HNCO
Comparison of various black box optimization algorithms

November 28, 2017

Contents

1 Rankings

algorithm	rank distribution									
	1	2	3	4	5	6	7	8	9	10
pbil	10	1	0	2	1	1	1	2	0	1
sa	7	3	1	3	0	1	0	0	2	2
umda	7	2	0	1	2	1	2	2	0	2
hc	6	4	2	2	1	0	0	0	2	2
ga	6	3	0	1	1	3	3	0	1	1
rls	5	5	0	5	1	0	0	1	0	2
ea-1c10	5	4	2	5	1	1	0	0	1	0
ea-1p1	4	3	0	4	1	4	0	1	1	1
ea-10p1	4	2	4	5	2	1	1	0	0	0
ea-1p10	4	2	0	3	0	3	1	3	3	0

2 Function one-max

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	100	100	100	100	100	1	0.000	0.000
hc	100	100	100	100	100	1	0.000	0.000
sa	100	100	100	100	100	1	0.005	0.005
ea-1p1	100	100	100	100	100	1	0.000	0.000
ea-1p10	100	100	100	100	100	1	0.001	0.002
ea-10p1	100	100	100	100	100	1	0.020	0.007
ea-1c10	100	100	100	100	100	1	0.003	0.005
ga	100	100	100	100	100	1	0.010	0.000
pbil	100	100	100	100	100	1	0.037	0.005
umda	100	100	100	100	100	1	0.000	0.000
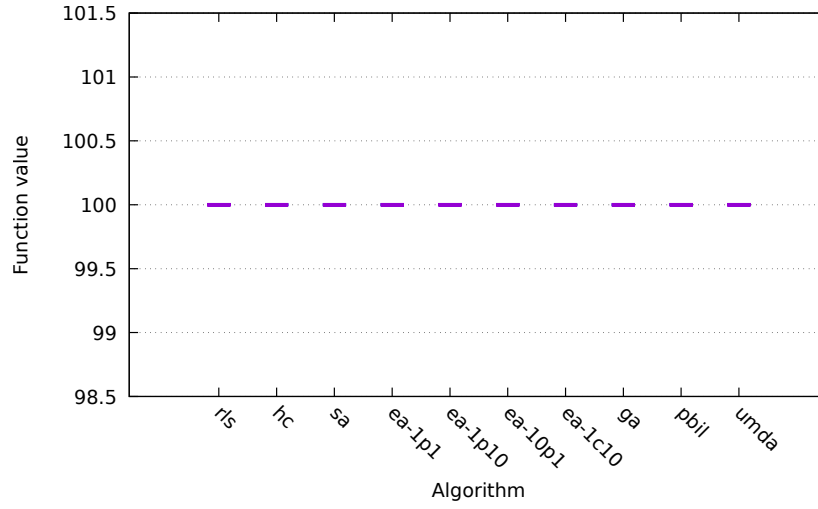
Figure 1: one-max
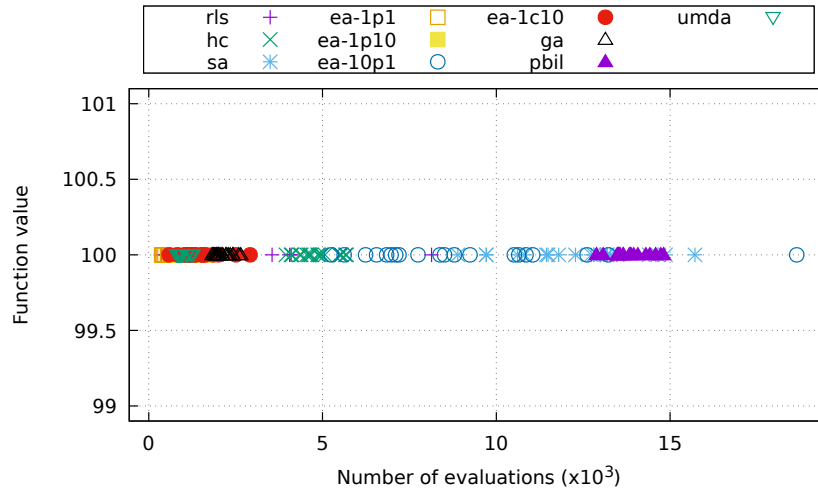
Figure 2: one-max

3 Function lin

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	45.03	45.03	45.03	45.03	45.03	1	0.101	0.008
hc	45.03	45.03	45.03	45.03	45.03	1	0.080	0.007
sa	45.03	45.03	45.03	45.03	45.03	1	0.094	0.005
ea-1p1	45.03	45.03	45.03	45.03	45.03	1	0.158	0.004
ea-1p10	45.03	45.03	45.03	45.03	45.03	1	0.510	0.005
ea-10p1	45.03	45.03	45.03	45.03	45.03	1	0.537	0.007
ea-1c10	45.03	45.03	45.03	45.03	45.03	1	0.516	0.007
ga	45.03	45.03	45.03	45.03	45.03	1	1.032	0.010
pbil	45.03	45.03	45.03	45.03	45.03	1	0.539	0.004
umda	45.03	45.03	45.03	45.03	45.03	1	0.523	0.006
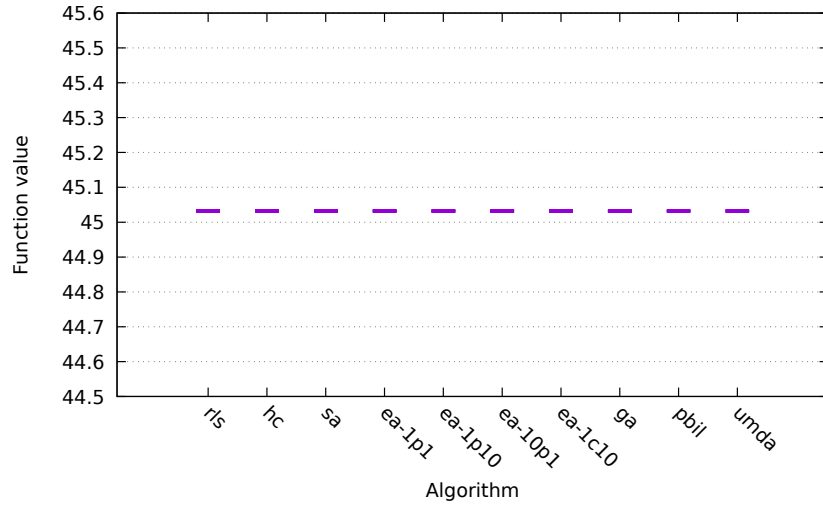
Figure 3: lin
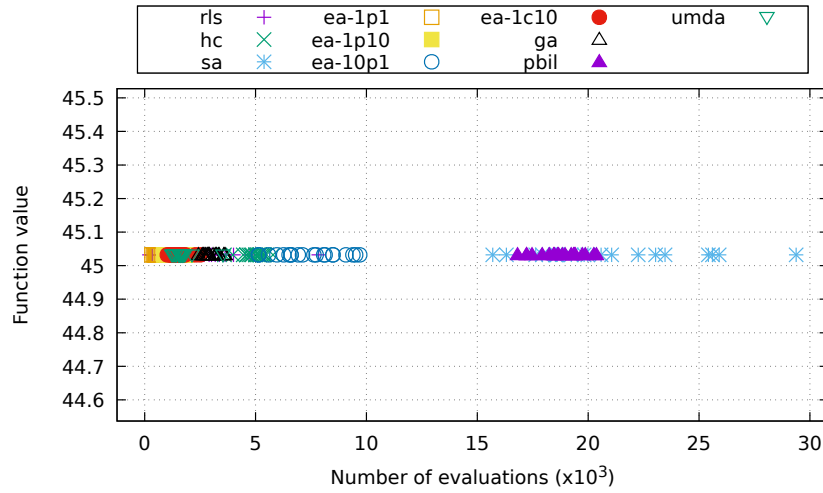
Figure 4: lin

4 Function leading-ones

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	100	100	100	100	100	1	0.006	0.006
hc	100	100	100	100	100	1	0.000	0.000
sa	3	100	100	100	100	10	0.009	0.022
ea-1p1	100	100	100	100	100	1	0.004	0.005
ea-1p10	100	100	100	100	100	1	0.016	0.005
ea-10p1	100	100	100	100	100	1	0.118	0.023
ea-1c10	100	100	100	100	100	1	0.021	0.006
ga	100	100	100	100	100	1	0.048	0.010
pbil	100	100	100	100	100	1	0.157	0.010
umda	100	100	100	100	100	1	0.025	0.006
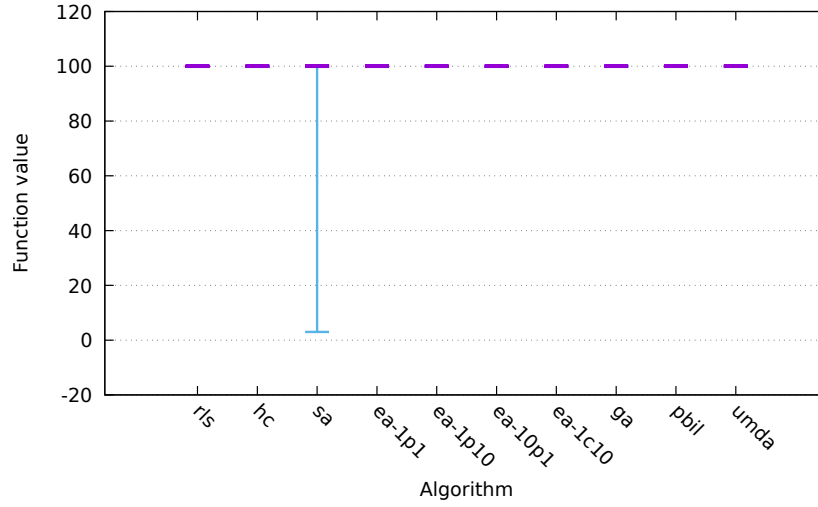
Figure 5: leading-ones
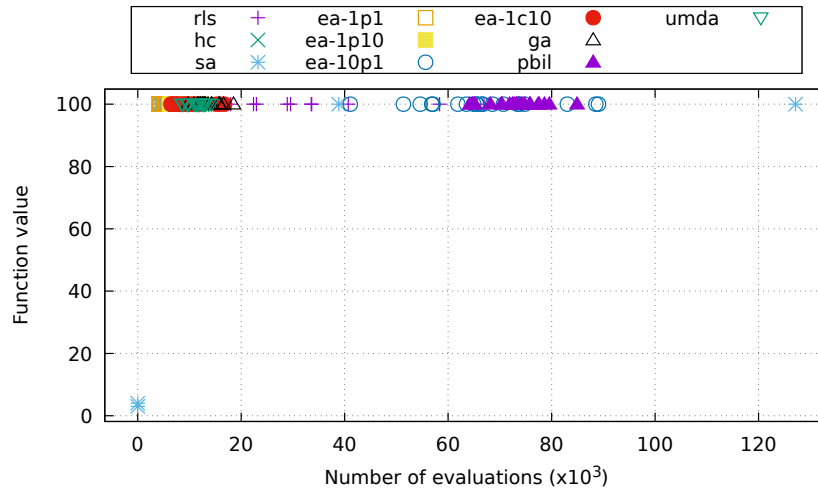
Figure 6: leading-ones

5 Function ridge

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	103	105	106	106	111	10	0.074	0.005
hc	200	200	200	200	200	1	0.005	0.005
sa	200	200	200	200	200	1	0.008	0.005
ea-1p1	200	200	200	200	200	1	0.011	0.004
ea-1p10	200	200	200	200	200	1	0.049	0.004
ea-10p1	193	200	200	200	200	7	0.471	0.047
ea-1c10	117	121	126	127	141	9	0.504	0.006
ga	200	200	200	200	200	1	0.170	0.011
pbil	153	154	155	156	157	8	0.532	0.008
umda	200	200	200	200	200	1	0.086	0.008
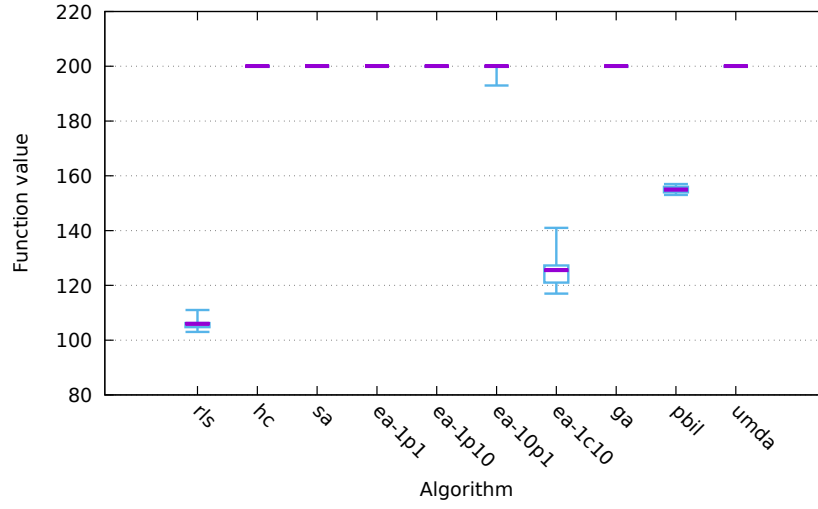
Figure 7: ridge
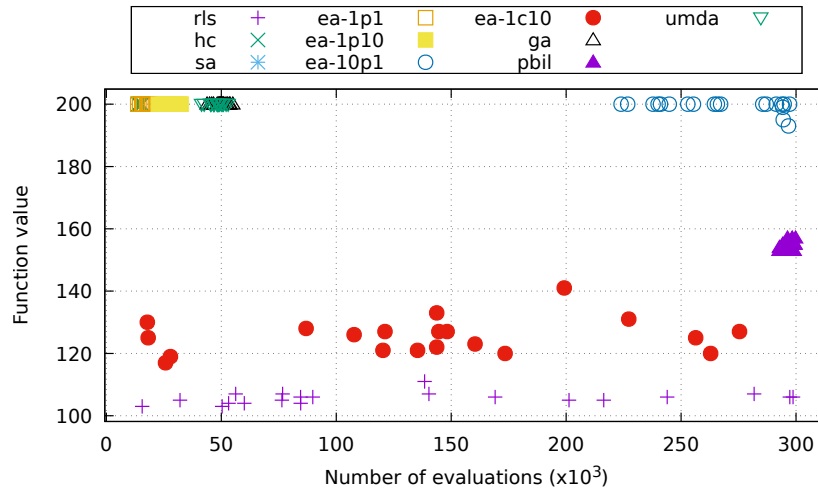
Figure 8: ridge

6 Function jmp-5

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	95	95	95	95	95	4	0.071	0.003
hc	95	95	95	95	95	4	0.056	0.006
sa	95	95	95	95	95	4	0.076	0.005
ea-1p1	95	95	95	95	95	4	0.142	0.005
ea-1p10	95	95	95	95	95	4	0.492	0.006
ea-10p1	95	95	95	95	95	4	0.513	0.005
ea-1c10	95	95	95	95	95	4	0.496	0.008
ga	100	100	100	100	100	1	0.170	0.116
pbil	100	100	100	100	100	1	0.039	0.004
umda	100	100	100	100	100	1	0.053	0.056
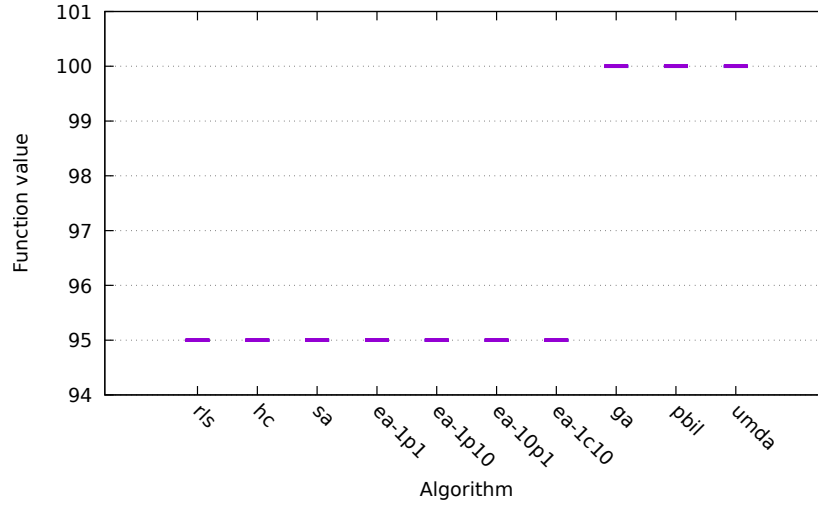
Figure 9: jmp-5
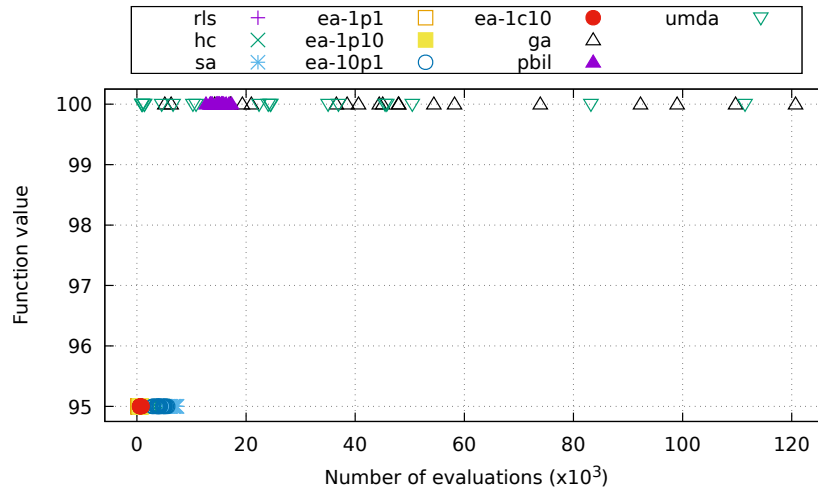
Figure 10: jmp-5

7 Function jmp-10

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	90	90	90	90	90	2	0.075	0.005
hc	90	90	90	90	90	2	0.059	0.004
sa	90	90	90	90	90	2	0.078	0.005
ea-1p1	90	90	90	90	90	2	0.140	0.003
ea-1p10	90	90	90	90	90	2	0.492	0.005
ea-10p1	90	90	90	90	90	2	0.519	0.009
ea-1c10	90	90	90	90	90	2	0.492	0.004
ga	90	90	90	90	90	2	1.003	0.006
pbil	90	90	90	100	100	1	0.381	0.258
umda	90	90	90	90	90	2	0.551	0.007
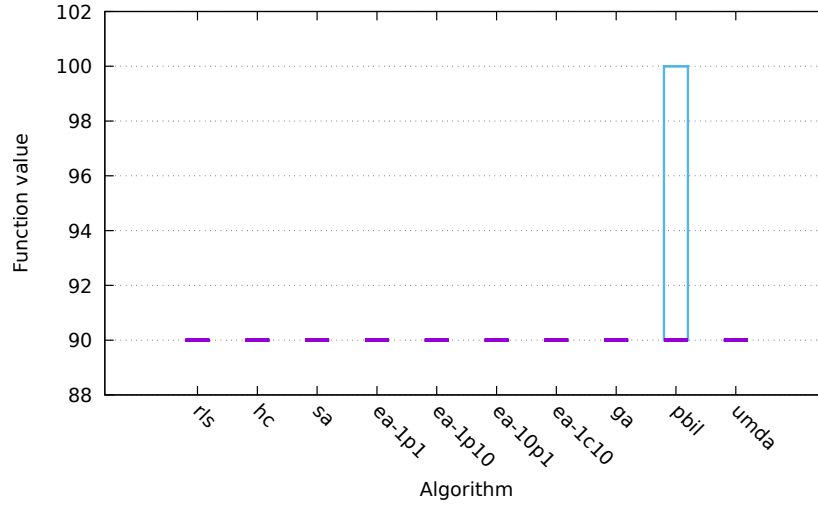
Figure 11: jmp-10
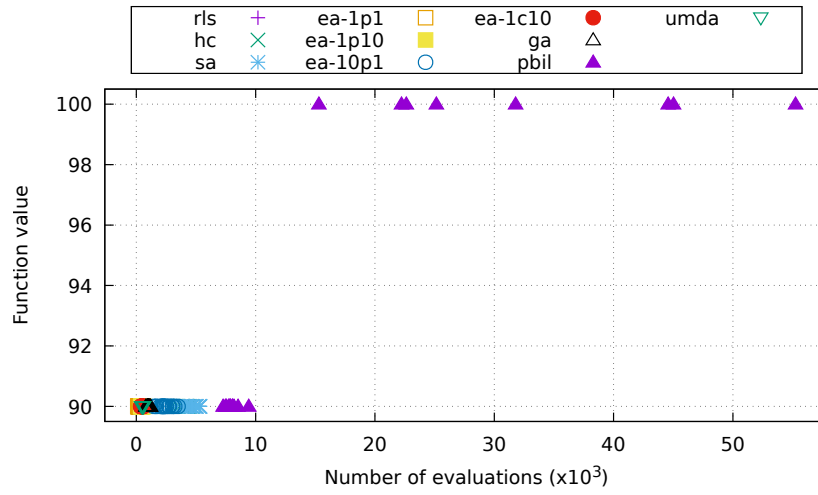
Figure 12: jmp-10

8   Function djmp-5

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	100	100	100	100	100	4	0.071	0.002
hc	100	100	100	100	100	4	0.057	0.005
sa	100	100	100	100	100	4	0.074	0.005
ea-1p1	100	100	100	100	100	4	0.141	0.005
ea-1p10	100	100	100	100	100	4	0.492	0.006
ea-10p1	100	100	100	100	100	4	0.519	0.007
ea-1c10	100	100	100	100	100	4	0.497	0.009
ga	105	105	105	105	105	1	0.201	0.163
pbil	105	105	105	105	105	1	0.036	0.006
umda	105	105	105	105	105	1	0.039	0.034
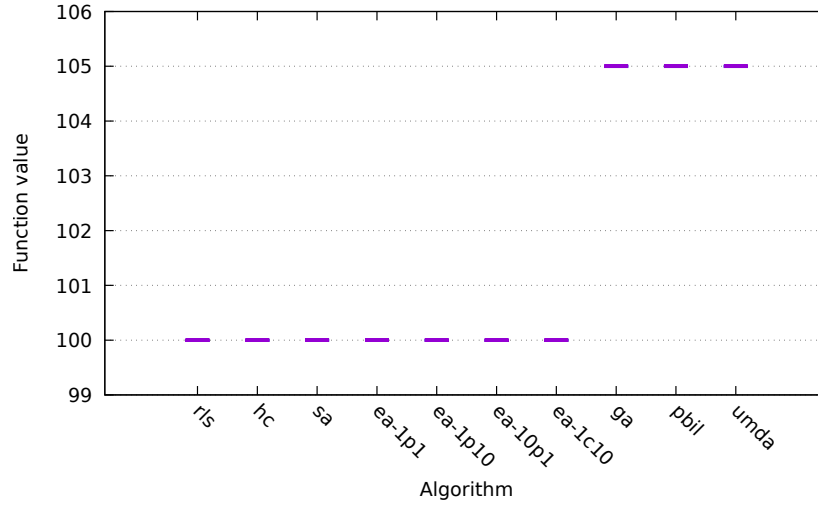
Figure 13: djmp-5
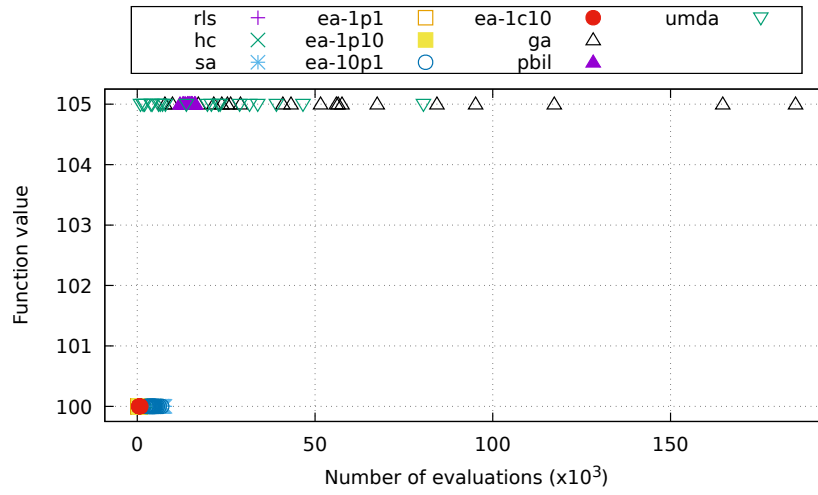
Figure 14: djmp-5

9 Function djmp-10

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	100	100	100	100	100	2	0.073	0.004
hc	100	100	100	100	100	2	0.060	0.005
sa	100	100	100	100	100	2	0.077	0.005
ea-1p1	100	100	100	100	100	2	0.141	0.003
ea-1p10	100	100	100	100	100	2	0.495	0.007
ea-10p1	100	100	100	100	100	2	0.515	0.005
ea-1c10	100	100	100	100	100	2	0.494	0.005
ga	100	100	100	100	100	2	1.026	0.019
pbil	100	100	110	110	110	1	0.260	0.248
umda	100	100	100	100	100	2	0.558	0.010
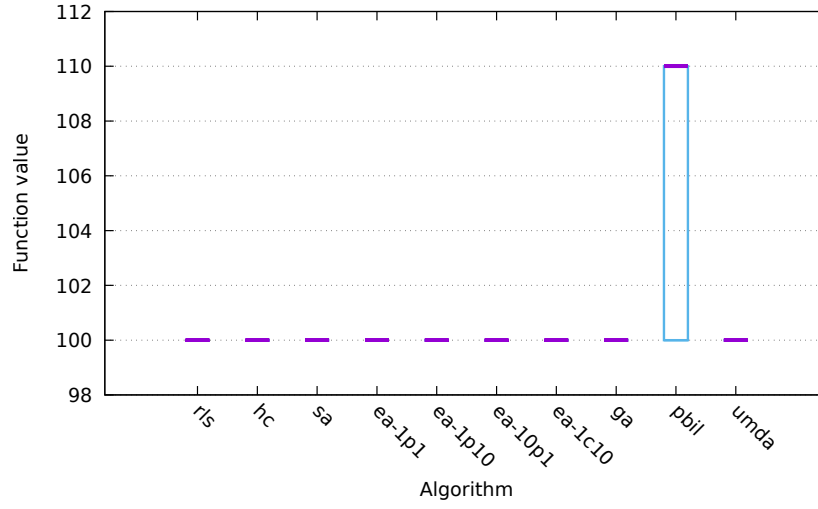
Figure 15: djmp-10
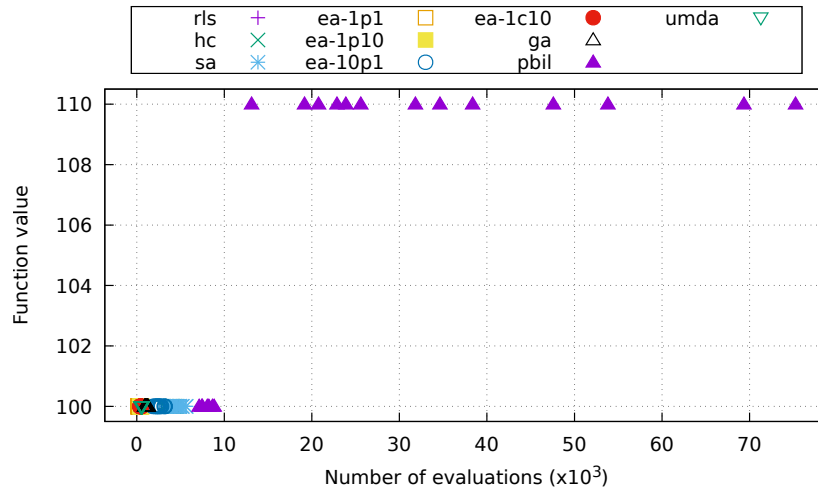
Figure 16: djmp-10

10 Function fp-5

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	194	194	194	194	194	1	0.005	0.006
hc	100	100	194	194	194	10	0.046	0.022
sa	4	194	194	194	194	9	0.018	0.031
ea-1p1	100	194	194	194	194	6	0.009	0.033
ea-1p10	100	194	194	194	194	6	0.093	0.183
ea-10p1	194	194	194	194	194	1	0.110	0.016
ea-1c10	194	194	194	194	194	1	0.027	0.018
ga	100	194	194	194	194	6	0.095	0.218
pbil	194	194	194	194	194	1	0.175	0.011
umda	194	194	194	194	194	1	0.025	0.005
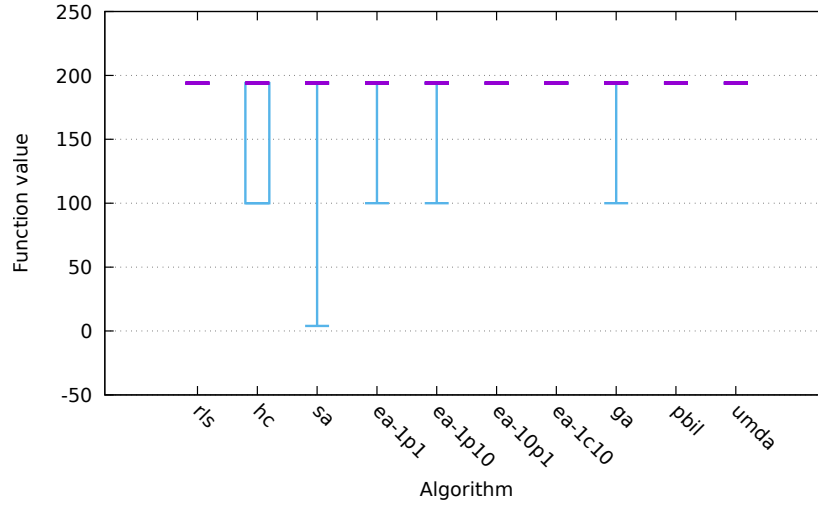
Figure 17: fp-5
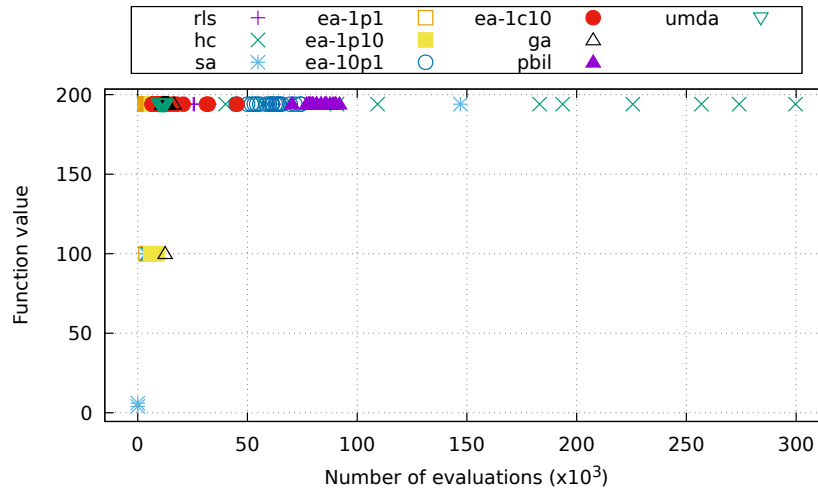
Figure 18: fp-5

11 Function fp-10

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	184	189	189	189	189	2	0.026	0.020
hc	100	100	100	100	100	9	0.060	0.000
sa	4	100	100	100	189	10	0.067	0.026
ea-1p1	100	100	100	189	189	5	0.096	0.071
ea-1p10	100	100	100	100	189	8	0.462	0.153
ea-10p1	100	189	189	189	189	3	0.175	0.152
ea-1c10	100	167	189	189	189	4	0.255	0.188
ga	100	100	100	189	189	5	0.674	0.475
pbil	189	189	189	189	189	1	0.156	0.009
umda	100	100	100	189	189	5	0.345	0.244
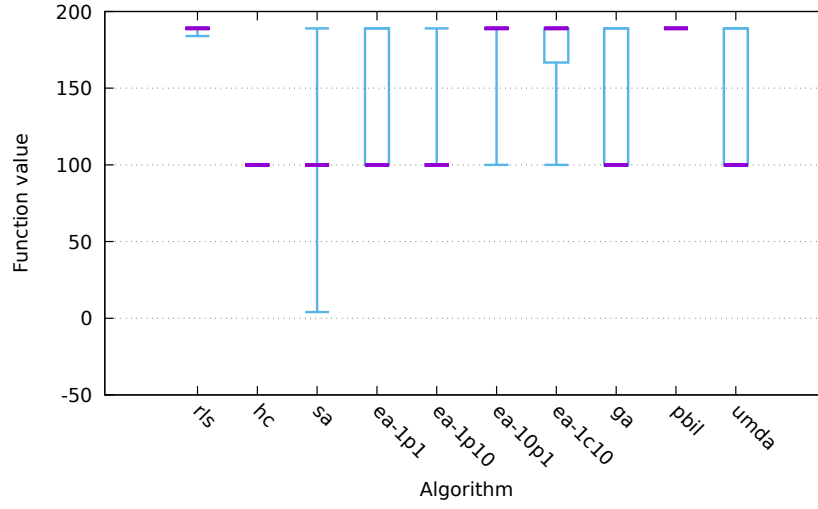
Figure 19: fp-10

Figure 20: fp-10

12
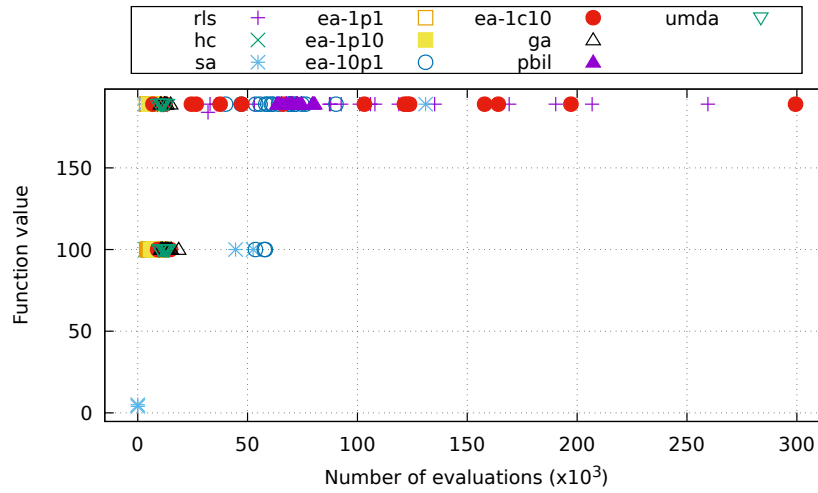
12 Function nk

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	0.97	0.98	0.99	1.01	1.06	4	0.272	0.007
hc	0.96	0.98	1.00	1.02	1.07	3	0.255	0.005
sa	1.00	1.04	1.06	1.06	1.10	1	0.276	0.005
ea-1p1	0.81	0.91	0.93	0.98	1.06	10	0.347	0.005
ea-1p10	0.89	0.93	0.94	0.95	1.04	9	0.693	0.008
ea-10p1	0.86	0.96	0.98	1.02	1.05	6	0.716	0.009
ea-1c10	0.97	0.99	1.01	1.03	1.06	2	0.697	0.009
ga	0.88	0.92	0.95	0.99	1.01	7	1.211	0.013
pbil	0.94	0.97	0.99	1.01	1.05	5	0.736	0.010
umda	0.80	0.91	0.95	0.96	0.99	8	0.707	0.007
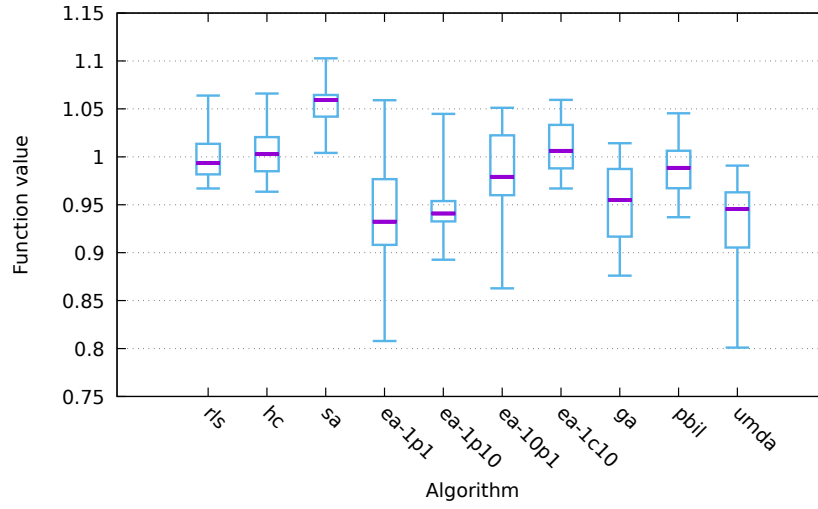
Figure 21: nk
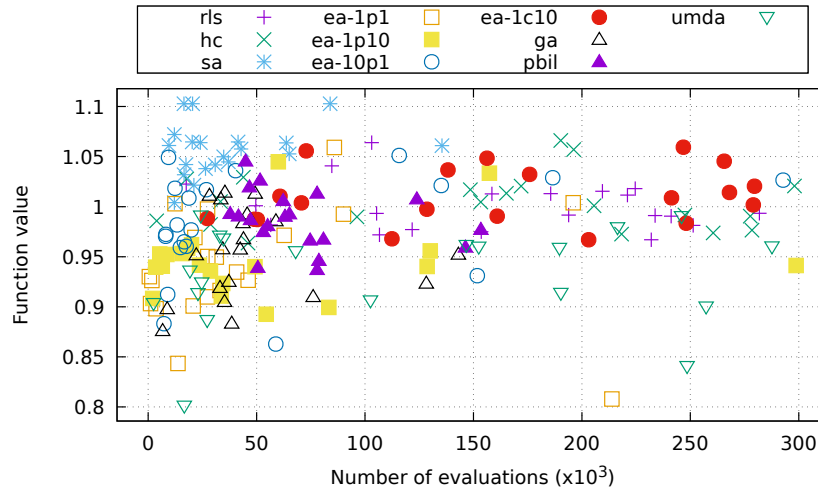
Figure 22: nk

13 Function max-sat

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	971	971	972	972	972	2	1.930	0.011
hc	952	965	967	968	972	9	0.258	0.047
sa	971	972	972	972	972	1	0.620	0.108
ea-1p1	958	966	968	972	972	6	0.848	0.216
ea-1p10	959	964	967	968	972	8	1.098	0.123
ea-10p1	960	967	968	968	972	4	2.005	0.071
ea-1c10	964	967	968	971	972	3	1.252	0.094
ga	957	963	965	969	972	10	1.621	0.092
pbil	964	966	967	967	969	7	1.411	0.049
umda	962	966	968	970	972	5	1.158	0.077
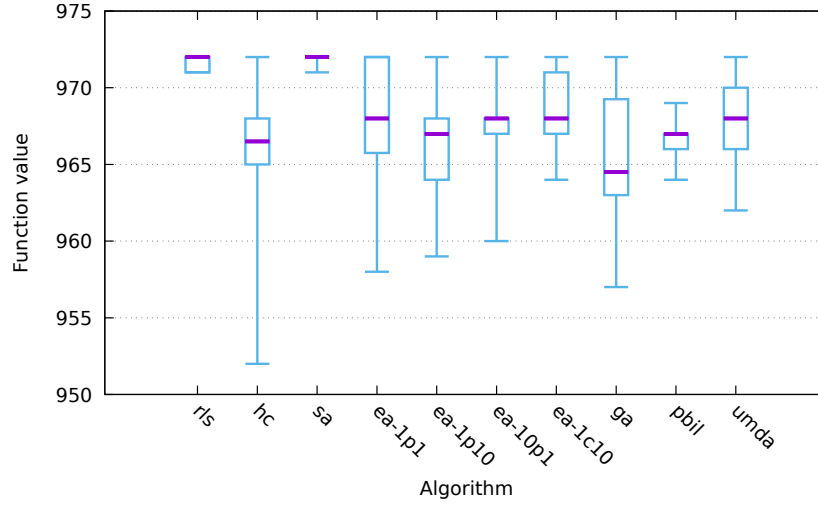
Figure 23: max-sat
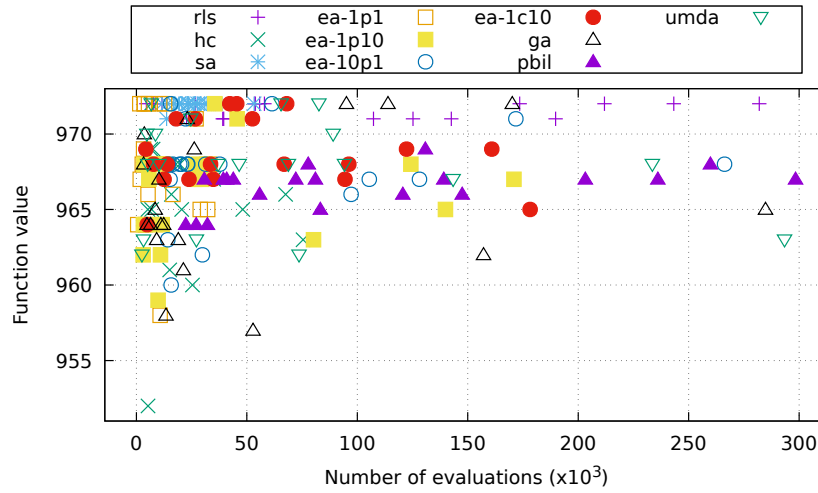
Figure 24: max-sat

14   Function labs

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	4.16	4.36	4.47	4.57	5.18	5	1.593	0.011
hc	4.54	4.58	4.76	4.90	5.33	2	1.607	0.041
sa	4.36	4.61	4.69	4.90	5.07	4	1.633	0.045
ea-1p1	3.51	4.04	4.17	4.36	4.55	6	1.705	0.069
ea-1p10	3.60	3.80	3.96	4.19	4.60	9	2.021	0.033
ea-10p1	4.26	4.47	4.73	4.88	5.33	3	2.043	0.046
ea-1c10	4.66	4.76	4.84	5.02	5.29	1	2.003	0.006
ga	3.61	3.79	4.05	4.23	4.57	7	2.516	0.014
pbil	3.84	3.96	4.03	4.13	5.05	8	2.122	0.008
umda	3.54	3.80	3.91	4.08	4.62	10	2.021	0.010
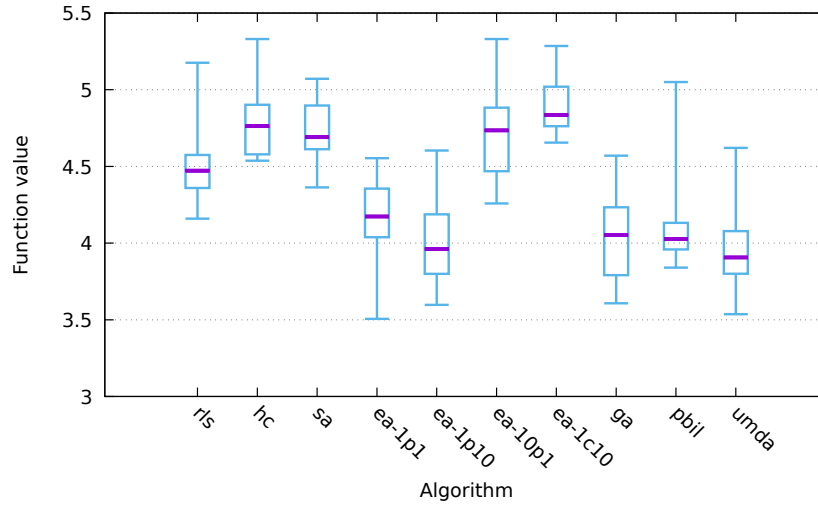
Figure 25: labs
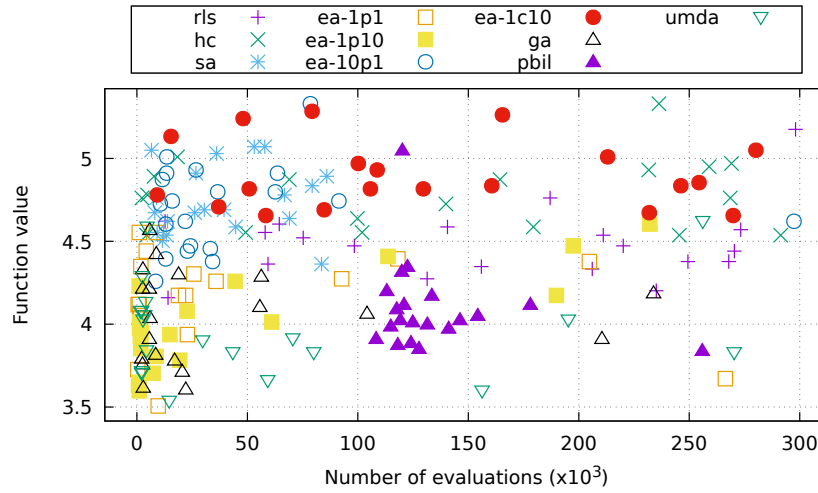
Figure 26: labs

15 Function ep

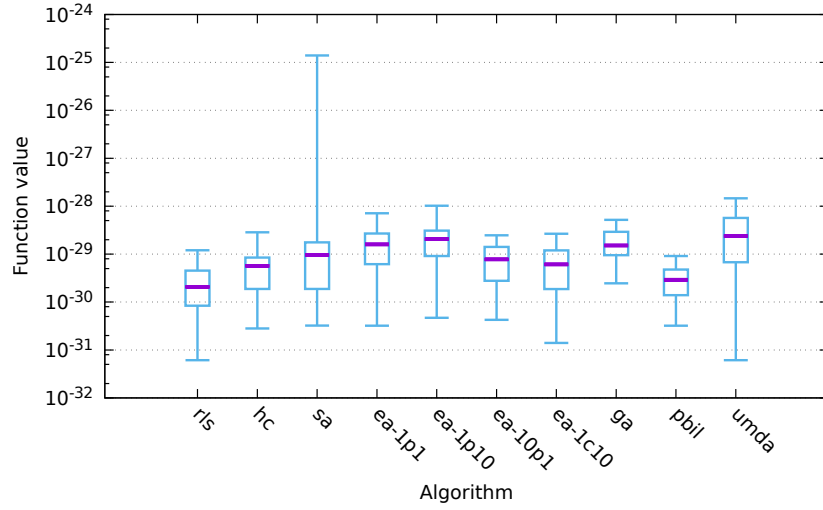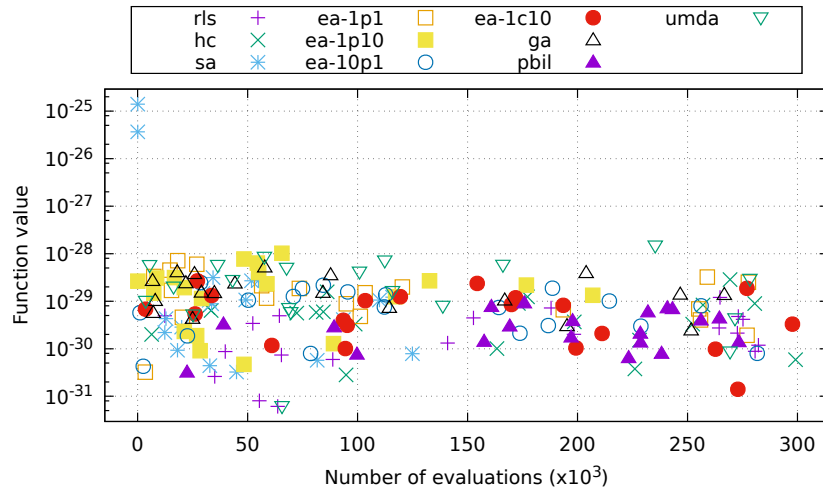| algorithm	function value					rk	time (s)	
	min	Q_1	med.	Q_3	max		mean	dev.
rls	6.1×10^{-32}	8.4×10^{-31}	2.1×10^{-30}	4.5×10^{-30}	1.2×10^{-29}	1	0.121	0.002
hc	2.8×10^{-31}	1.9×10^{-30}	5.7×10^{-30}	8.5×10^{-30}	2.9×10^{-29}	3	0.094	0.005
sa	3.2×10^{-31}	1.9×10^{-30}	9.6×10^{-30}	1.8×10^{-29}	1.4×10^{-25}	6	0.107	0.005
ea-1p1	3.2×10^{-31}	6.2×10^{-30}	1.6×10^{-29}	2.7×10^{-29}	7.1×10^{-29}	8	0.169	0.004
ea-1p10	4.7×10^{-31}	9.1×10^{-30}	2.1×10^{-29}	3.1×10^{-29}	1.0×10^{-28}	9	0.519	0.004
ea-10p1	4.3×10^{-31}	2.8×10^{-30}	7.8×10^{-30}	1.4×10^{-29}	2.5×10^{-29}	5	0.553	0.006
ea-1c10	1.4×10^{-31}	1.9×10^{-30}	6.1×10^{-30}	1.2×10^{-29}	2.7×10^{-29}	4	0.522	0.004
ga	2.5×10^{-30}	9.5×10^{-30}	1.5×10^{-29}	2.9×10^{-29}	5.2×10^{-29}	7	1.038	0.006
pbil	3.2×10^{-31}	1.4×10^{-30}	2.9×10^{-30}	4.8×10^{-30}	9.1×10^{-30}	2	0.755	0.019
umda	6.1×10^{-32}	6.8×10^{-30}	2.4×10^{-29}	5.7×10^{-29}	1.5×10^{-28}	10	0.541	0.007

Figure 27: ep

Figure 28: ep

16 Function cancel

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	0.15	1.11	1.54	1.88	2.30	8	0.101	0.011
hc	1.38	2.23	3.07	3.94	6.34	10	0.082	0.004
sa	0.06	1.71	2.38	2.90	4.60	9	0.100	0.000
ea-1p1	0.06	0.42	0.60	1.19	1.65	4	0.168	0.004
ea-1p10	0.12	0.42	0.83	1.33	2.62	6	0.516	0.006
ea-10p1	0.05	0.19	0.60	1.34	2.09	3	0.541	0.008
ea-1c10	0.08	0.20	0.69	1.35	2.58	5	0.515	0.005
ga	0.06	0.23	0.46	0.77	1.98	2	1.033	0.015
pbil	0.05	0.07	0.08	0.11	1.36	1	0.586	0.011
umda	0.13	0.67	1.22	1.93	3.19	7	0.530	0.006
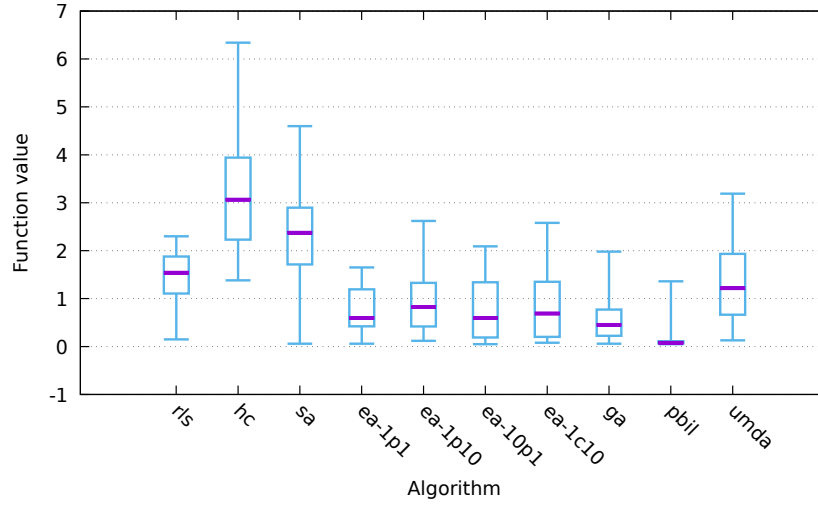
Figure 29: cancel
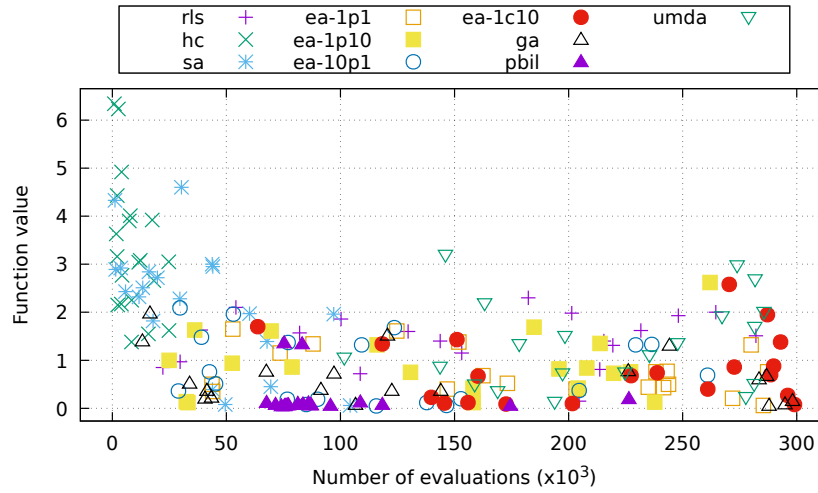
Figure 30: cancel

17

17 Function trap

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	91	91	91	91	92	2	0.092	0.004
hc	91	91	91	92	92	1	0.080	0.002
sa	90	90	90	91	91	3	0.099	0.004
ea-1p1	90	90	90	90	91	4	0.162	0.004
ea-1p10	90	90	90	90	90	6	0.513	0.006
ea-10p1	90	90	90	90	91	4	0.541	0.009
ea-1c10	90	90	90	90	90	6	0.519	0.011
ga	90	90	90	90	90	6	1.025	0.009
pbil	90	90	90	90	90	6	0.551	0.015
umda	90	90	90	90	90	6	0.533	0.016
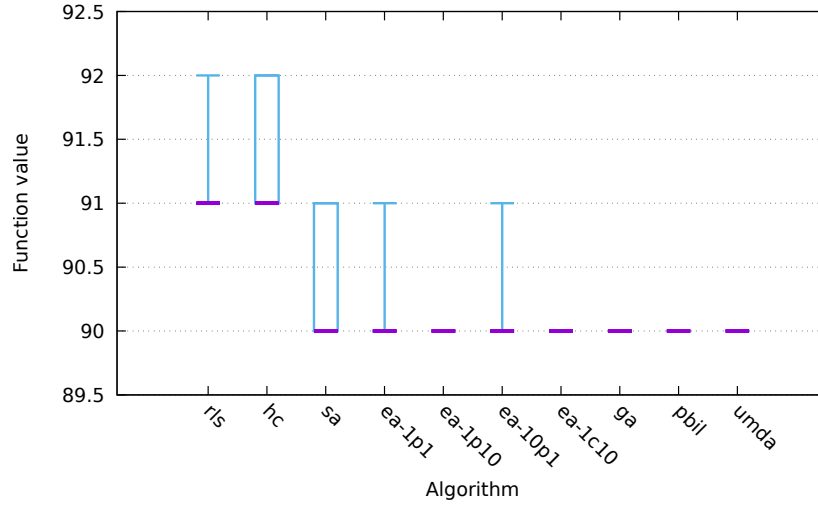
Figure 31: trap
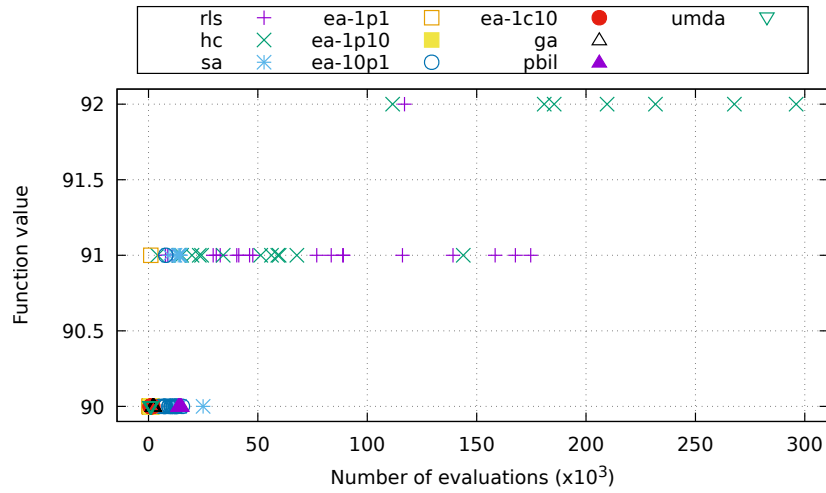
Figure 32: trap

18 Function hiff

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	400	410	416	420	434	10	0.308	0.015
hc	480	500	510	521	568	5	0.278	0.006
sa	640	672	704	744	896	1	0.317	0.012
ea-1p1	432	456	484	504	536	9	0.363	0.009
ea-1p10	456	480	496	524	568	8	0.825	0.008
ea-10p1	528	608	656	704	800	3	0.879	0.008
ea-1c10	584	640	658	692	776	2	0.849	0.011
ga	456	480	504	516	560	6	1.442	0.008
pbil	472	518	536	560	608	4	0.898	0.008
umda	452	486	498	528	568	7	0.848	0.008
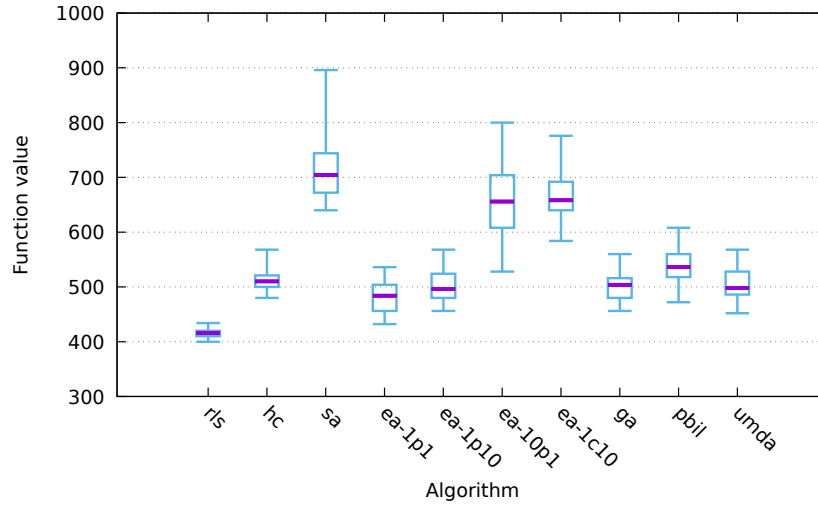
Figure 33: hiff
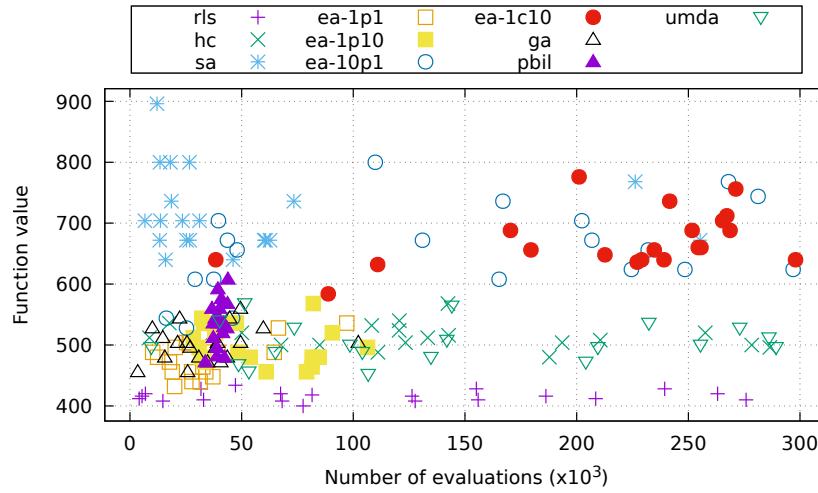
Figure 34: hiff

19 Function plateau

algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	101	101	101	101	101	4	0.071	0.003
hc	101	101	101	101	102	2	0.061	0.011
sa	101	101	101	102	102	1	0.073	0.022
ea-1p1	101	101	101	101	102	2	0.149	0.012
ea-1p10	101	101	101	101	101	4	0.503	0.009
ea-10p1	101	101	101	101	101	4	0.525	0.012
ea-1c10	101	101	101	101	101	4	0.502	0.004
ga	101	101	101	101	101	4	1.039	0.034
pbil	101	101	101	101	101	4	0.524	0.005
umda	101	101	101	101	101	4	0.511	0.003
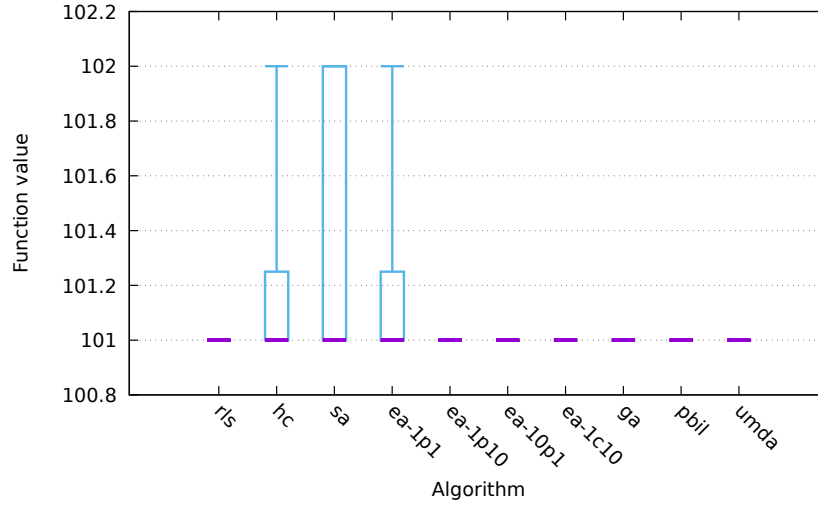
Figure 35: plateau
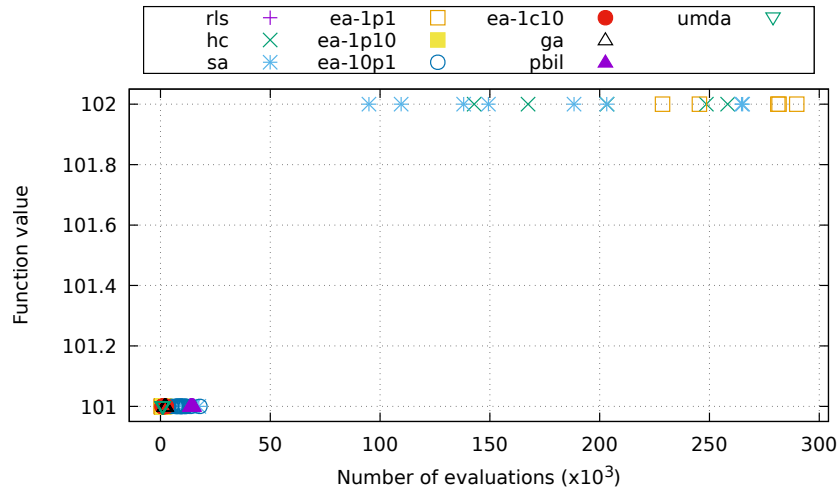
Figure 36: plateau

20 Function walsh2

| algorithm	function value						time (s)	
	min	Q_1	med.	Q_3	max	rk	mean	dev.
rls	689.45	696.41	704.22	707.99	712.93	4	2.376	0.093
hc	699.91	708.03	714.03	720.04	721.22	1	2.443	0.017
sa	697.00	702.06	709.61	713.69	721.22	2	0.487	0.046
ea-1p1	636.33	667.22	687.25	695.02	721.22	6	0.665	0.024
ea-1p10	609.35	662.43	672.42	681.70	716.57	7	0.913	0.024
ea-10p1	660.96	689.76	699.77	714.70	721.22	5	1.268	0.072
ea-1c10	688.35	698.69	707.77	720.24	721.22	3	1.222	0.089
ga	609.04	655.74	661.75	691.01	718.26	9	1.453	0.046
pbil	620.24	647.93	658.54	683.79	720.85	10	1.308	0.043
umda	612.24	652.50	667.96	684.47	705.37	8	0.932	0.019
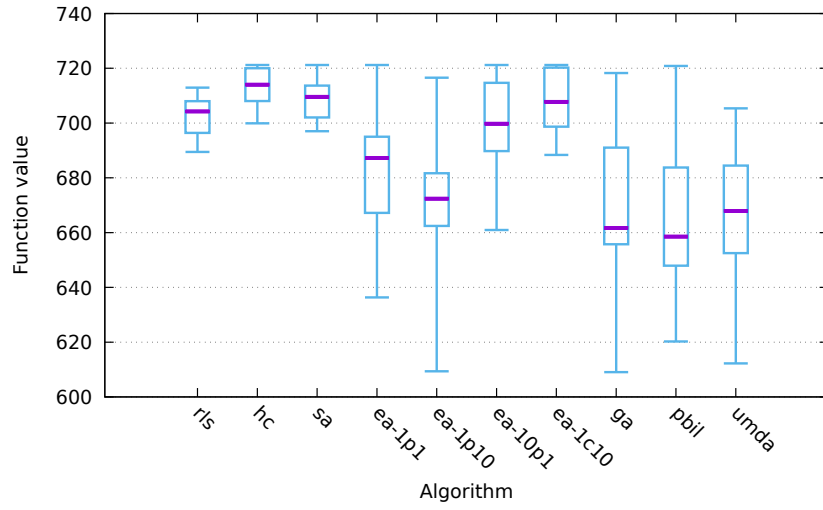
Figure 37: walsh2
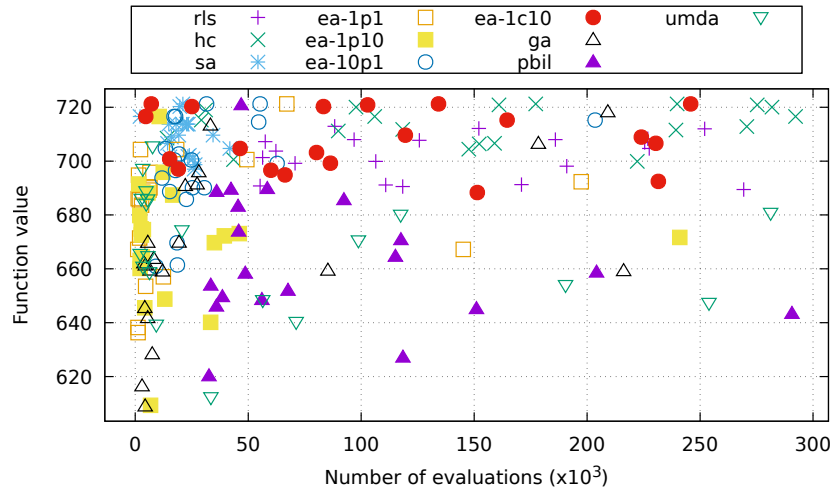
Figure 38: walsh2

A Plan

```
{
    "exec": "hnco",
```

```json
"opt": "--print-performance --map 1 --map-random -s 100 -i 0 -b 300000",
"num_runs": 20,
"parallel": false,
"results": "results",
"graphics": "graphics",
"report": "report",
"functions": [
    {
        "id": "one-max",
        "opt": "-F 0 --stop-on-maximum",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "lin",
        "opt": "-F 1 -p instances/lin.100",
        "col": ">{{\\nprounddigits{2}}}N{2}{2}"
    },
    {
        "id": "leading-ones",
        "opt": "-F 10 --stop-on-maximum",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "ridge",
        "opt": "-F 11 --stop-on-maximum",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "jmp-5",
        "opt": "-F 30 --stop-on-maximum -t 5",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "jmp-10",
        "opt": "-F 30 --stop-on-maximum -t 10",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "djmp-5",
        "opt": "-F 31 --stop-on-maximum -t 5",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "djmp-10",
        "opt": "-F 31 --stop-on-maximum -t 10",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "fp-5",
        "opt": "-F 40 --stop-on-maximum -t 5",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "fp-10",
        "opt": "-F 40 --stop-on-maximum -t 10",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {
        "id": "nk",
        "opt": "-F 60 -p instances/nk.100.4",
        "col": ">{{\\nprounddigits{2}}}N{1}{2}"
    },
    {
```

```json
        "id": "max-sat",
        "opt": "-F 70 -p instances/ms.100.3.1000 --cache",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {

        "id": "labs",
        "opt": "-F 80",
        "col": ">{{\\nprounddigits{2}}}N{1}{2}"
    },
    {

        "id": "ep",
        "opt": "-F 90 -p instances/ep.100",
        "reverse": true,
        "logscale": true,
        "col": ">{{\\nprounddigits{1}}}N{1}{1}"
    },
    {

        "id": "cancel",
        "opt": "-F 100 -s 99",
        "reverse": true,
        "col": ">{{\\nprounddigits{2}}}N{1}{2}"
    },
    {

        "id": "trap",
        "opt": "-F 110 --stop-on-maximum --fun-num-traps 10",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {

        "id": "hiff",
        "opt": "-F 120 --stop-on-maximum -s 128",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {

        "id": "plateau",
        "opt": "-F 130 --stop-on-maximum",
        "col": ">{{\\nprounddigits{0}}}N{3}{0}"
    },
    {

        "id": "walsh2",
        "opt": "-F 162 -p instances/walsh2.100 --cache",
        "col": ">{{\\nprounddigits{2}}}N{3}{2}"
    }
],
"algorithms": [
    {
        "id": "rls",
        "opt": "-A 100 --restart"
    },
    {

        "id": "hc",
        "opt": "-A 150 --restart"
    },
    {

        "id": "sa",
        "opt": "-A 200 --sa-rate 1.05 --sa-num-trials 10"
    },
    {

        "id": "ea-1p1",
        "opt": "-A 300"
    },
    {

        "id": "ea-1p10",
        "opt": "-A 310 --ea-mu 1 --ea-lambda 10"
```

```
        },
        {
            "id": "ea-10p1",
            "opt": "-A 310 --ea-mu 10 --ea-lambda 1"
        },
        {

            "id": "ea-1c10",
            "opt": "-A 320 --ea-mu 1 --ea-lambda 10"
        },
        {

            "id": "ga",
            "opt": "-A 400 --ea-mu 100"
        },
        {

            "id": "pbil",
            "opt": "-A 500 -r 5e-3"
        },
        {

            "id": "umda",
            "opt": "-A 600 -x 100 -y 10"
        }
    ]
}
```

B   Default parameters

```
# algorithm = 100
# bm_mc_reset_strategy = 1
# bm_num_gs_cycles = 1
# bm_num_gs_steps = 100
# bm_sampling = 1
# budget = 10000
# bv_size = 100
# ea_lambda = 100
# ea_mu = 10
# fun_name = noname
# fun_num_traps = 10
# fun_prefix_length = 2
# fun_threshold = 10
# function = 0
# ga_crossover_probability = 0.5
# ga_tournament_size = 10
# hea_binary_dynamics = 0
# hea_delay = 10000
# hea_num_par_updates = 1
# hea_num_seq_updates = 100
# hea_rate_strategy = 0
# hea_reset_period = 0
# hea_sampling_method = 0
# hea_time_constant = 1000
# hea_weight = 1
# learning_rate = 0.001
# map = 0
# map_input_size = 100
# map_path = nopath
# neighborhood = 0
# neighborhood_iterator = 0
# noise_stddev = 1
# num_iterations = 0
# num_threads = 1
# path = nopath
# population_size = 10
```

```
# pv_log_num_components = 5
# radius = 2
# rls_patience = 50
# sa_initial_acceptance_probability = 0.6
# sa_num_transitions = 50
# sa_num_trials = 100
# sa_rate = 1.2
# scaled_mutation_probability = 1
# seed = 0
# selection_size = 1
# target = 100
# print_default_parameters
# last_parameter
# exec_name = hnco
# version = 0.7
# Generated from hnco.json
```