of functions that were solved in at least one trial. FEvals denotes number of function evaluations,  $D$  and DIM denote search space dimension, and  $\Delta f$  and Df denote the difference to the optimal function value.

<i>f121</i> in 5-D, N=15, mFE=5.00e6							<i>f121</i> in 20-D, N=15, mFE=2.00e7							<i>f122</i> in 5-D, N=15, mFE=5.00e6							<i>f122</i> in 20-D, N=15, mFE=2.00e7										
$\Delta f$	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>						
10	15	2.6e1	2.1e1	3.2e1	2.6e1	15	4.1e3	3.0e3	5.3e3	4.1e3	10	1.8e2	1.3e2	2.2e2	1.8e2	15	1.4e5	6.1e4	2.2e5	1.4e5	1	15	5.0e2	3.6e2	6.5e2	5.0e2					
1	15	5.0e2	3.6e2	6.5e2	5.0e2	0	<i>16e-1</i>	<i>12e-1</i>	<i>21e-1</i>	7.9e6	1	1.2e5	9.2e4	1.6e5	1.2e5	0	<i>57e-1</i>	<i>39e-1</i>	<i>62e-1</i>	7.9e6											
1e-1	15	1.3e4	1.0e4	1.7e4	1.3e4	.	.	.	.	.	1e-1	0	<i>24e-2</i>	<i>17e-2</i>	<i>40e-2</i>	1.6e6	.	.	.	.	.	1e-3	0	<i>51e-4</i>	<i>28e-4</i>	<i>80e-4</i>	2.5e6				
le-3	0	.	.	.	.	.	.	.	.	.	le-3	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.	.					
le-5	.	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.					
le-8	.	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.					
<i>f123</i> in 5-D, N=15, mFE=5.00e6							<i>f123</i> in 20-D, N=15, mFE=2.00e7							<i>f124</i> in 5-D, N=15, mFE=5.00e6							<i>f124</i> in 20-D, N=15, mFE=2.00e7										
$\Delta f$	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>						
10	15	2.5e2	1.6e2	3.4e2	2.5e2	15	2.1e5	1.4e5	2.9e5	2.1e5	10	4.6e1	1.8e1	7.5e1	4.6e1	15	1.3e4	8.4e3	1.7e4	1.3e4	1	15	3.7e5	2.6e5	4.9e5	3.7e5					
1	15	3.7e5	2.6e5	4.9e5	3.7e5	0	<i>64e-1</i>	<i>59e-1</i>	<i>68e-1</i>	7.9e6	1	7.0e3	4.5e3	9.8e3	7.0e3	0	<i>36e-1</i>	<i>32e-1</i>	<i>43e-1</i>	7.1e6											
1e-1	0	<i>59e-2</i>	<i>45e-2</i>	<i>63e-2</i>	2.2e6	.	.	.	.	.	1e-1	2	<i>3.6e-7</i>	<i>1.9e-7</i>	<i>&gt;7e-7</i>	5.0e6	.	.	.	.	.	le-3	0	.	.	.	.				
le-3	.	.	.	.	.	.	.	.	.	le-3	0	<i>12e-2</i>	<i>92e-3</i>	<i>15e-2</i>	2.0e6	.	.	.	.	.	le-5	.	.	.	.	.					
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.						
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.						
<i>f125</i> in 5-D, N=15, mFE=5.00e6							<i>f125</i> in 20-D, N=15, mFE=2.00e7							<i>f126</i> in 5-D, N=15, mFE=5.00e6							<i>f126</i> in 20-D, N=15, mFE=2.00e7										
$\Delta f$	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>						
10	15	2.5e0	1.1e0	4.0e0	2.5e0	15	1.0e0	1.0e0	1.0e0	1.0e0	10	15	2.1e2	1.9e0	3.4e1	1.8e1	15	1.0e0	1.0e0	1.0e0	1.0e0	1	15	2.1e2	1.3e2	3.0e2	2.1e2				
1	15	6.5e1	3.1e1	3.0e2	6.5e1	15	6.5e5	5.0e5	8.2e5	6.5e5	1	4.3e2	2.7e2	6.1e2	4.3e2	15	3.1e6	2.1e6	4.1e6	3.1e6	le-1	15	3.3e4	2.3e4	4.3e4	3.3e4					
le-1	0	<i>13e-3</i>	<i>71e-4</i>	<i>23e-3</i>	2.0e6	0	<i>75e-2</i>	<i>66e-2</i>	<i>77e-2</i>	1.3e7	le-1	15	<i>2.4e-5</i>	<i>1.7e-5</i>	<i>3.0e-5</i>	2.4e5	0	<i>83e-2</i>	<i>77e-2</i>	<i>90e-2</i>	8.9e6	le-3	0	.	.	.	.				
le-3	0	.	.	.	.	.	.	.	.	le-3	0	<i>27e-3</i>	<i>15e-3</i>	<i>41e-3</i>	2.0e6	.	.	.	.	.	le-5	.	.	.	.	.					
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.						
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.						
<i>f127</i> in 5-D, N=15, mFE=5.00e6							<i>f127</i> in 20-D, N=15, mFE=2.00e7							<i>f128</i> in 5-D, N=15, mFE=5.00e6							<i>f128</i> in 20-D, N=15, mFE=2.00e7										
$\Delta f$	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>						
10	15	1.1e0	1.0e0	1.3e0	1.1e0	15	1.3e0	1.0e0	1.5e0	1.3e0	10	15	8.4e2	6.4e2	1.0e3	8.4e2	10	<i>34e+0</i>	<i>24e+0</i>	<i>48e+0</i>	7.1e6	1	15	6.5e1	3.1e1	1.0e2	6.5e1				
1	15	6.5e1	3.1e1	3.0e2	6.5e1	15	2.8e4	1.8e4	3.8e4	2.8e4	1	2.5e4	1.9e4	3.0e4	2.5e4	15	6.5e4	4.9e4	8.3e4	6.5e4	le-1	15	3.6e4	2.5e4	4.9e4	3.6e4					
le-1	0	<i>24e-3</i>	<i>15e-3</i>	<i>30e-3</i>	2.5e6	0	<i>62e-2</i>	<i>50e-2</i>	<i>66e-2</i>	1.1e7	le-1	15	<i>3.2e-5</i>	<i>2.2e-5</i>	<i>4.3e-5</i>	3.2e5	0	<i>17e-7</i>	<i>16e-9</i>	<i>68e-7</i>	2.5e6	le-3	15	.	.	.	.				
le-3	0	.	.	.	.	.	.	.	.	le-3	0	<i>14e-5</i>	<i>1.7e-6</i>	<i>3.0e-6</i>	2.1e6	.	.	.	.	.	le-5	14	<i>2.3e-6</i>	<i>1.7e-6</i>	<i>3.0e-6</i>	2.1e6	0	.	.	.	.
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.	.	.	.	.	.	le-8	0	<i>17e-7</i>	<i>16e-9</i>	<i>68e-7</i>	2.5e6	.	.	.	.	.	
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.						
<i>f129</i> in 5-D, N=15, mFE=5.00e6							<i>f129</i> in 20-D, N=15, mFE=2.00e7							<i>f130</i> in 5-D, N=15, mFE=5.00e6							<i>f130</i> in 20-D, N=15, mFE=2.00e7										
$\Delta f$	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>	#	ERT	10%	90%	RT <sub>succ</sub>						
10	15	1.9e3	1.5e3	2.3e3	1.9e3	0	<i>48e+0</i>	<i>34e+0</i>	<i>56e+0</i>	1.0e7	10	1.8e2	1.1e2	2.5e2	1.8e2	10	1.8e7	1.2e7	2.8e7	9.2e6	1	15	7.3e4	5.2e4	9.2e4	7.3e4					
1	15	7.3e4	5.2e4	9.2e4	7.3e4	.	.	.	.	.	1	4.7e3	3.4e3	6.0e3	4.7e3	10	1.8e7	1.2e7	2.8e7	9.2e6	le-1	15	5.3e5	4.3e5	6.4e5	5.3e5					
le-1	0	<i>60e-4</i>	<i>24e-4</i>	<i>18e-3</i>	2.2e6	.	.	.	.	.	le-1	15	9.3e3	7.3e3	1.1e4	9.3e3	0	<i>74e-2</i>	<i>46e-2</i>	<i>16e-1</i>	7.1e6	le-3	15	.	.	.	.				
le-3	0	.	.	.	.	.	.	.	.	le-3	15	2.3e5	1.4e5	3.3e5	2.3e5	.	.	.	.	.	le-5	5	<i>1.3e7</i>	<i>8.6e6</i>	<i>2.3e7</i>	4.3e6	0	<i>37e-6</i>	<i>31e-7</i>	<i>13e-5</i>	2.5e6
le-5	.	.	.	.	.	.	.	.	.	le-5	.	.	.	.	.	.	.	.	.	le-8	0	.	.	.	.						
le-8	.	.	.	.	.	.	.	.	.	le-8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.						

Table 2: Shown are, for functions  $f_{121}$ - $f_{130}$  and for a given target difference to the optimal function value  $\Delta f$ : the number of successful trials (#); the expected running time to surpass  $f_{\text{opt}} + \Delta f$  (ERT, see Figure 1); the 10%-tile and 90%-tile of the bootstrap distribution of ERT; the average number of function evaluations in successful trials or, if none was successful, as last entry the median number of function evaluations to reach the best function value (RT<sub>succ</sub>). If  $f_{\text{opt}} + \Delta f$  was never reached, figures in *italics* denote the best achieved  $\Delta f$ -value of the median trial and the 10% and 90%-tile trial. Furthermore, N denotes the number of trials, and mFE denotes the maximum of number of function evaluations executed in one trial. See Figure 1 for the names of functions.