Report of Experiment ExpF. k-Symmetry: Scalability of Learning by Grammar Tuning and Language Tuning

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Abstract

Grammar tuning adapts the language. Language tuning adds new language elements. In this experiment we study the complexity of learning with increasing k with a grammar with symmetric pairs and an additional function.

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5 C xega

Description of Experiment

The purpose of this computational experiment is to study the development of `Seconds` and `t` Generations with increasing k for the grammar T5.

The **problem environment** is the k-symmetry problem: Finding a boolean expression (with and, or, and not) which is TRUE for symmetric k-bit strings.

The **solution method** is grammar-based genetic programming (option `algorithm="sgp"` of `xegaRun`). The **solver** used is `xegaRun` from the R-package `xega`.

The experiment consists of 11 treatments, 1 grammar for 11 problem sizes $k \in 2, \ldots, 12$.

Description of Experiment

The control variable in this experiment is

- the bit-length of the k-symmetry problem: 2 to 12. for grammar **T5**:
  1. With symmetric pairs.
  2. And a new base function, the function sPair(x, y) which is implemented by
     sPair <- function(x,y)
     {OR(AND(x,y),AND(NOT(x),NOT(y)))}

Common Parameters of Experiment ExpF

	Parameter Value
Experiment	EE
Optimize	Minimize!
Trials	40
Algorithm	sgp
Max.Depth.of.DTs	7
Grammar	AndOrNotTuned5.txt
Replay	0
Evaluation.Method	Deterministic
Execution.Model	MultiCore
Verbose	1
Semantics	byValue
Report.Eval.Errors	TRUE
Termination.Condition	AbsoluteError
Termination.Eps	-0.1
Gene.Map	Bin2Dec

Table: Common Parameters of Experiment ExpF (Part 1)

Common Parameters of Experiment ExpF

	Parameter Value
Init.Gene	InitGene
Codon.Precision	LCM
Population.Size	400
Max.Generations	1000
Crossover.Rate	0.2
Mutation.Rate	0.4
IV.Crossover.Rate	Const
Crossover.Rate.2	0.4
IV.Mutation.Rate	Const
Mutation.Rate.2	0.8

Table: Common Parameters of Experiment ExpF (Part 2)

Parameters of Treatments of Experiment ExpF

	Treatment	Problem Environment	Worst Fitness	Codons
1	BoolT5sgp02k	2-Symmetry Problem	-4	80
2	BoolT5sgp03k	3-Symmetry Problem	-8	120
3	BoolT5sgp04k	4-Symmetry Problem	-16	160
4	BoolT5sgp05k	5-Symmetry Problem	-32	200
5	BoolT5sgp06k	6-Symmetry Problem	-64	240
6	BoolT5sgp07k	7-Symmetry Problem	-128	280
7	BoolT5sgp08k	8-Symmetry Problem	-256	320
8	BoolT5sgp09k	9-Symmetry Problem	-512	360
9	BoolT5sgp10k	10-Symmetry Problem	-1024	400
10	BoolT5sgp11k	11-Symmetry Problem	-2048	440
11	BoolT5sgp12k	12-Symmetry Problem	-4096	480

Table: Parameters of Treatments of Experiment ExpF

The Production Table of Experiment ExpF

	LHS	RHS
1	<fe>	<f0>
2	<fe>	<f1>(<fe>)
3	<fe>	<f2>(<fe>,<fe>)
4	<f0>	D1
5	<f0>	D2
6	<fe>	sPair<sympairs>
7	<sympairs>	(D1,D2)
8	<sympairs>	(NOT(D1),NOT(D2))
9	<f1>	NOT
10	<f2>	OR
11	<f2>	AND

Table: The Production Table of Experiment ExpF

Fitness. k=2, ... 12.

	Treatment	Trials	Variable	min	mean	sd	max
1	BoolT5sgp02k	40	Fitness	0.00	0.00	0.00	0.00
5	BoolT5sgp03k	40	Fitness	0.00	0.00	0.00	0.00
9	BoolT5sgp04k	40	Fitness	0.00	0.00	0.00	0.00
13	BoolT5sgp05k	40	Fitness	0.00	0.00	0.00	0.00
17	BoolT5sgp06k	40	Fitness	0.00	0.00	0.00	0.00
21	BoolT5sgp07k	40	Fitness	0.00	0.00	0.00	0.00
25	BoolT5sgp08k	40	Fitness	0.00	0.00	0.00	0.00
29	BoolT5sgp09k	40	Fitness	0.00	0.00	0.00	0.00
33	BoolT5sgp10k	40	Fitness	0.00	0.00	0.00	0.00
37	BoolT5sgp11k	40	Fitness	0.00	0.00	0.00	0.00
41	BoolT5sgp12k	40	Fitness	0.00	0.80	5.06	32.00

Table: Fitness. k=2, ... 12.

Seconds. k=2, ... 12.

	Treatment	Trials	Variable	min	mean	sd	max
2	BoolT5sgp02k	40	Seconds	0.28	0.43	0.16	0.97
6	BoolT5sgp03k	40	Seconds	0.30	0.46	0.15	0.84
10	BoolT5sgp04k	40	Seconds	0.37	0.55	0.20	1.08
14	BoolT5sgp05k	40	Seconds	0.41	0.64	0.20	1.28
18	BoolT5sgp06k	40	Seconds	0.54	2.59	1.77	6.32
22	BoolT5sgp07k	40	Seconds	0.99	3.97	3.29	18.66
26	BoolT5sgp08k	40	Seconds	3.43	27.82	23.84	97.55
30	BoolT5sgp09k	40	Seconds	1.61	28.24	17.52	65.63
34	BoolT5sgp10k	40	Seconds	34.67	284.52	238.05	1134.77
38	BoolT5sgp11k	40	Seconds	56.67	644.85	493.13	1832.77
42	BoolT5sgp12k	40	Seconds	470.98	4376.96	3895.03	19775.30

Table: Seconds. k=2, ... 12.

Generations. k=2, ... 12.

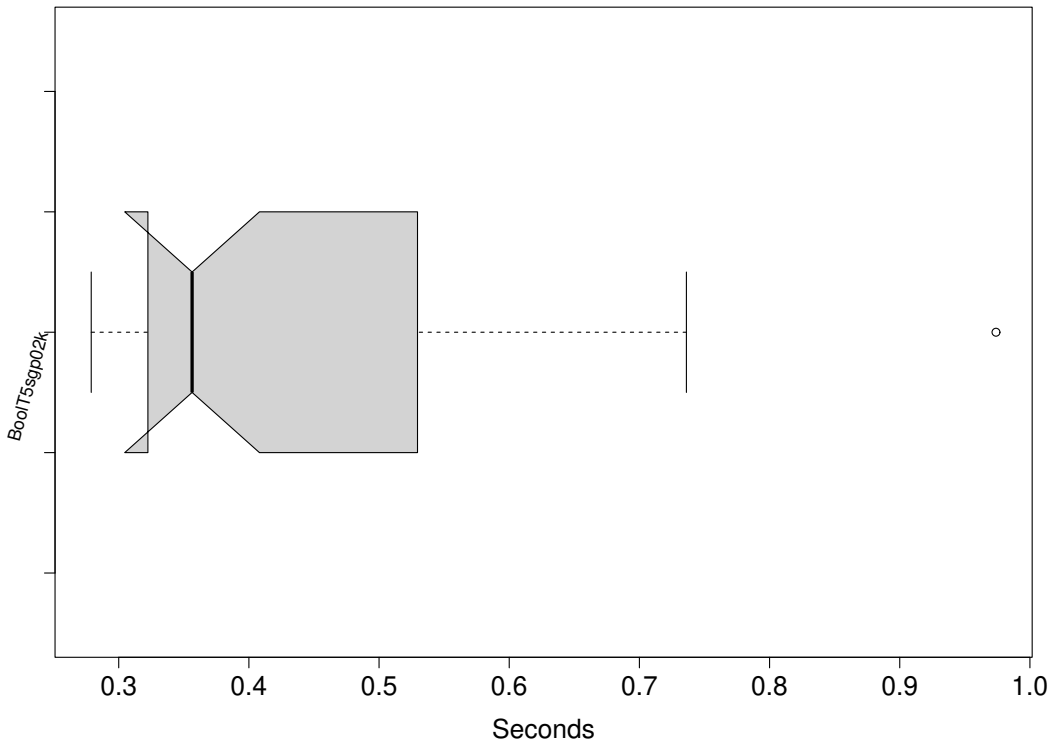
	Treatment	Trials	Variable	min	mean	sd	max
3	BoolT5sgp02k	40	Generations	1.00	1.00	0.00	1.00
7	BoolT5sgp03k	40	Generations	1.00	1.00	0.00	1.00
11	BoolT5sgp04k	40	Generations	1.00	1.02	0.16	2.00
15	BoolT5sgp05k	40	Generations	1.00	1.00	0.00	1.00
19	BoolT5sgp06k	40	Generations	1.00	5.08	3.35	13.00
23	BoolT5sgp07k	40	Generations	1.00	5.92	4.83	28.00
27	BoolT5sgp08k	40	Generations	4.00	23.88	15.00	59.00
31	BoolT5sgp09k	40	Generations	1.00	15.97	8.67	38.00
35	BoolT5sgp10k	40	Generations	14.00	73.85	53.10	234.00
39	BoolT5sgp11k	40	Generations	12.00	87.50	55.35	195.00
43	BoolT5sgp12k	40	Generations	40.00	284.20	216.58	1000.00

Table: Generations. k=2, ... 12.

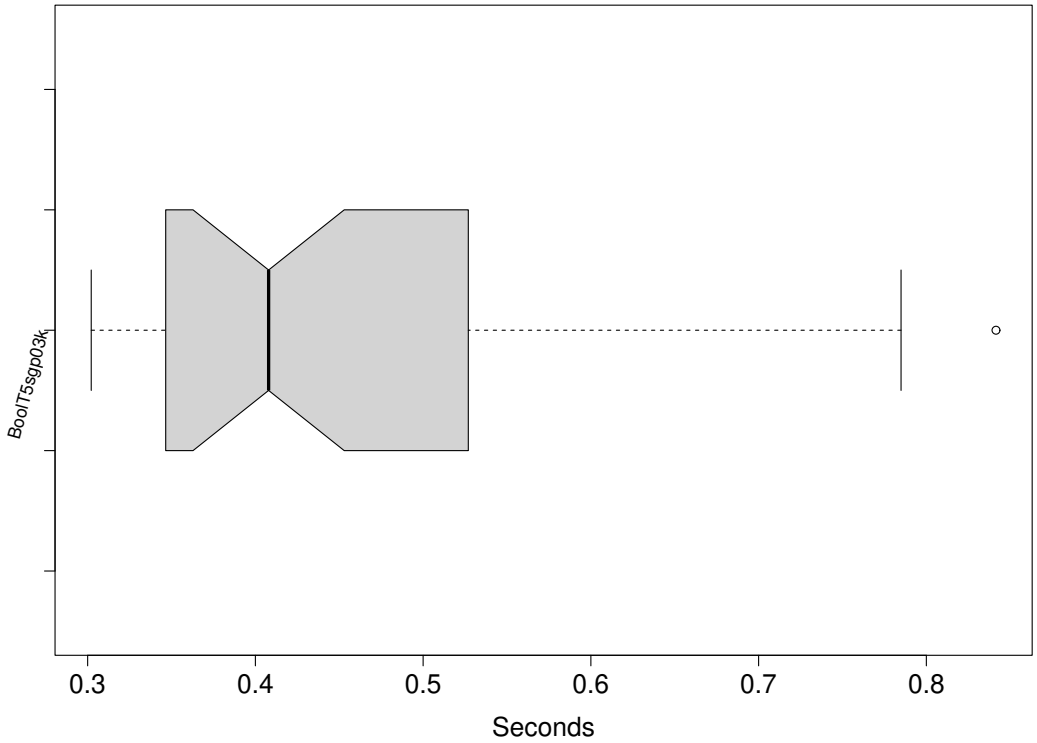
Do we always find the optimal program?

- For grammar T5: **No.** Not for the 12-symmetry problem.
- For the the 12-symmetry problem, errors range from $0 - 32$ with a mean of 0.80 and a standard deviation of 5.06 for 40 trials.

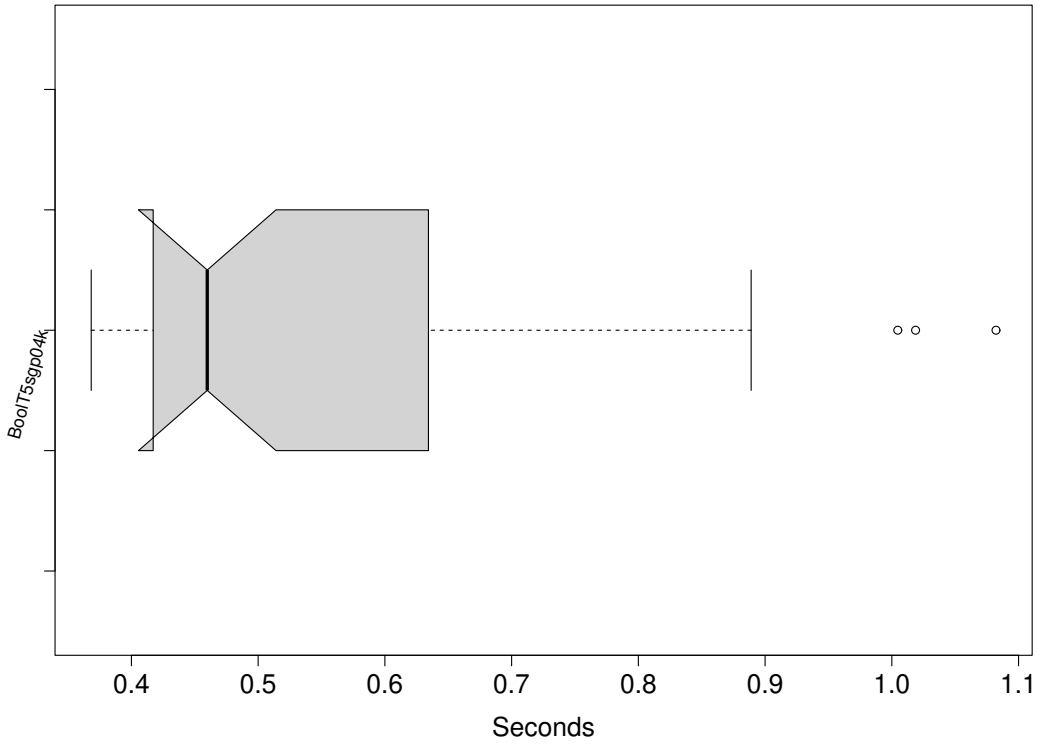
Distribution of Time (s) for Grammar T5. 2-symmetry.



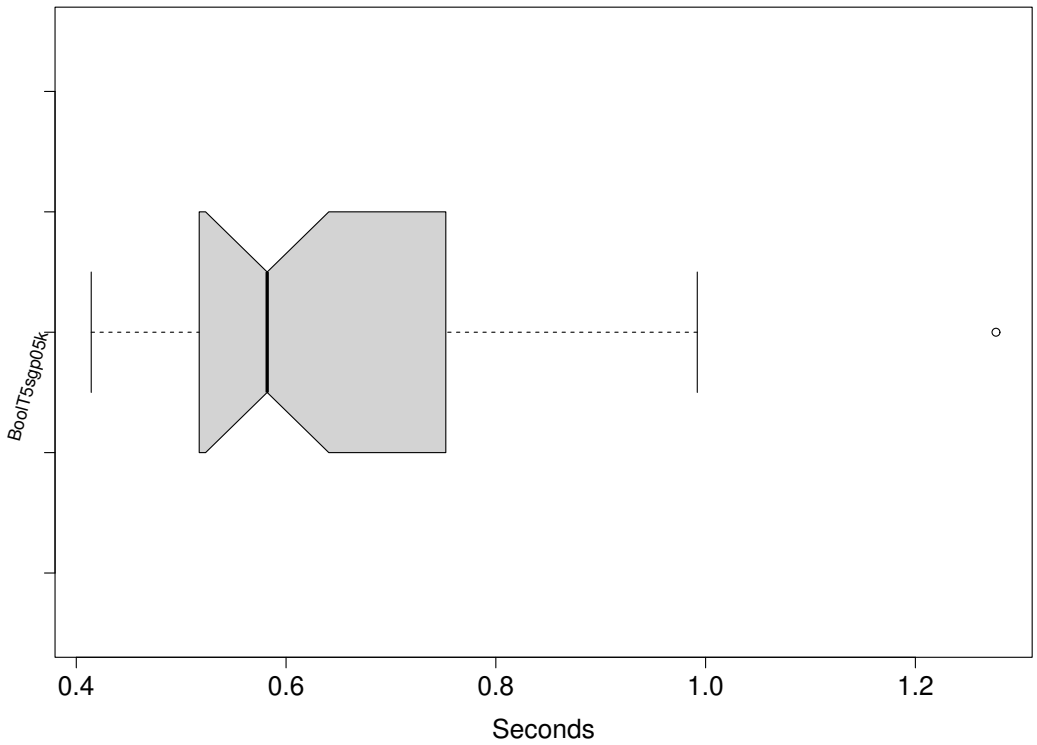
Distribution of Time (s) for Grammar T5. 3-symmetry.



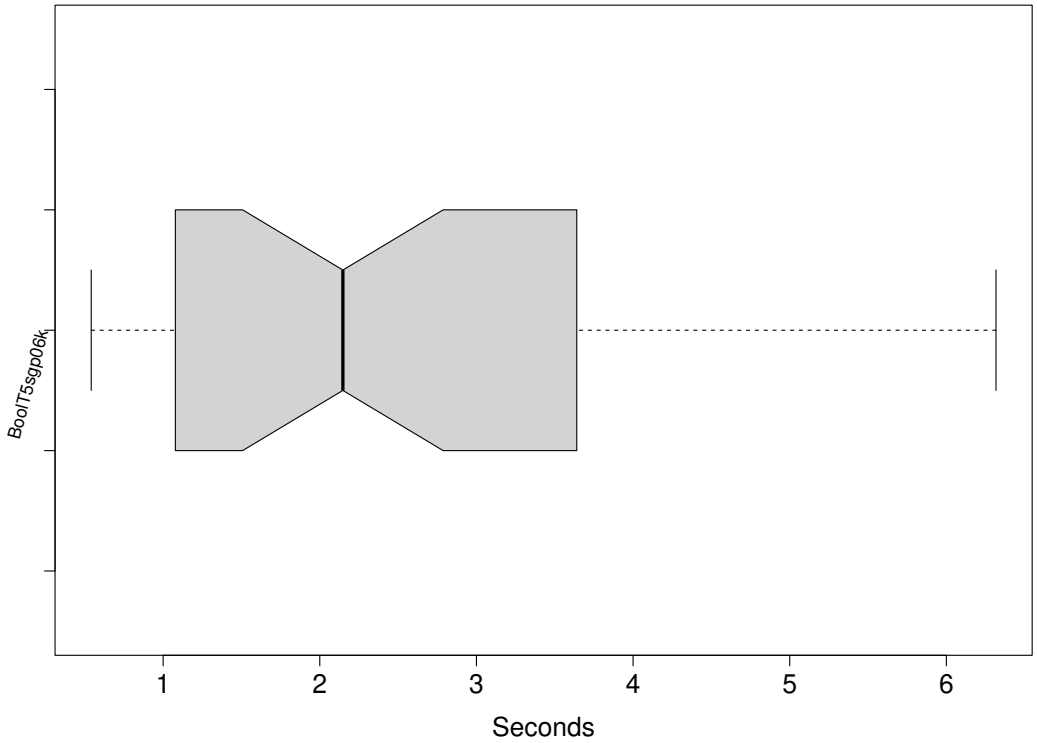
Distribution of Time (s) for Grammar T5. 4-symmetry.



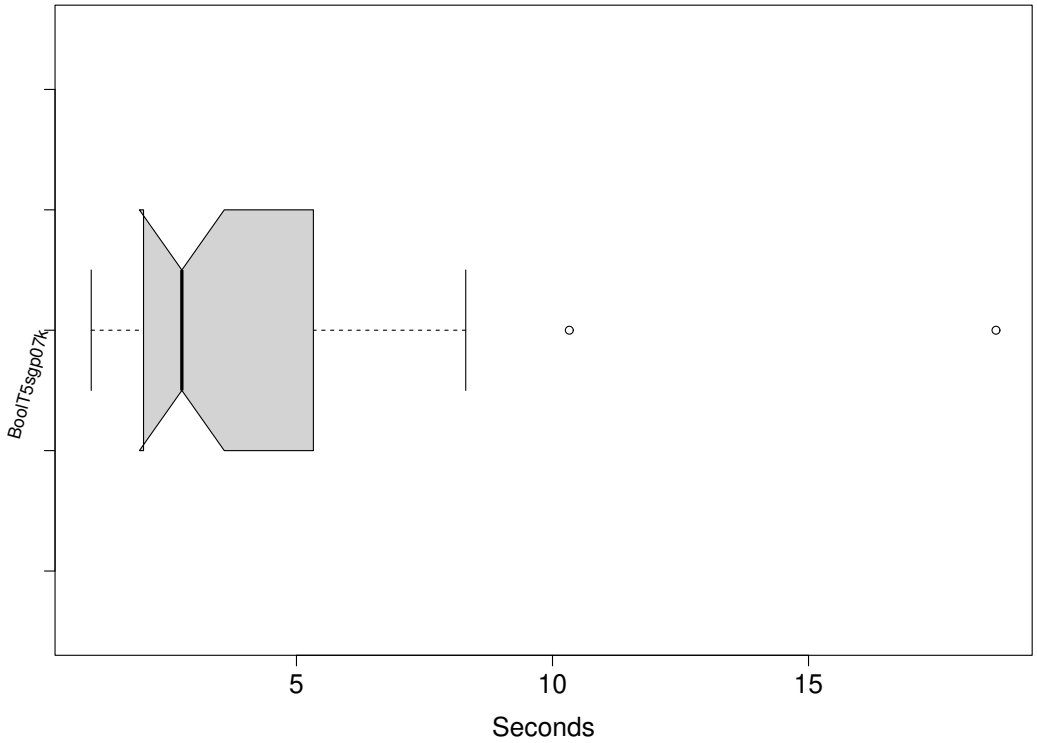
Distribution of Time (s) for Grammar T5. 5-symmetry.



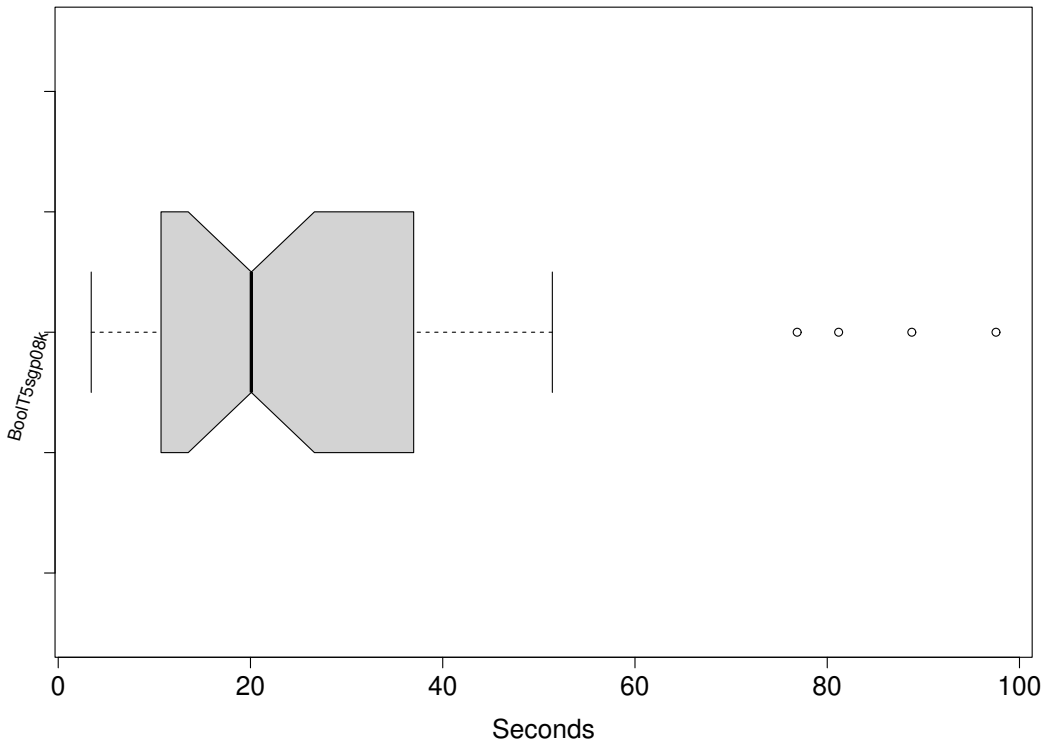
Distribution of Time (s) for Grammar T5. 6-symmetry.



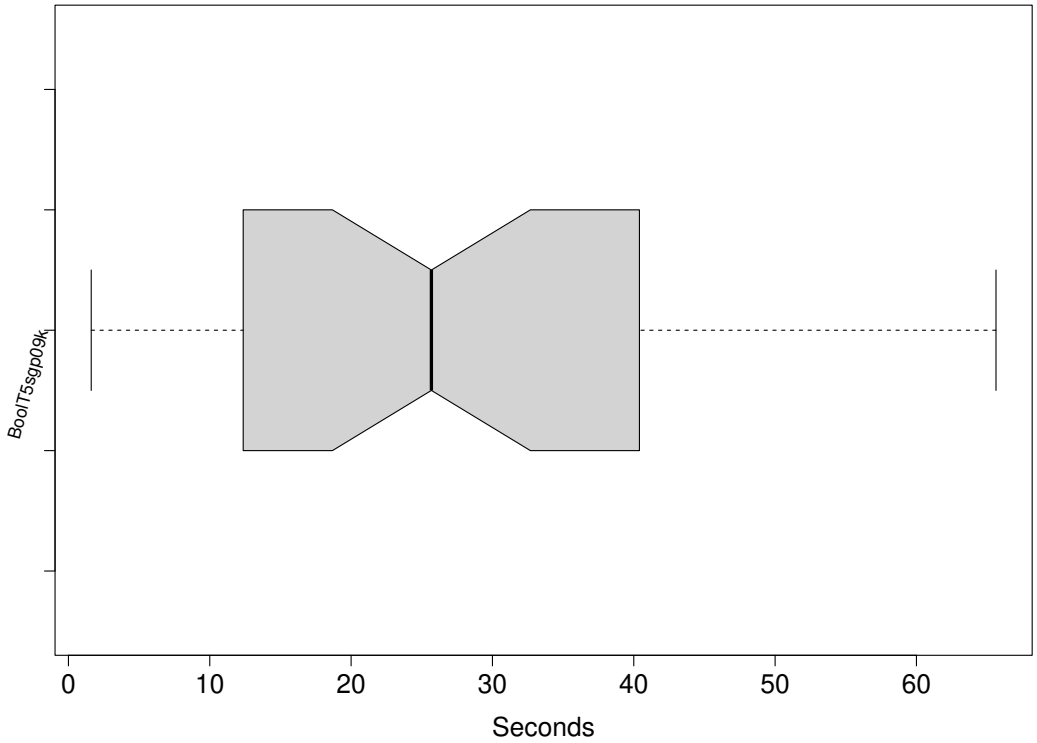
Distribution of Time (s) for Grammar T5. 7-symmetry.



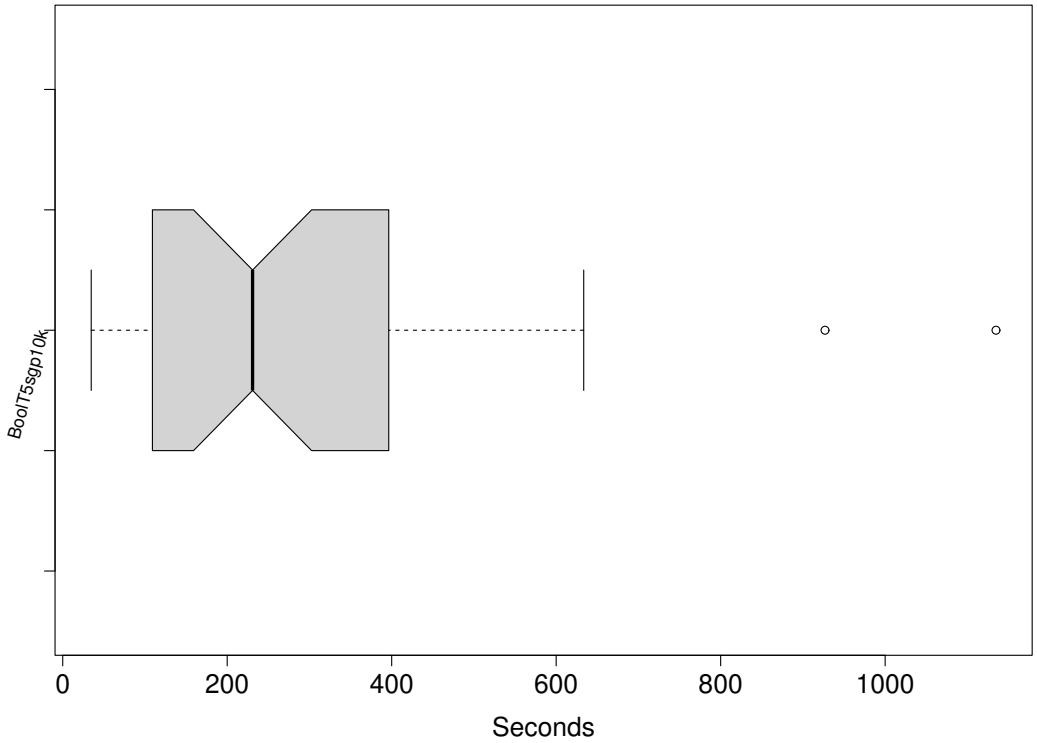
Distribution of Time (s) for Grammar T5. 8-symmetry.



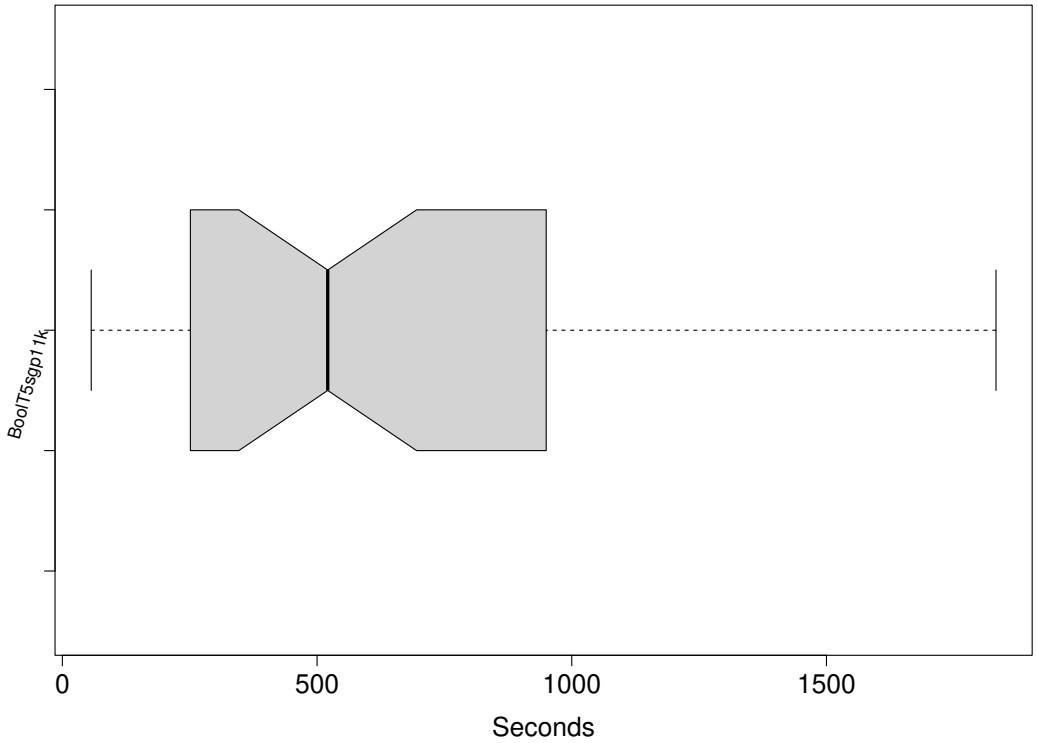
Distribution of Time (s) for Grammar T5. 9-symmetry.



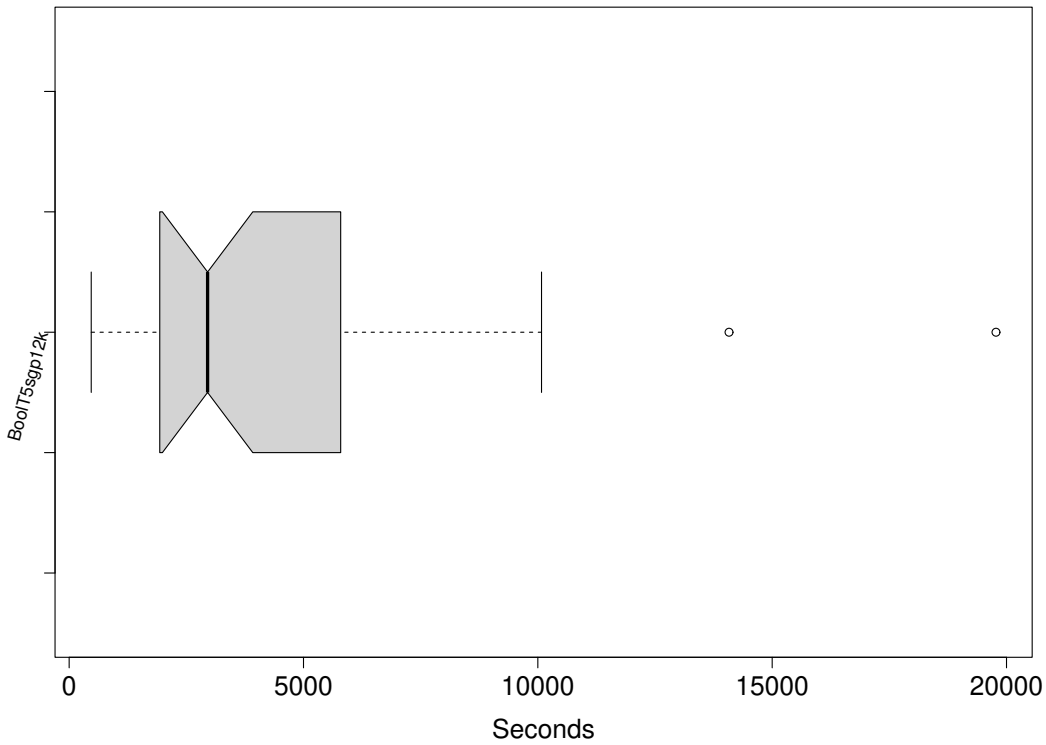
Distribution of Time (s) for Grammar T5. 10-symmetry.



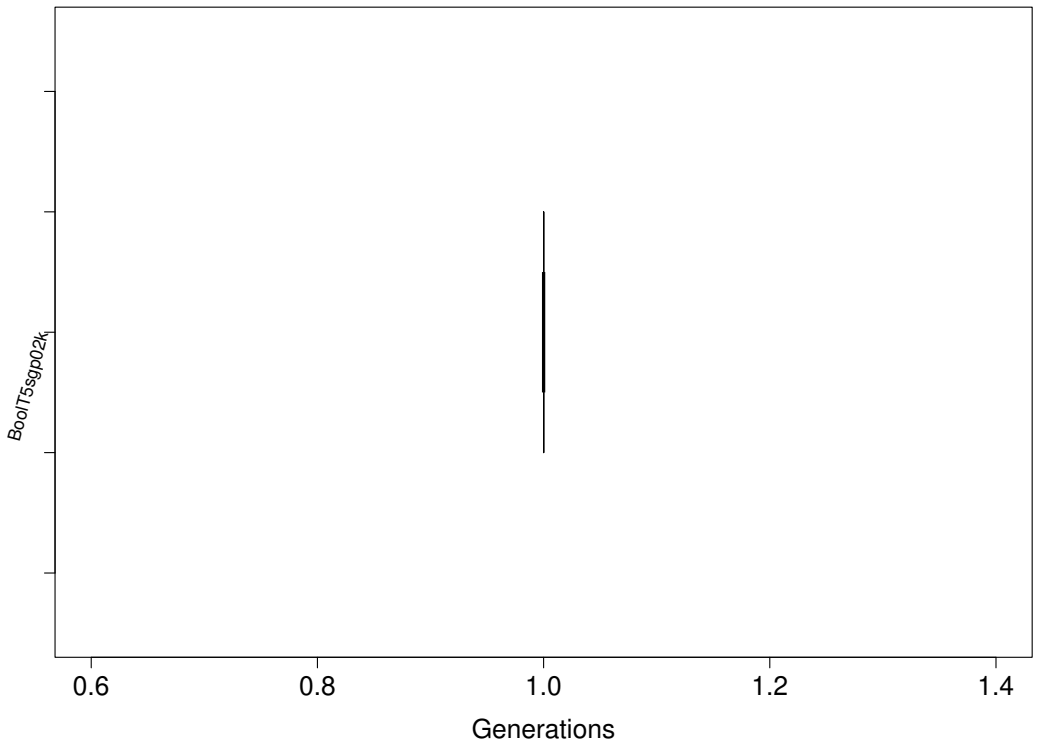
Distribution of Time (s) for Grammar T5. 11-symmetry.



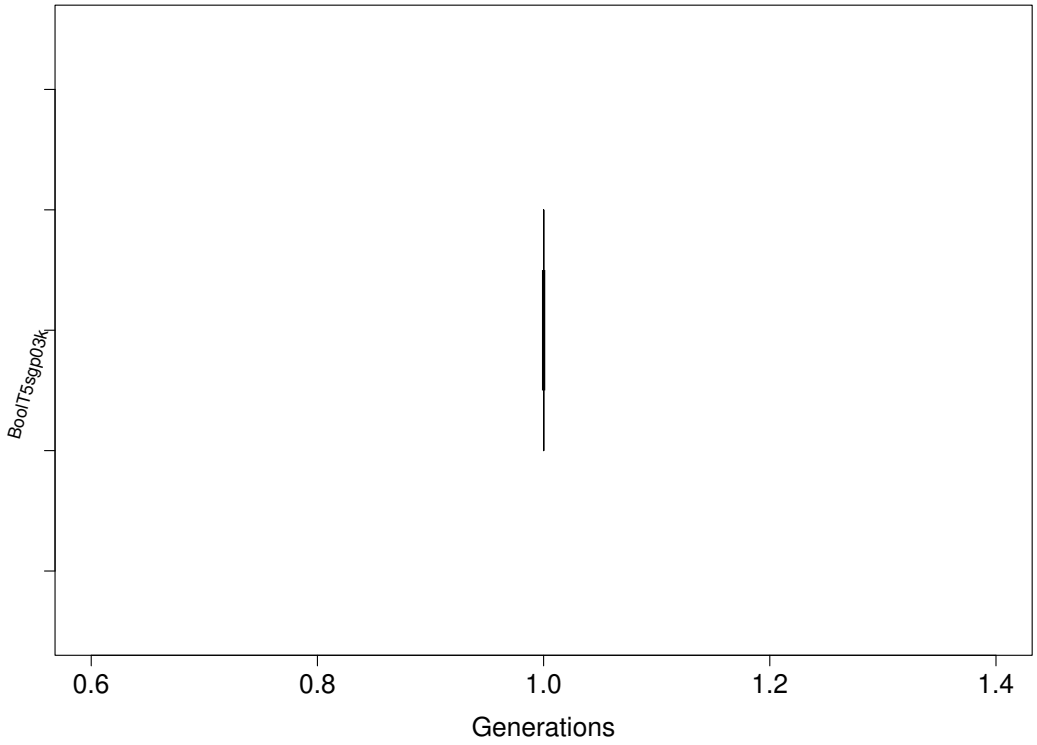
Distribution of Time (s) for Grammar T5. 12-symmetry.



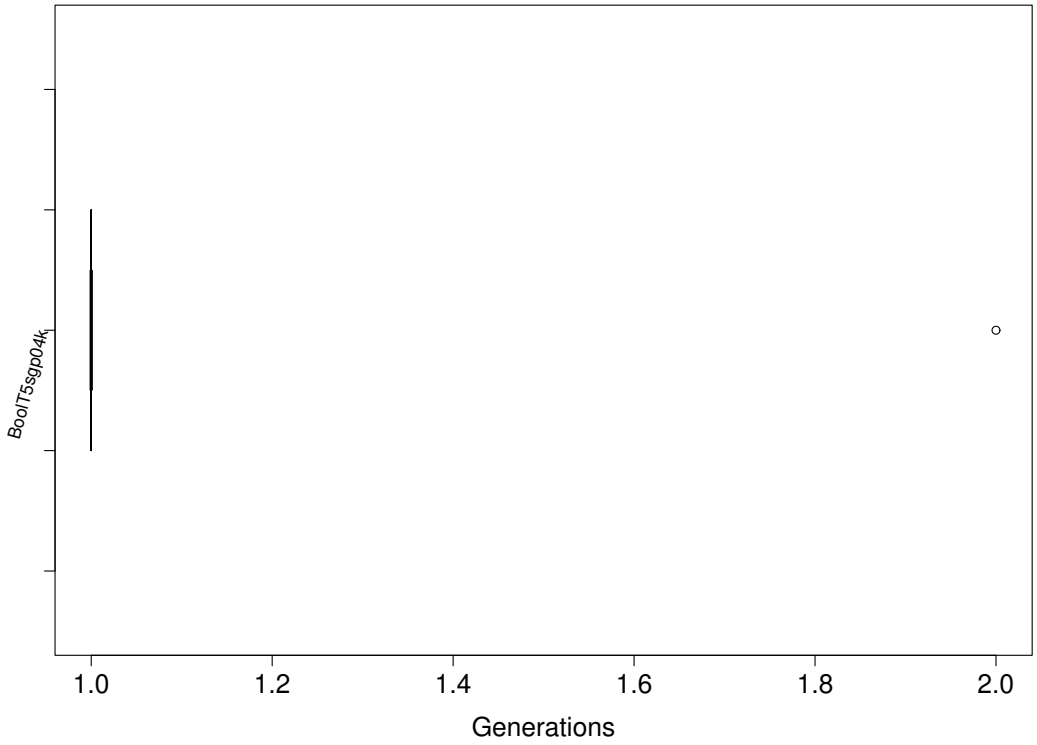
Distribution of Number of Generations for Grammar T5. 2-symmetry.



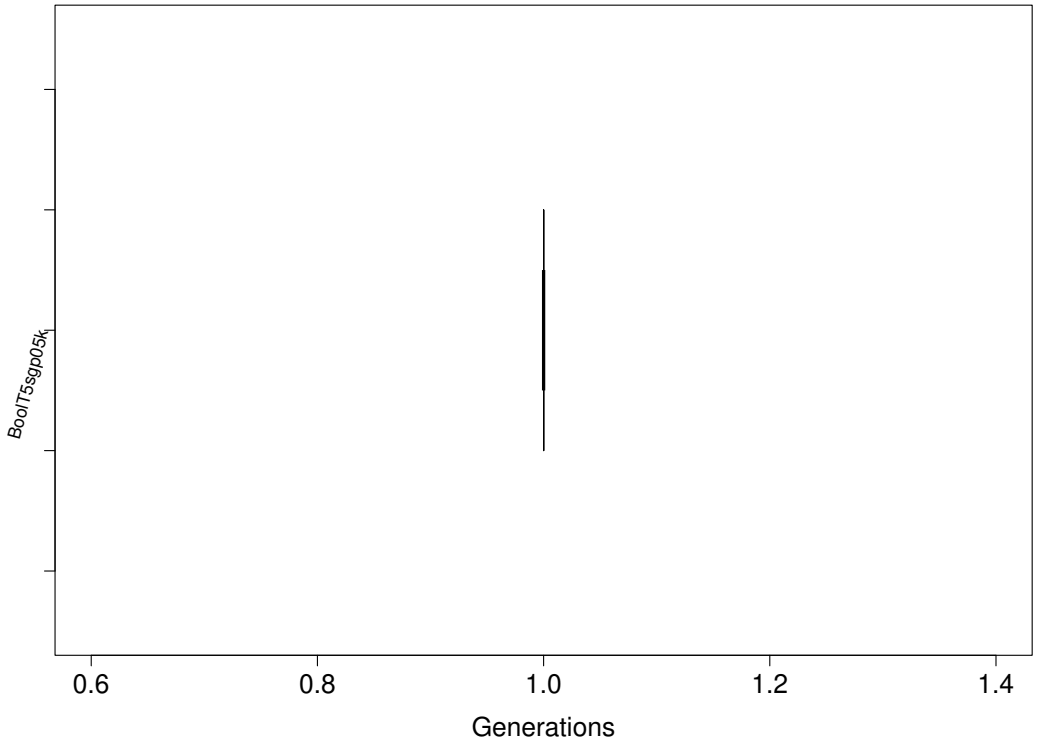
Distribution of Number of Generations for Grammar T5. 3-symmetry.



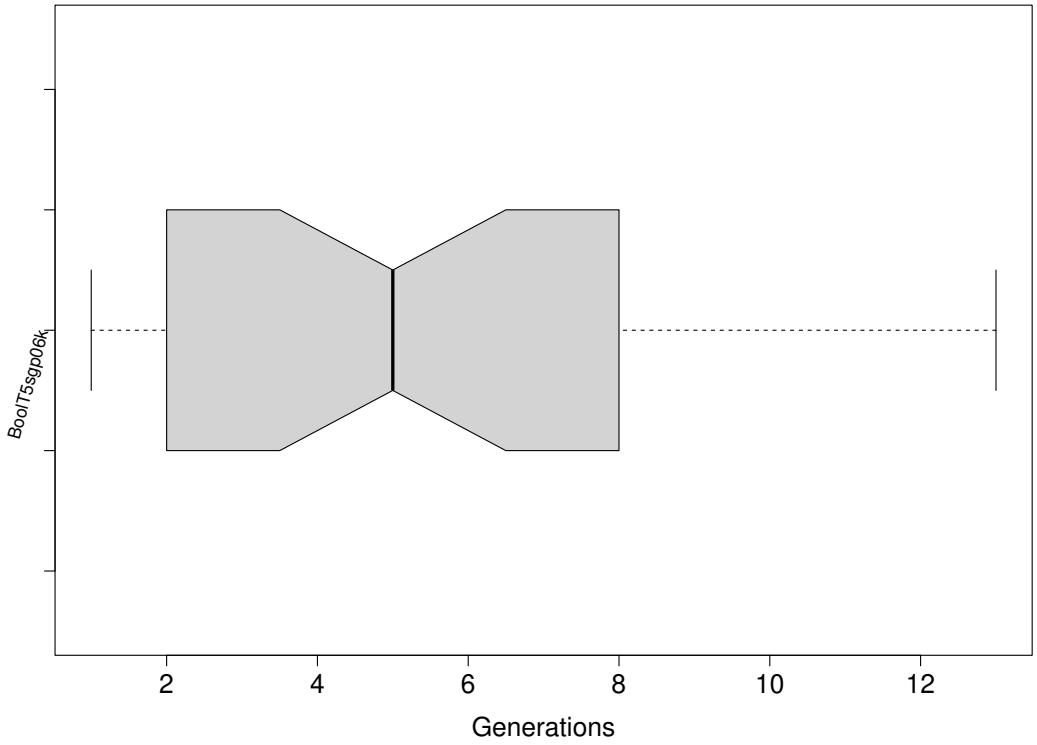
Distribution of Number of Generations for Grammar T5. 4-symmetry.



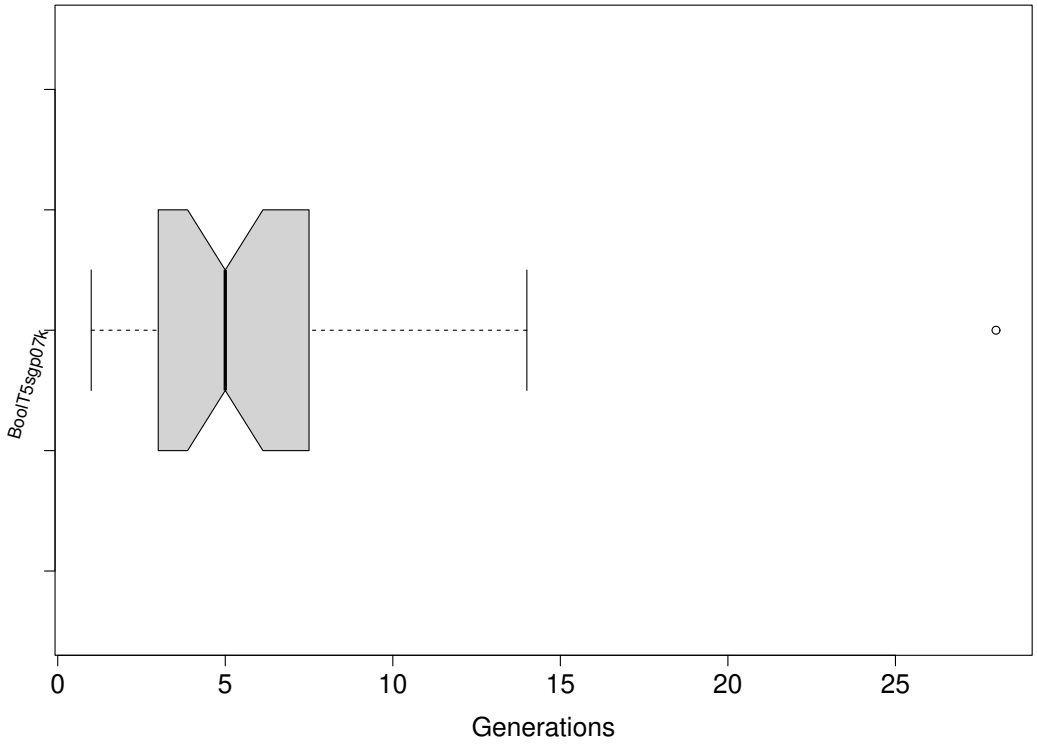
Distribution of Number of Generations for Grammar T5. 5-symmetry.



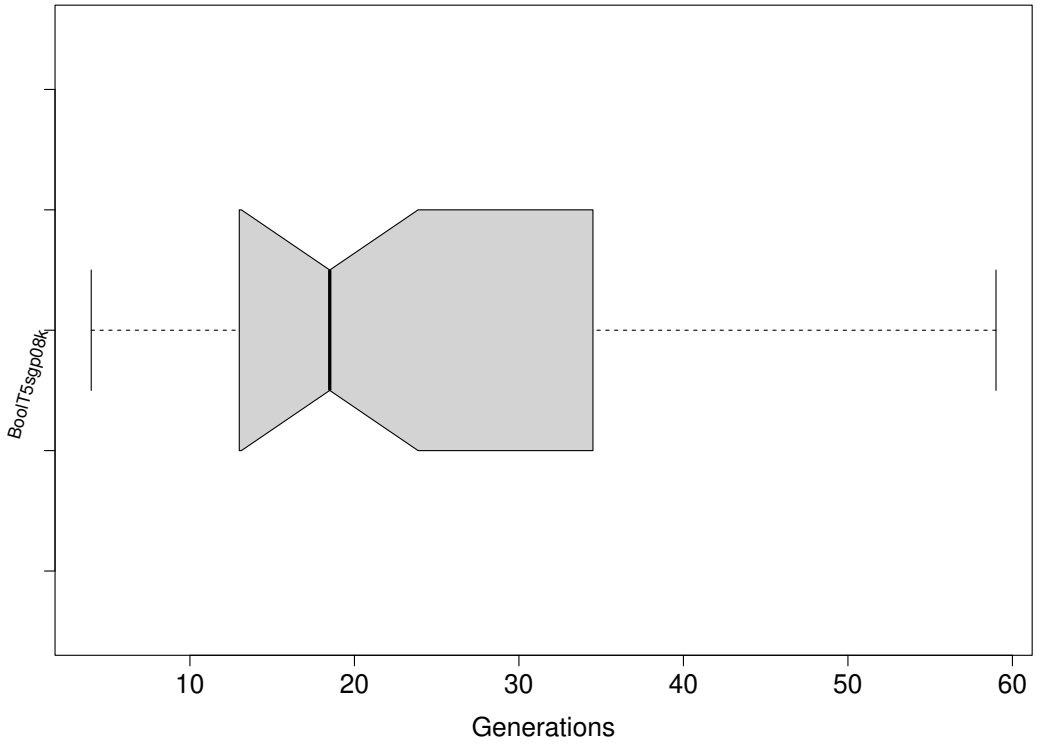
Distribution of Number of Generations for Grammar T5. 6-symmetry.



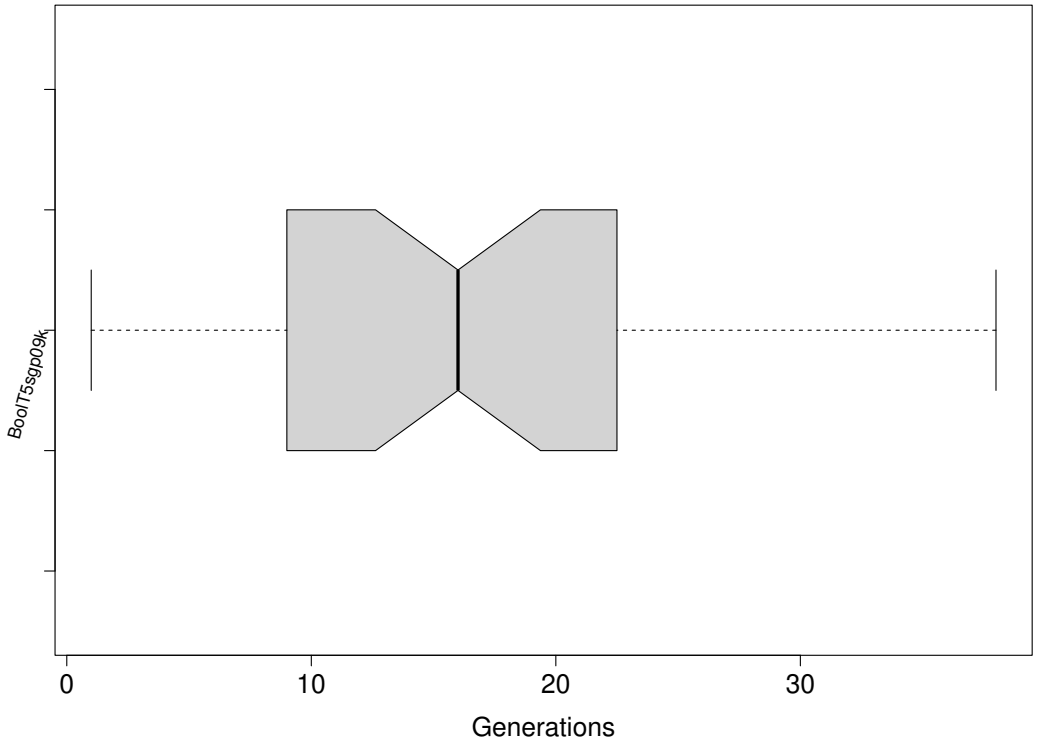
Distribution of Number of Generations for Grammar T5. 7-symmetry.



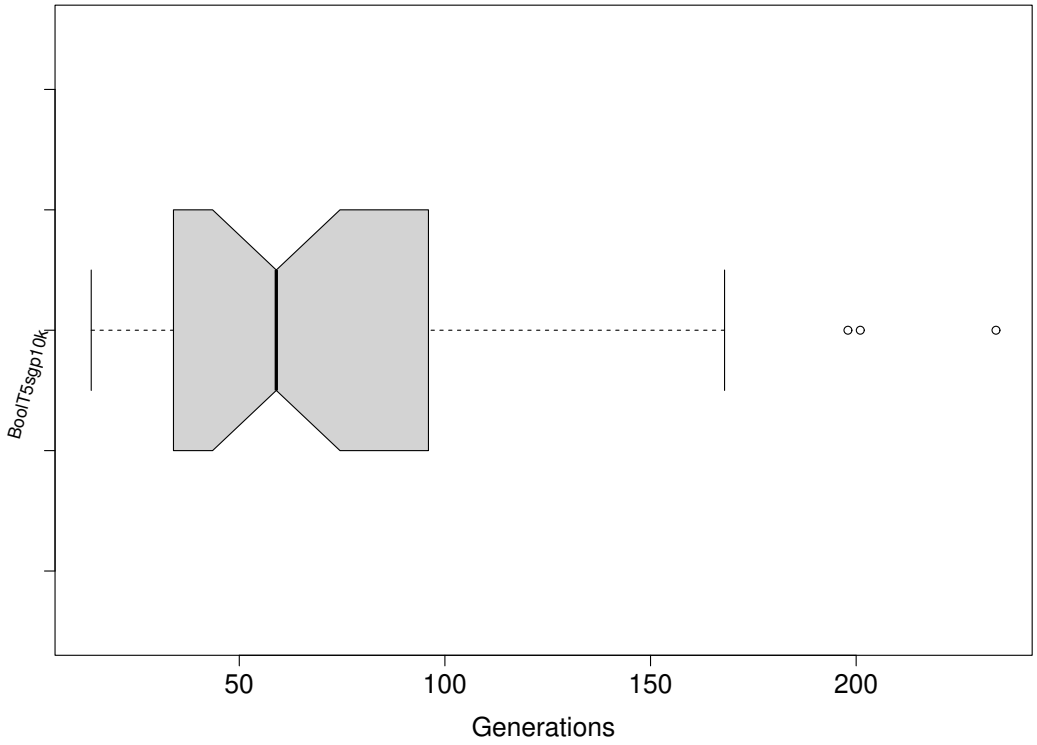
Distribution of Number of Generations for Grammar T5. 8-symmetry.



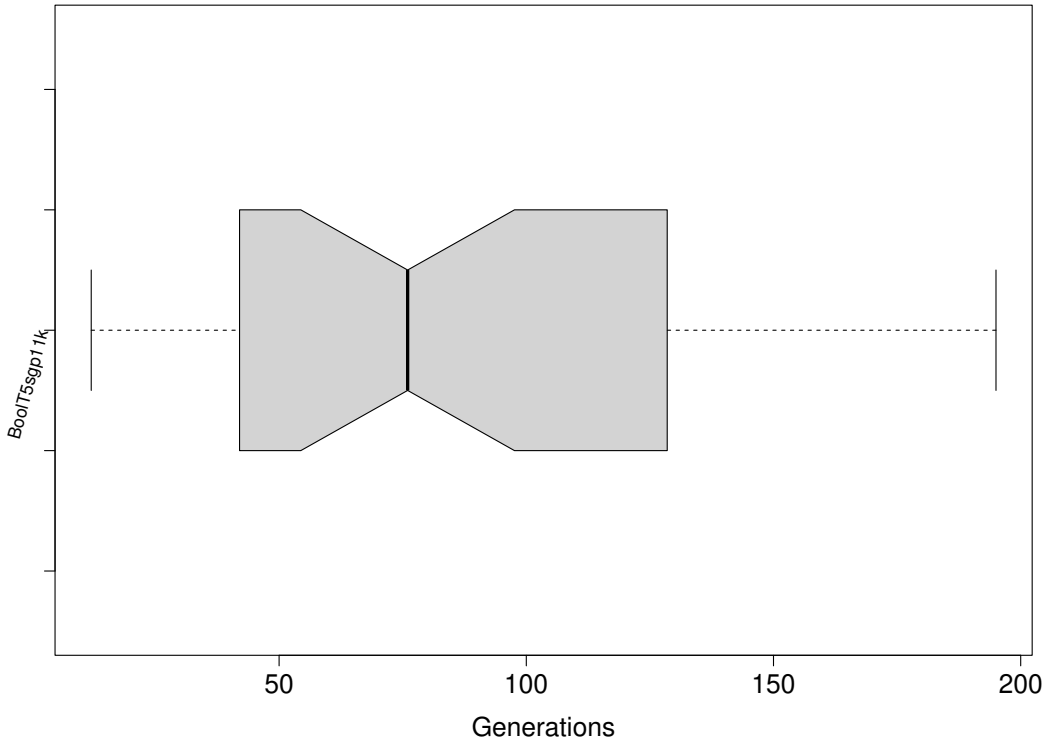
Distribution of Number of Generations for Grammar T5. 9-symmetry.



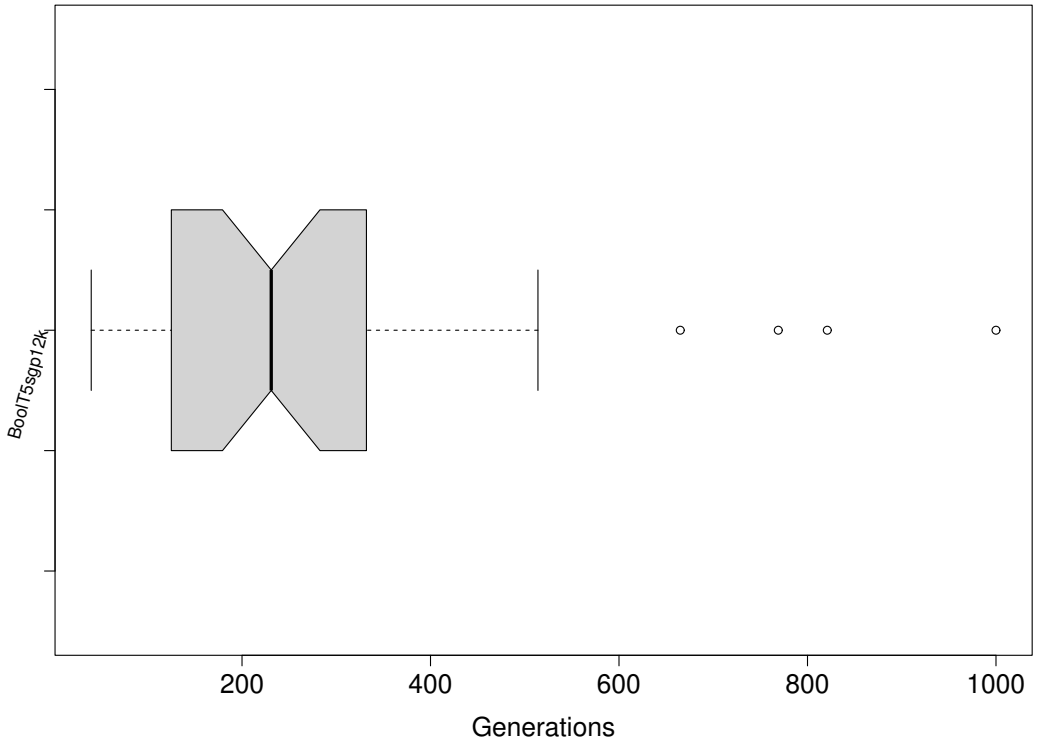
Distribution of Number of Generations for Grammar T5. 10-symmetry.



Distribution of Number of Generations for Grammar T5. 11-symmetry.



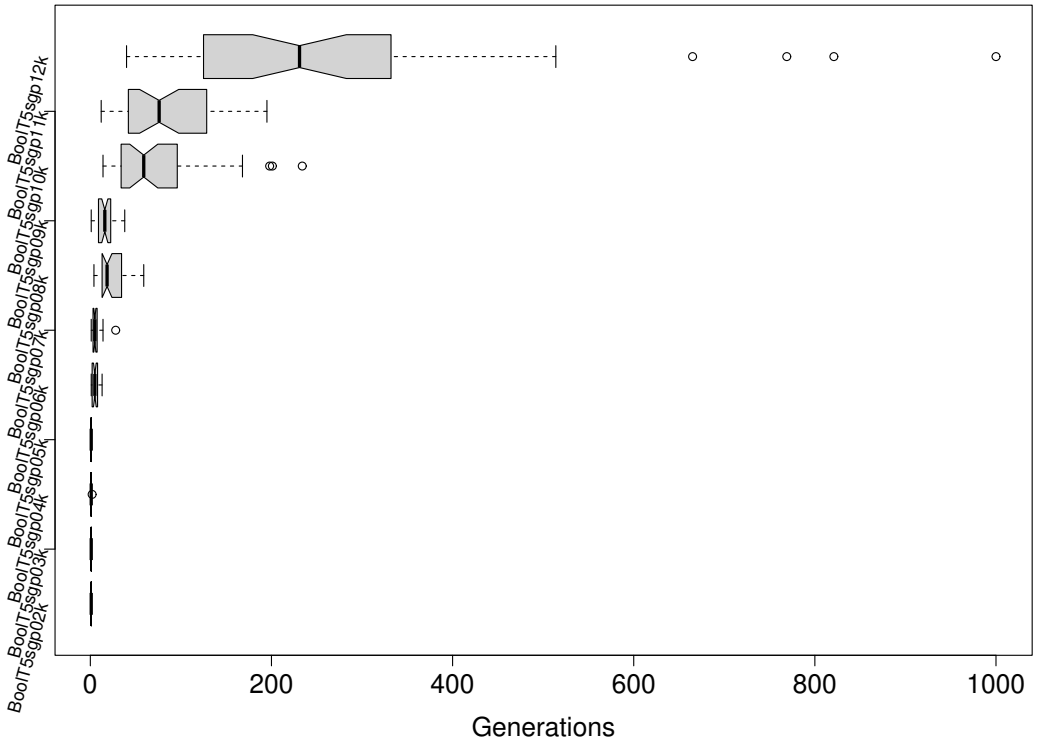
Distribution of Number of Generations for Grammar T5. 12-symmetry.



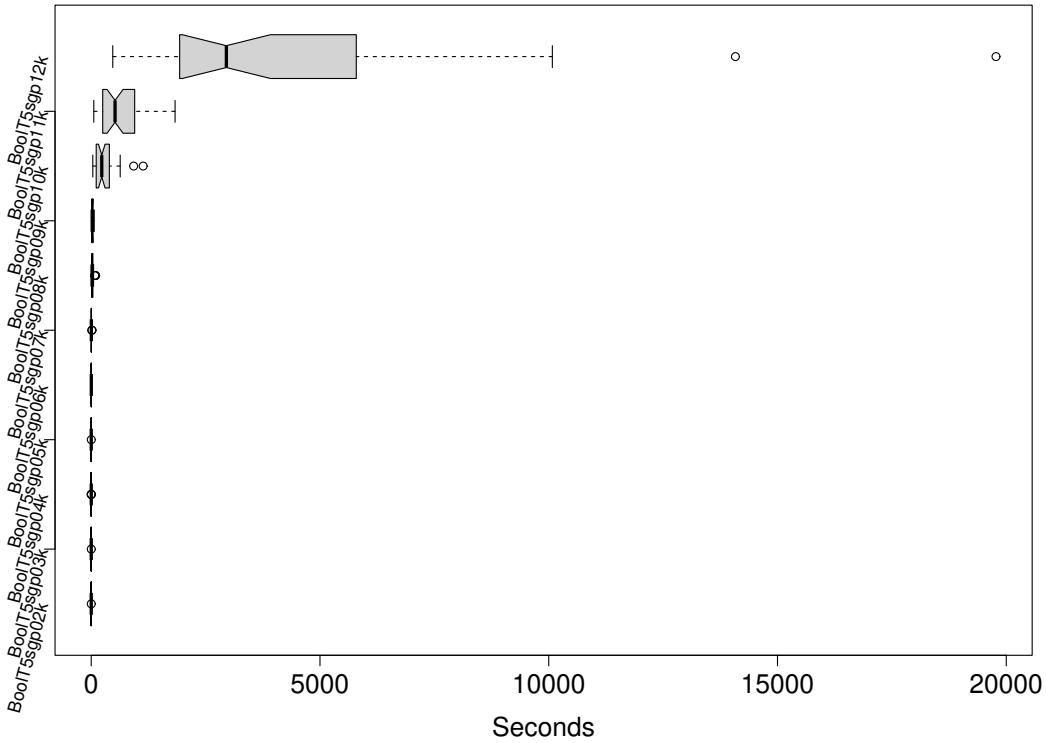
How does the algorithm behave with growing k?

- The 12-symmetry problem did not find the optimum in 1 of out 40 trials

Distribution of Number of Generations for Grammar T5



Distribution of Seconds for Grammar T5



Growth of Complexity?

- Complexity grows in steps of 2 of k. The 2 and 3, 4 and 5, 6 and 7, 8 and 9, 10 and 11 took a similar number of generations. **Reason:** The 2- and 3-symmetry problem need the same boolean expression, but with different variables: For the 2-symmetry problem, D1 and D2. For the 3-symmetry problem, D1 and D3, D2 is ignored.
- The number of generations grows slower than the time needed.
  Reason: The cost of testing a boolean expression grows with 2^k

Further Research.

Integrate grammar and language tuning into grammar-based genetic programming algorithms!

Mechanisms:

- Automatic function definitions.
- Make optimal solutions of small problem instances reusable.
- Grammar evolution from frontiers of derivation trees.
- Very few, but costly outliers in execution time. (12-symmetry: 5:30h.)

Testing by sampling?

Summary of statistics of experiment ExpF.

	Treatment	Trials	Variable	min	mean	sd	m
4	BoolT5sgp02k	40	Evaluations	400.00	400.00	0.00	400
8	BoolT5sgp03k	40	Evaluations	400.00	400.00	0.00	400
12	BoolT5sgp04k	40	Evaluations	400.00	410.00	63.25	800
16	BoolT5sgp05k	40	Evaluations	400.00	400.00	0.00	400
20	BoolT5sgp06k	40	Evaluations	400.00	2030.00	1338.62	5200
24	BoolT5sgp07k	40	Evaluations	400.00	2370.00	1930.88	11200
28	BoolT5sgp08k	40	Evaluations	1600.00	9550.00	5999.10	23600
32	BoolT5sgp09k	40	Evaluations	400.00	6390.00	3467.64	15200
36	BoolT5sgp10k	40	Evaluations	5600.00	29540.00	21239.64	93600
40	BoolT5sgp11k	40	Evaluations	4800.00	35000.00	22140.62	78000
44	BoolT5sgp12k	40	Evaluations	16000.00	113680.00	86630.47	400000
1	BoolT5sgp02k	40	Fitness	0.00	0.00	0.00	0
5	BoolT5sgp03k	40	Fitness	0.00	0.00	0.00	0
9	BoolT5sgp04k	40	Fitness	0.00	0.00	0.00	0
13	BoolT5sgp05k	40	Fitness	0.00	0.00	0.00	0

Table: Summary of statistics of experiment ExpF. (Part 1)

Summary of statistics of experiment ExpF.

	Treatment	Trials	Variable	min	mean	sd	max
17	BoolT5sgp06k	40	Fitness	0.00	0.00	0.00	0.00
21	BoolT5sgp07k	40	Fitness	0.00	0.00	0.00	0.00
25	BoolT5sgp08k	40	Fitness	0.00	0.00	0.00	0.00
29	BoolT5sgp09k	40	Fitness	0.00	0.00	0.00	0.00
33	BoolT5sgp10k	40	Fitness	0.00	0.00	0.00	0.00
37	BoolT5sgp11k	40	Fitness	0.00	0.00	0.00	0.00
41	BoolT5sgp12k	40	Fitness	0.00	0.80	5.06	32.00
3	BoolT5sgp02k	40	Generations	1.00	1.00	0.00	1.00
7	BoolT5sgp03k	40	Generations	1.00	1.00	0.00	1.00
11	BoolT5sgp04k	40	Generations	1.00	1.02	0.16	2.00
15	BoolT5sgp05k	40	Generations	1.00	1.00	0.00	1.00
19	BoolT5sgp06k	40	Generations	1.00	5.08	3.35	13.00
23	BoolT5sgp07k	40	Generations	1.00	5.92	4.83	28.00
27	BoolT5sgp08k	40	Generations	4.00	23.88	15.00	59.00
31	BoolT5sgp09k	40	Generations	1.00	15.97	8.67	38.00

Table: Summary of statistics of experiment ExpF. (Part 2)

Summary of statistics of experiment ExpF.

	Treatment	Trials	Variable	min	mean	sd	max
35	BoolT5sgp10k	40	Generations	14.00	73.85	53.10	234.00
39	BoolT5sgp11k	40	Generations	12.00	87.50	55.35	195.00
43	BoolT5sgp12k	40	Generations	40.00	284.20	216.58	1000.00
2	BoolT5sgp02k	40	Seconds	0.28	0.43	0.16	0.97
6	BoolT5sgp03k	40	Seconds	0.30	0.46	0.15	0.84
10	BoolT5sgp04k	40	Seconds	0.37	0.55	0.20	1.08
14	BoolT5sgp05k	40	Seconds	0.41	0.64	0.20	1.28
18	BoolT5sgp06k	40	Seconds	0.54	2.59	1.77	6.32
22	BoolT5sgp07k	40	Seconds	0.99	3.97	3.29	18.66
26	BoolT5sgp08k	40	Seconds	3.43	27.82	23.84	97.55
30	BoolT5sgp09k	40	Seconds	1.61	28.24	17.52	65.63
34	BoolT5sgp10k	40	Seconds	34.67	284.52	238.05	1134.77
38	BoolT5sgp11k	40	Seconds	56.67	644.85	493.13	1832.77
42	BoolT5sgp12k	40	Seconds	470.98	4376.96	3895.03	19775.30

Table: Summary of statistics of experiment ExpF. (Part 3)

Parameters of treatment: BoolT5sgp02k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp02k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp02k

Parameters of treatment BoolT5sgp02k passed to xegaRun

	Parameter Values
penv	2-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-4
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp02k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp02k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	80
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp02k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp02k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp02k passed to xegaRun (Part 3)

Treatment: BoolT5sgp02k

	Treatment	Trials	Variable	min	mean	sd	max
4	BoolT5sgp02k	40	Evaluations	400.00	400.00	0.00	400.00
1	BoolT5sgp02k	40	Fitness	0.00	0.00	0.00	0.00
3	BoolT5sgp02k	40	Generations	1.00	1.00	0.00	1.00
2	BoolT5sgp02k	40	Seconds	0.28	0.43	0.16	0.97

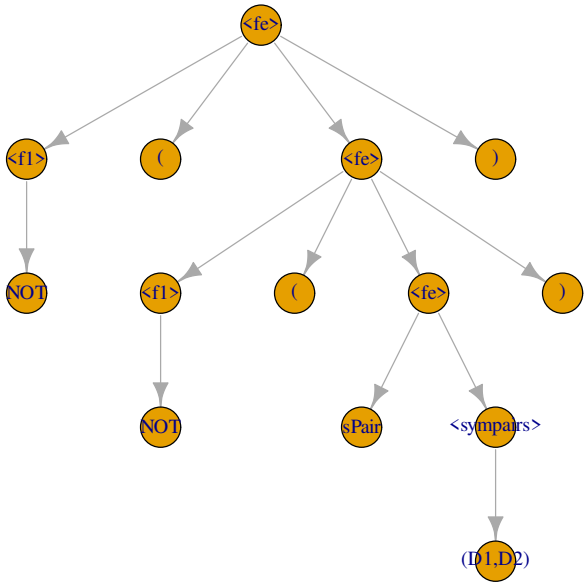
Table: Treatment: BoolT5sgp02k

The Solution Table of Treatment BoolT5sgp02k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 11.

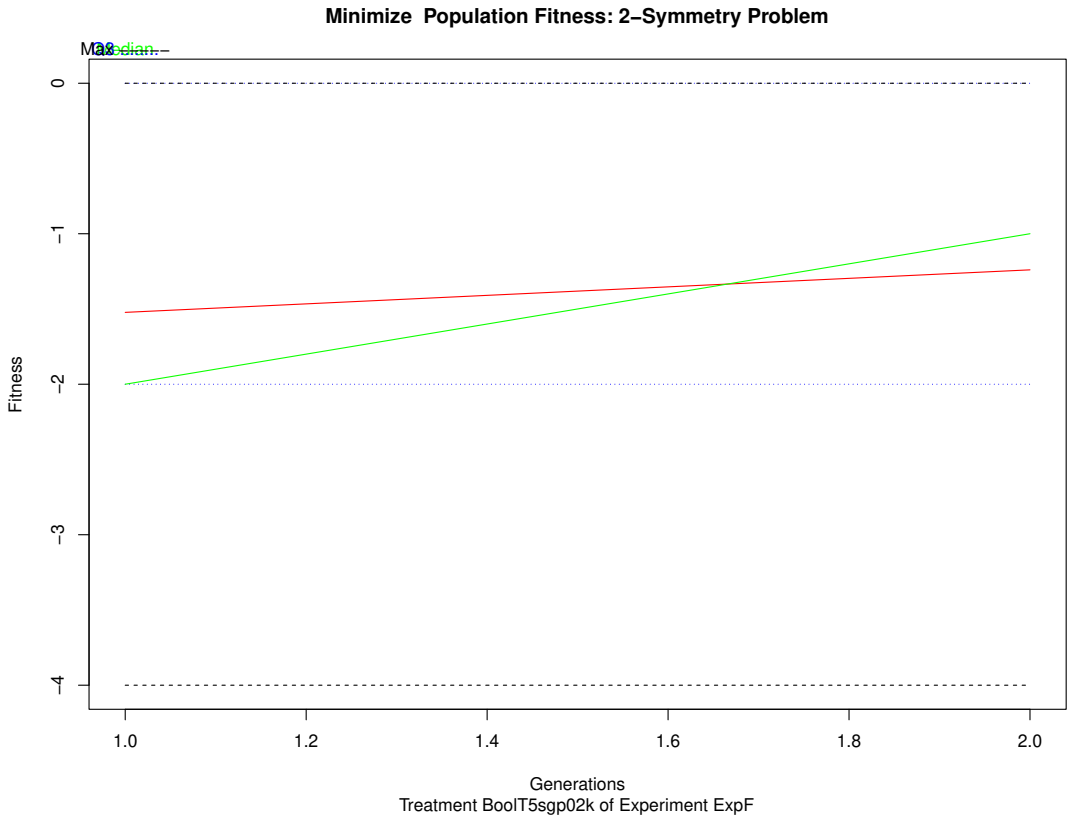
	Solution
1	sPair(D1, D2)

Table: The Solution Table of Treatment BoolT5sgp02k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 11.

The Derivation Tree of a Solution of Treatment BoolT5sgp02k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp02k of Experiment ExpF



Parameters of treatment: BoolT5sgp03k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp03k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp03k

Parameters of treatment BoolT5sgp03k passed to xegaRun

	Parameter Values
penv	3-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-8
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp03k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp03k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	120
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp03k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp03k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp03k passed to xegaRun (Part 3)

Treatment: BoolT5sgp03k

	Treatment	Trials	Variable	min	mean	sd	max
8	BoolT5sgp03k	40	Evaluations	400.00	400.00	0.00	400.00
5	BoolT5sgp03k	40	Fitness	0.00	0.00	0.00	0.00
7	BoolT5sgp03k	40	Generations	1.00	1.00	0.00	1.00
6	BoolT5sgp03k	40	Seconds	0.30	0.46	0.15	0.84

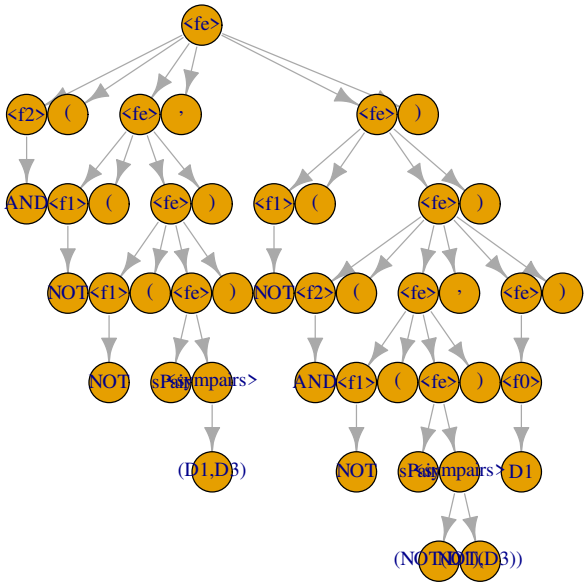
Table: Treatment: BoolT5sgp03k

The Solution Table of Treatment BoolT5sgp03k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 10.

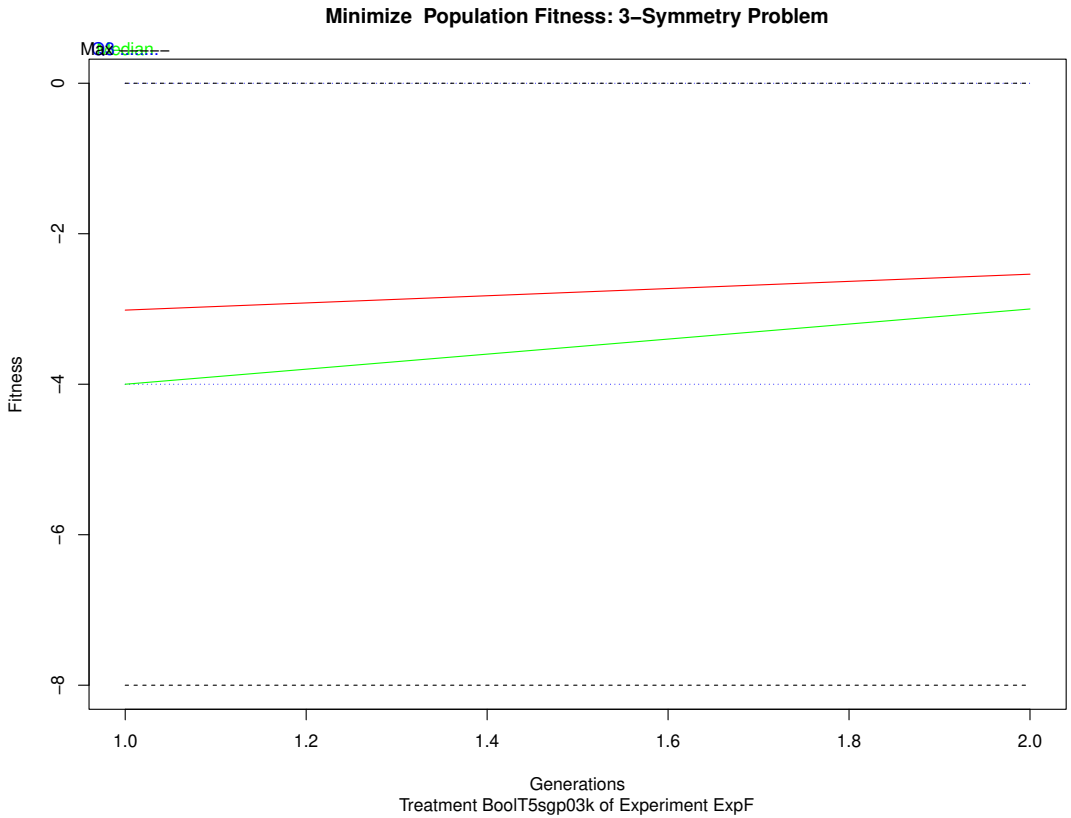
	Solution
1	sPair(D1, D3)

Table: The Solution Table of Treatment BoolT5sgp03k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 10.

The Derivation Tree of a Solution of Treatment BoolT5sgp03k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp03k of Experiment ExpF



Parameters of treatment: BoolT5sgp04k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp04k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp04k

Parameters of treatment BoolT5sgp04k passed to xegaRun

	Parameter Values
penv	4-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-16
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp04k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp04k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	160
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp04k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp04k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp04k passed to xegaRun (Part 3)

Treatment: BoolT5sgp04k

	Treatment	Trials	Variable	min	mean	sd	max
12	BoolT5sgp04k	40	Evaluations	400.00	410.00	63.25	800.00
9	BoolT5sgp04k	40	Fitness	0.00	0.00	0.00	0.00
11	BoolT5sgp04k	40	Generations	1.00	1.02	0.16	2.00
10	BoolT5sgp04k	40	Seconds	0.37	0.55	0.20	1.08

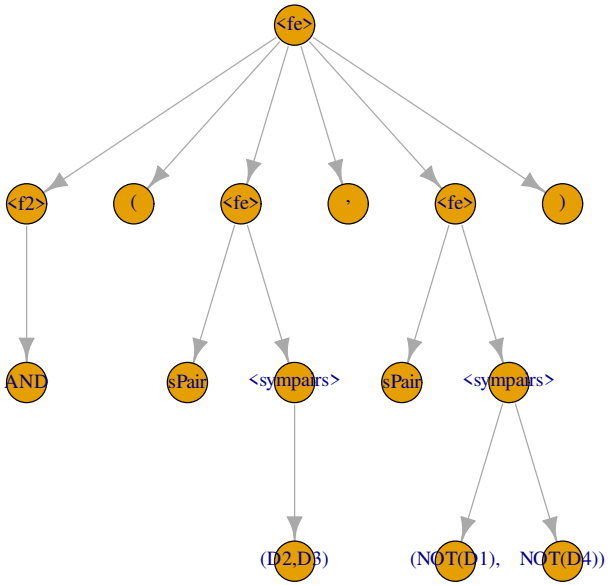
Table: Treatment: BoolT5sgp04k

The Solution Table of Treatment BoolT5sgp04k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 27.

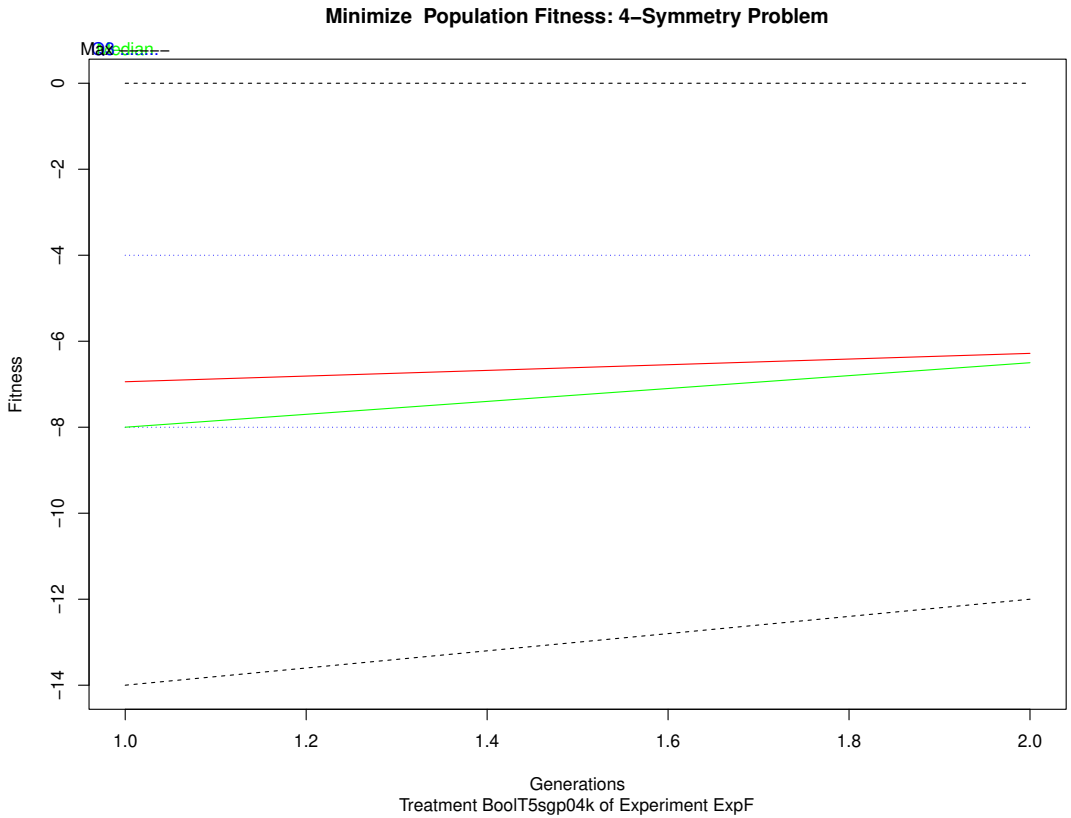
	Solution
1	AND(sPair(D2, D3), sPair(D1, D4))

Table: The Solution Table of Treatment BoolT5sgp04k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 27.

The Derivation Tree of a Solution of Treatment BoolT5sgp04k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp04k of Experiment ExpF



Parameters of treatment: BoolT5sgp05k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp05k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp05k

Parameters of treatment BoolT5sgp05k passed to xegaRun

	Parameter Values
penv	5-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-32
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp05k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp05k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	200
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp05k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp05k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp05k passed to xegaRun (Part 3)

Treatment: BoolT5sgp05k

	Treatment	Trials	Variable	min	mean	sd	max
16	BoolT5sgp05k	40	Evaluations	400.00	400.00	0.00	400.00
13	BoolT5sgp05k	40	Fitness	0.00	0.00	0.00	0.00
15	BoolT5sgp05k	40	Generations	1.00	1.00	0.00	1.00
14	BoolT5sgp05k	40	Seconds	0.41	0.64	0.20	1.28

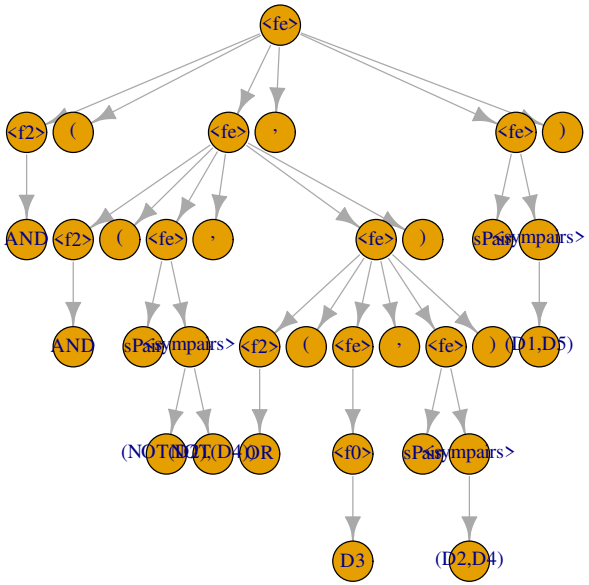
Table: Treatment: BoolT5sgp05k

The Solution Table of Treatment BoolT5sgp05k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 25.

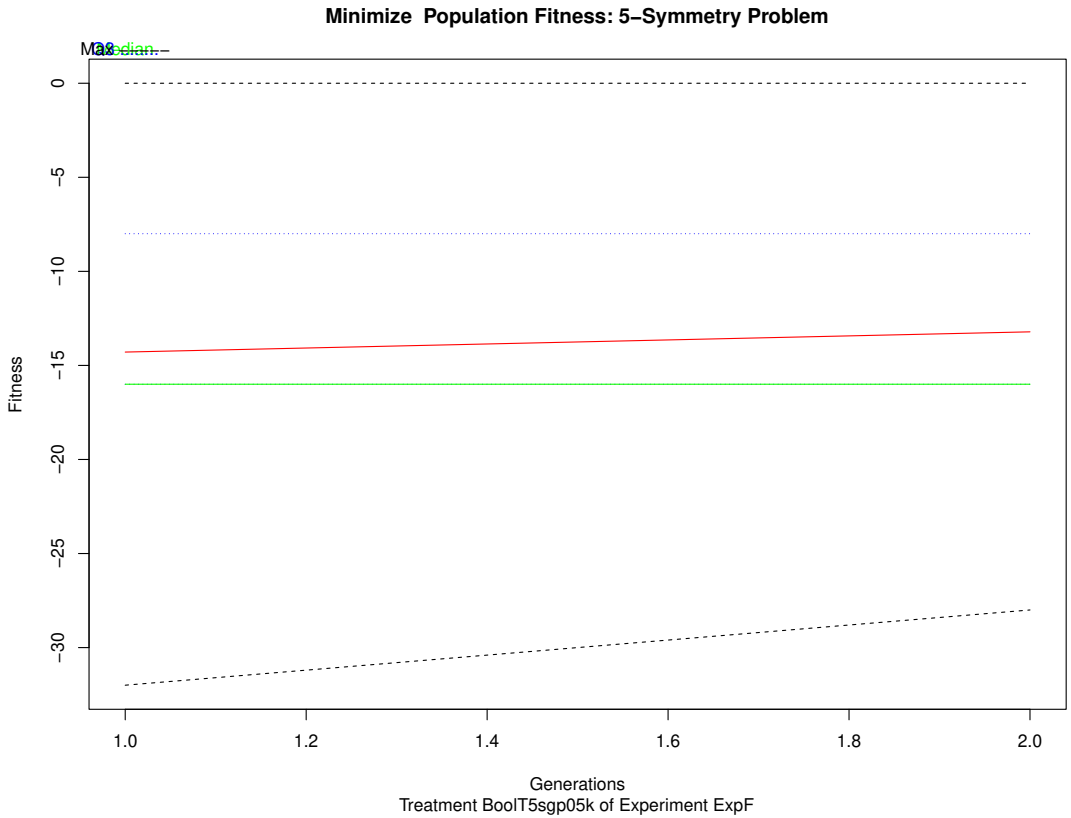
	Solution
1	AND(sPair(D1, D5), sPair(D2, D4))

Table: The Solution Table of Treatment BoolT5sgp05k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 25.

The Derivation Tree of a Solution of Treatment BoolT5sgp05k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp05k of Experiment ExpF



Parameters of treatment: BoolT5sgp06k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp06k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp06k

Parameters of treatment BoolT5sgp06k passed to xegaRun

	Parameter Values
penv	6-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-64
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp06k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp06k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	240
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp06k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp06k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp06k passed to xegaRun (Part 3)

Treatment: BoolT5sgp06k

	Treatment	Trials	Variable	min	mean	sd	max
20	BoolT5sgp06k	40	Evaluations	400.00	2030.00	1338.62	5200.00
17	BoolT5sgp06k	40	Fitness	0.00	0.00	0.00	0.00
19	BoolT5sgp06k	40	Generations	1.00	5.08	3.35	13.00
18	BoolT5sgp06k	40	Seconds	0.54	2.59	1.77	6.32

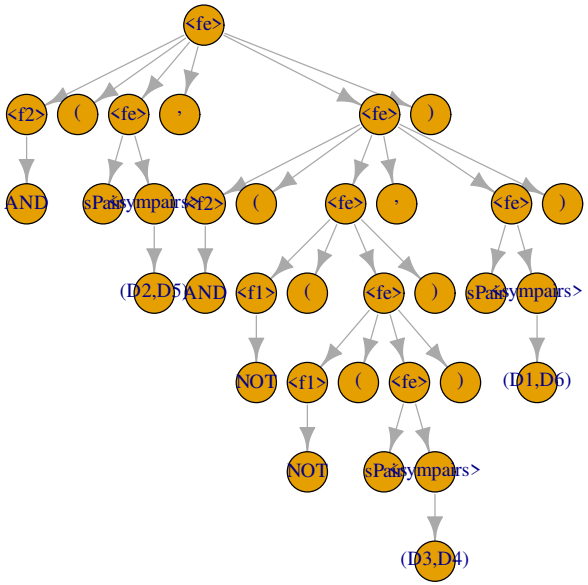
Table: Treatment: BoolT5sgp06k

The Solution Table of Treatment BoolT5sgp06k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 39.

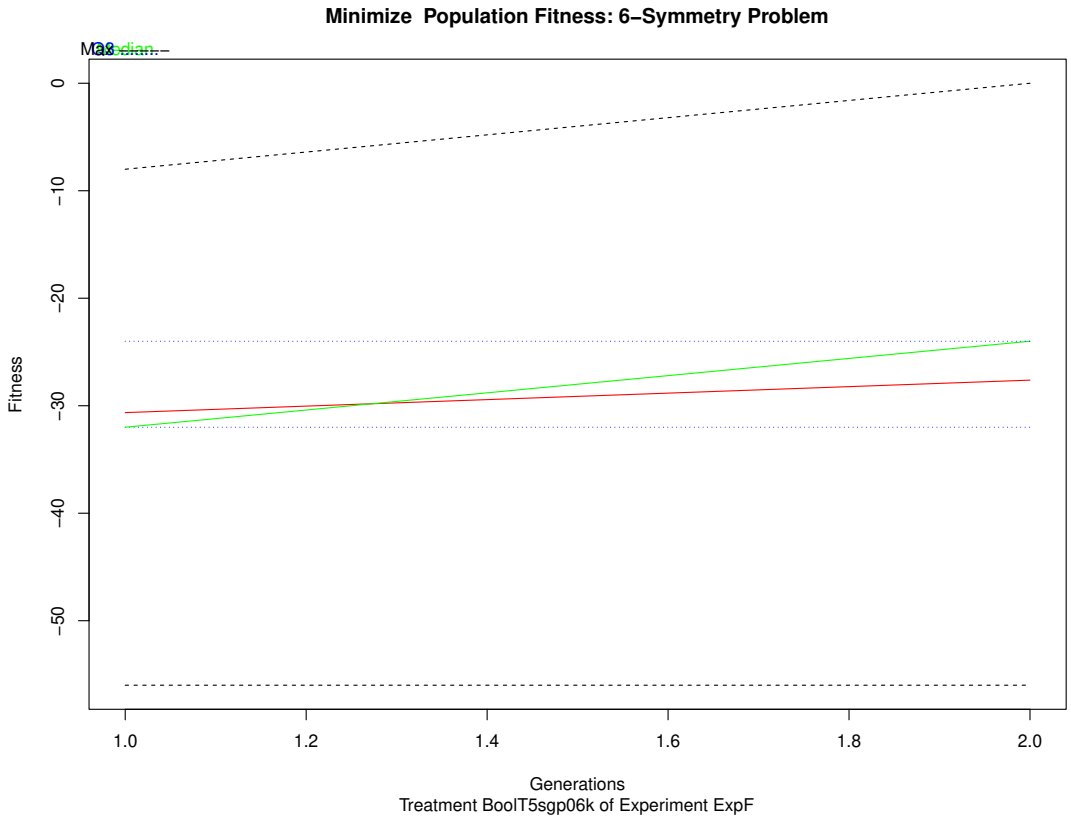
	Solution
1	AND(sPair(D2, D5), AND(sPair(D3, D4), sPair(D1, D6)))

Table: The Solution Table of Treatment BoolT5sgp06k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 39.

The Derivation Tree of a Solution of Treatment BoolT5sgp06k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp06k of Experiment ExpF



Parameters of treatment: BoolT5sgp07k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp07k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp07k

Parameters of treatment BoolT5sgp07k passed to xegaRun

	Parameter Values
penv	7-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-128
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp07k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp07k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	280
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp07k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp07k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp07k passed to xegaRun (Part 3)

Treatment: BoolT5sgp07k

	Treatment	Trials	Variable	min	mean	sd	max
24	BoolT5sgp07k	40	Evaluations	400.00	2370.00	1930.88	11200.00
21	BoolT5sgp07k	40	Fitness	0.00	0.00	0.00	0.00
23	BoolT5sgp07k	40	Generations	1.00	5.92	4.83	28.00
22	BoolT5sgp07k	40	Seconds	0.99	3.97	3.29	18.66

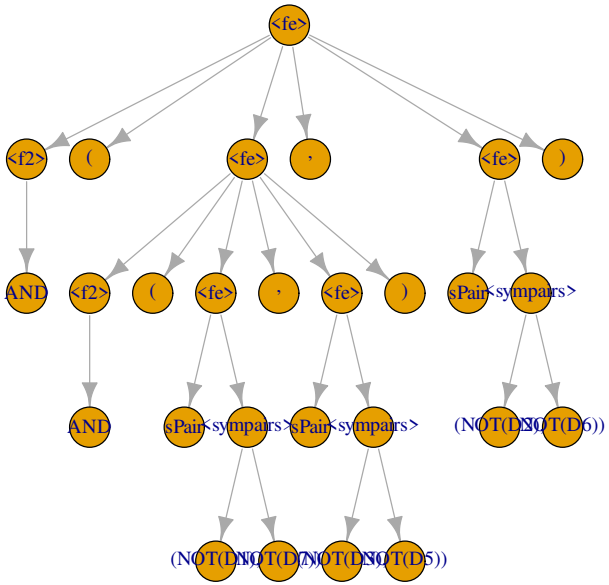
Table: Treatment: BoolT5sgp07k

The Solution Table of Treatment BoolT5sgp07k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 37.

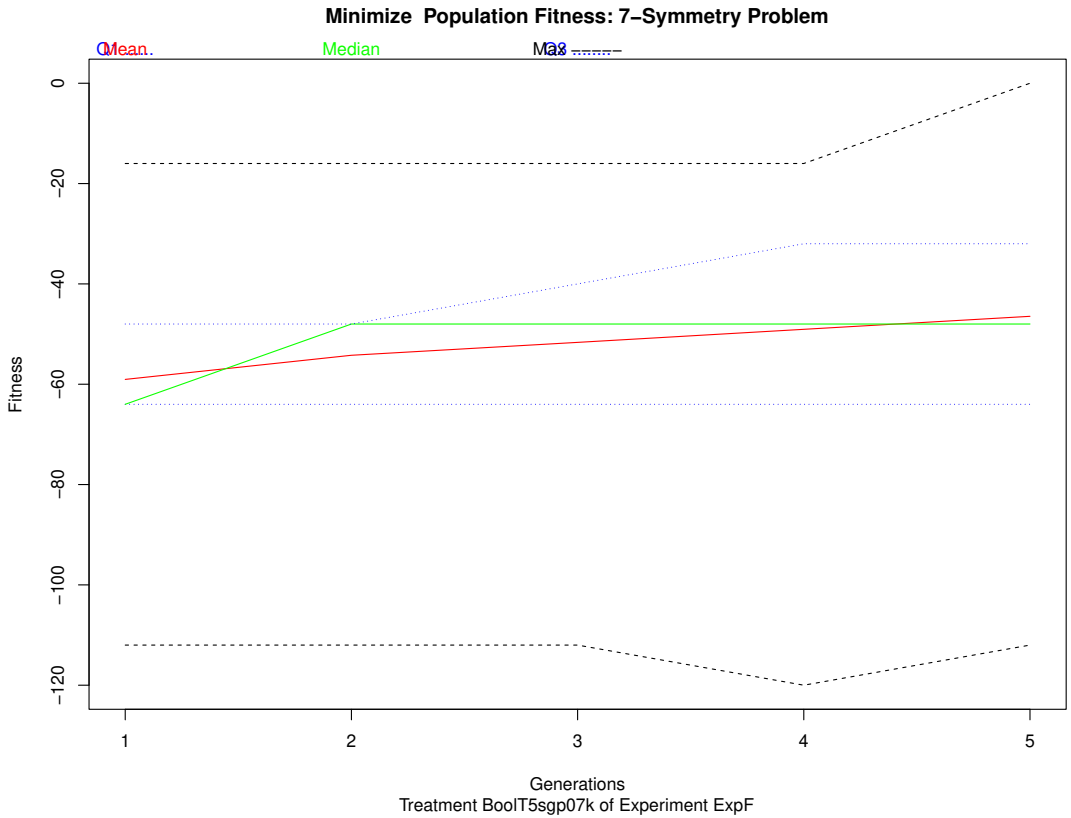
	Solution
1	AND(sPair(D3, D5), AND(sPair(NOT(D1), NOT(D7)), sPair(D2, D6)))

Table: The Solution Table of Treatment BoolT5sgp07k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 37.

The Derivation Tree of a Solution of Treatment BoolT5sgp07k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp07k of Experiment ExpF



Parameters of treatment: BoolT5sgp08k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp08k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp08k

Parameters of treatment BoolT5sgp08k passed to xegaRun

	Parameter Values
penv	8-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-256
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp08k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp08k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	320
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp08k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp08k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp08k passed to xegaRun (Part 3)

Treatment: BoolT5sgp08k

	Treatment	Trials	Variable	min	mean	sd	max
28	BoolT5sgp08k	40	Evaluations	1600.00	9550.00	5999.10	23600.00
25	BoolT5sgp08k	40	Fitness	0.00	0.00	0.00	0.00
27	BoolT5sgp08k	40	Generations	4.00	23.88	15.00	59.00
26	BoolT5sgp08k	40	Seconds	3.43	27.82	23.84	97.55

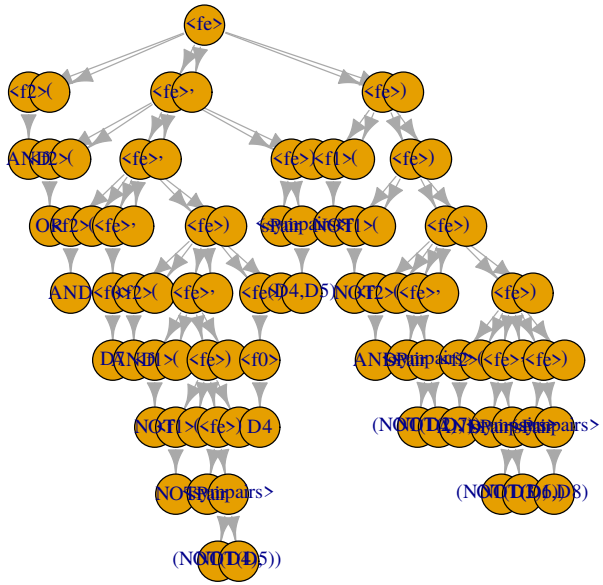
Table: Treatment: BoolT5sgp08k

The Solution Table of Treatment BoolT5sgp08k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

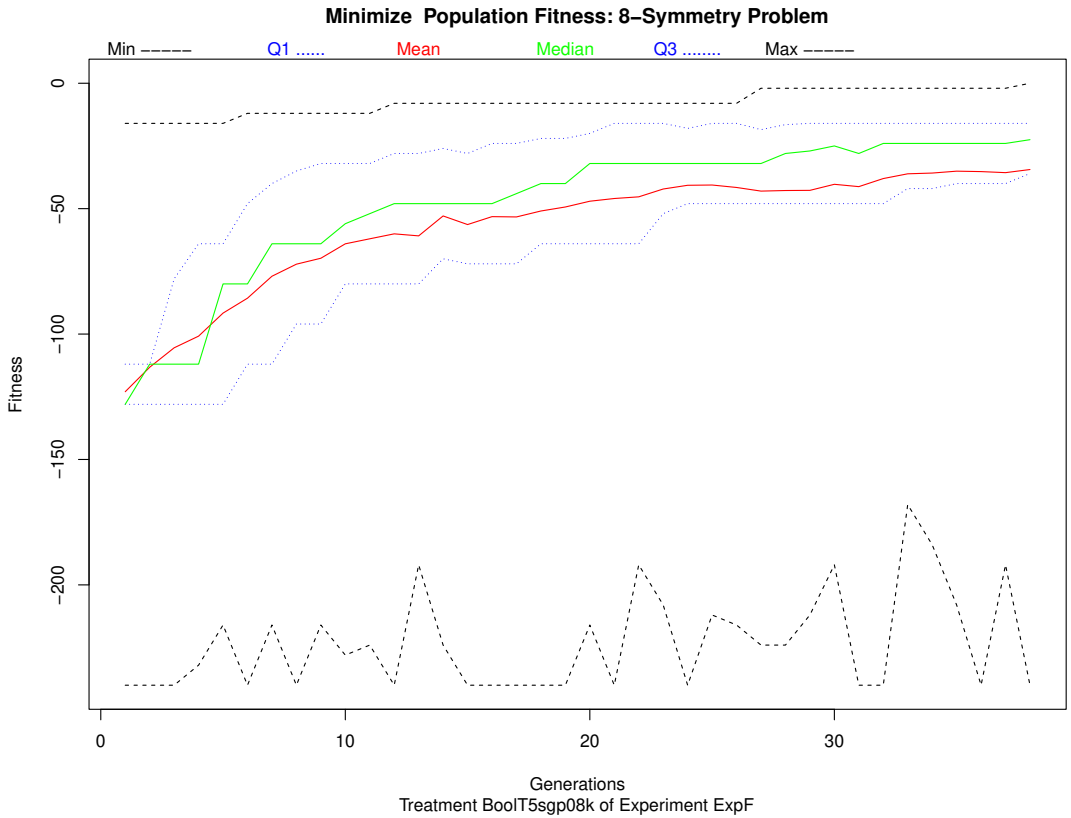
	Solution
1	AND(sPair(D2, D7), AND(sPair(D1, D8), AND(sPair(NOT(D3), NOT(D6)), NOT(NOT(sPair(D4, D5))))))

Table: The Solution Table of Treatment BoolT5sgp08k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

The Derivation Tree of a Solution of Treatment BoolT5sgp08k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp08k of Experiment ExpF



Parameters of treatment: BoolT5sgp09k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp09k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp09k

Parameters of treatment BoolT5sgp09k passed to xegaRun

	Parameter Values
penv	9-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-512
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp09k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp09k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	360
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp09k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp09k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp09k passed to xegaRun (Part 3)

Treatment: BoolT5sgp09k

	Treatment	Trials	Variable	min	mean	sd	max
32	BoolT5sgp09k	40	Evaluations	400.00	6390.00	3467.64	15200.00
29	BoolT5sgp09k	40	Fitness	0.00	0.00	0.00	0.00
31	BoolT5sgp09k	40	Generations	1.00	15.97	8.67	38.00
30	BoolT5sgp09k	40	Seconds	1.61	28.24	17.52	65.63

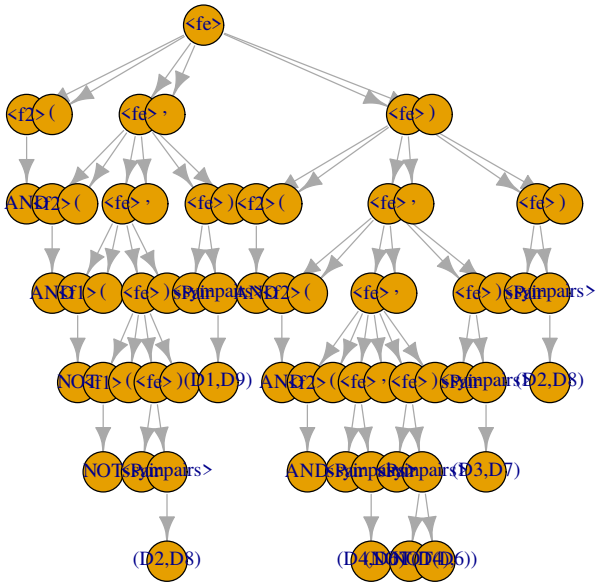
Table: Treatment: BoolT5sgp09k

The Solution Table of Treatment BoolT5sgp09k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

	Solution
1	AND(sPair(D2, D8), AND(sPair(D3, D7), AND(sPair(D4, D6), sPair(NOT(D1), NOT(D9)))))

Table: The Solution Table of Treatment BoolT5sgp09k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

The Derivation Tree of a Solution of Treatment BoolT5sgp09k of Experiment ExpF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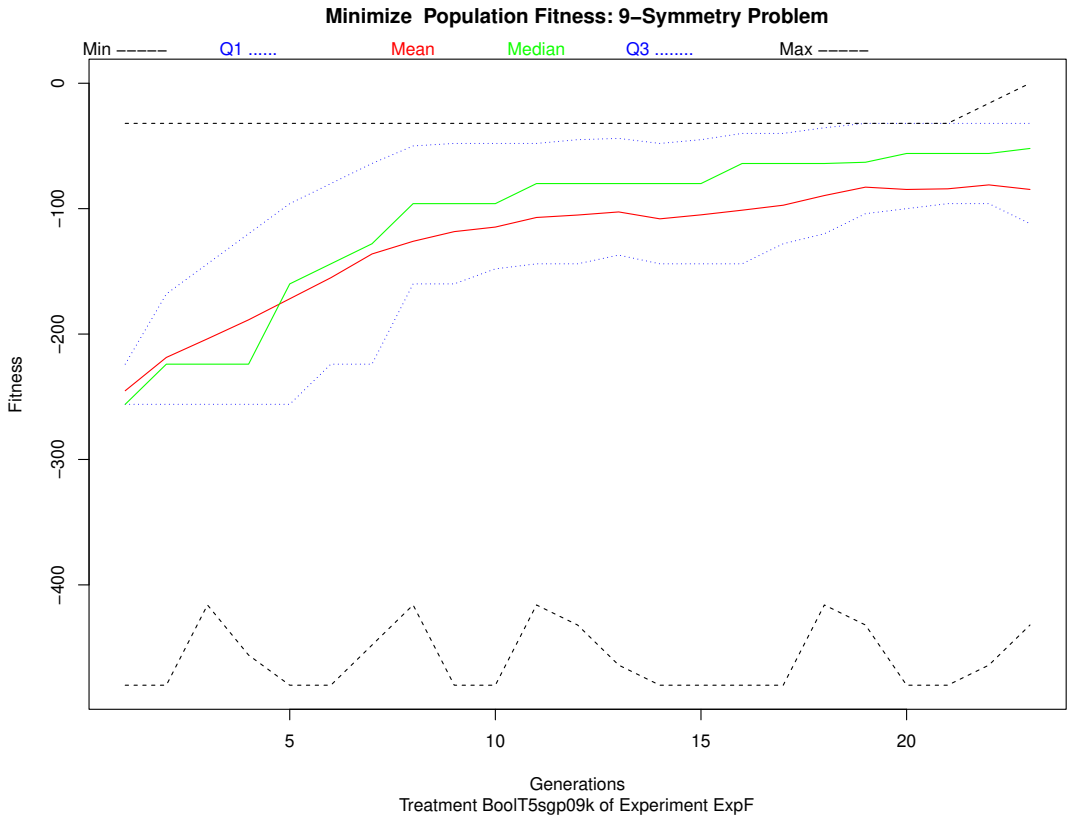
Plot of last xegaRun for Treatment BoolT5sgp09k of Experiment ExpF



Parameters of treatment: BoolT5sgp10k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp10k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp10k

Parameters of treatment BoolT5sgp10k passed to xegaRun

	Parameter Values
penv	10-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-1024
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp10k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp10k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	400
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp10k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp10k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp10k passed to xegaRun (Part 3)

Treatment: BoolT5sgp10k

	Treatment	Trials	Variable	min	mean	sd	max
36	BoolT5sgp10k	40	Evaluations	5600.00	29540.00	21239.64	93600.00
33	BoolT5sgp10k	40	Fitness	0.00	0.00	0.00	0.00
35	BoolT5sgp10k	40	Generations	14.00	73.85	53.10	234.00
34	BoolT5sgp10k	40	Seconds	34.67	284.52	238.05	1134.77

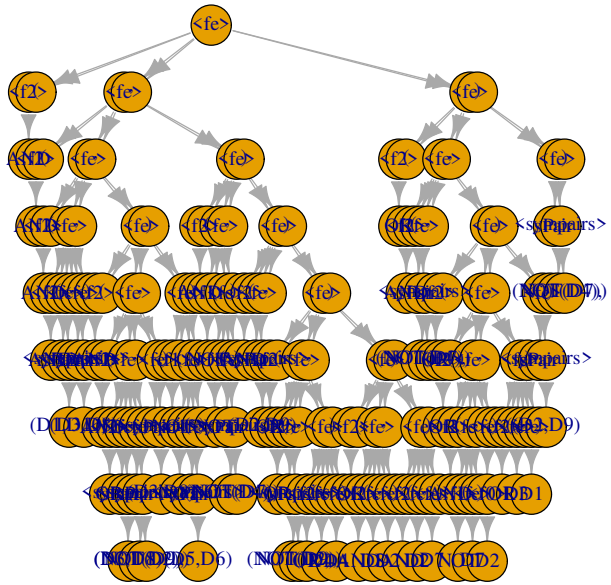
Table: Treatment: BoolT5sgp10k

The Solution Table of Treatment BoolT5sgp10k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

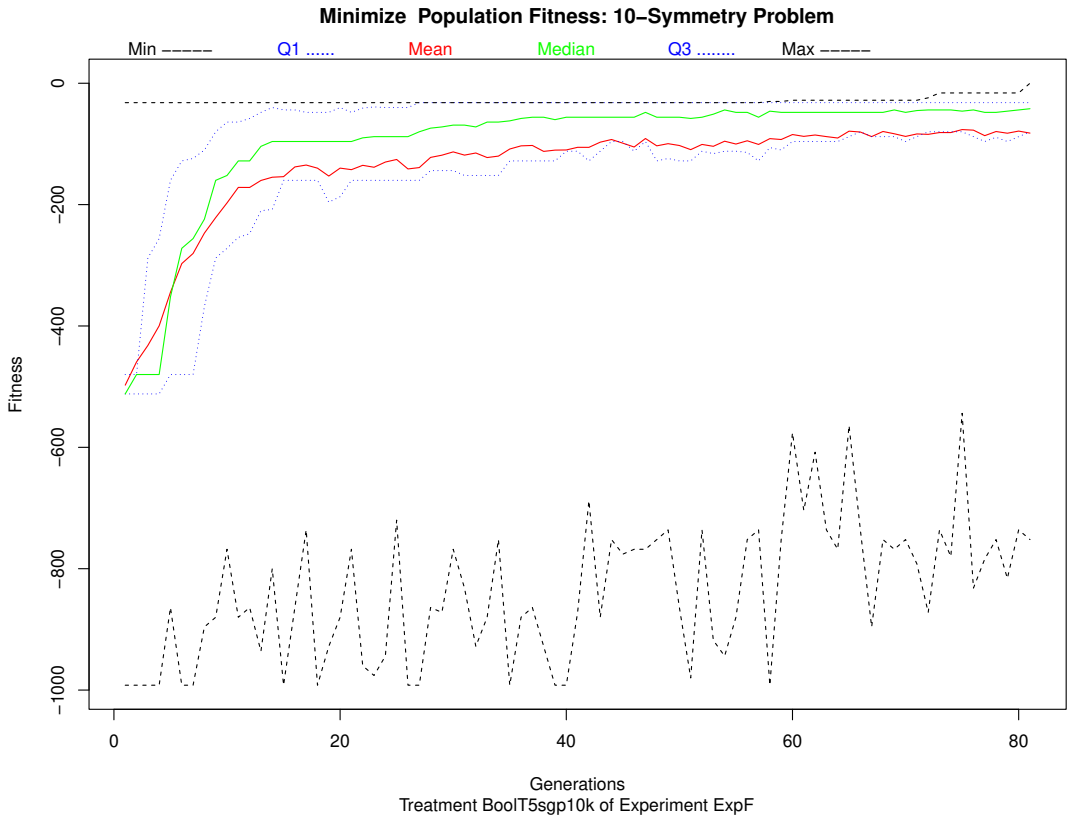
	Solution
1	AND(AND(AND(AND(sPair(NOT(D4), NOT(D7)), sPair(D3, D8)), sPair(D2, D9)), sPair(D1, D10)), sPair(NOT(D5), NOT(D6)))

Table: The Solution Table of Treatment BoolT5sgp10k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

The Derivation Tree of a Solution of Treatment BoolT5sgp10k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp10k of Experiment ExpF



Parameters of treatment: BoolT5sgp11k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp11k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp11k

Parameters of treatment BoolT5sgp11k passed to xegaRun

	Parameter Values
penv	11-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-2048
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp11k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp11k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	440
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp11k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp11k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp11k passed to xegaRun (Part 3)

Treatment: BoolT5sgp11k

	Treatment	Trials	Variable	min	mean	sd	max
40	BoolT5sgp11k	40	Evaluations	4800.00	35000.00	22140.62	78000.00
37	BoolT5sgp11k	40	Fitness	0.00	0.00	0.00	0.00
39	BoolT5sgp11k	40	Generations	12.00	87.50	55.35	195.00
38	BoolT5sgp11k	40	Seconds	56.67	644.85	493.13	1832.77

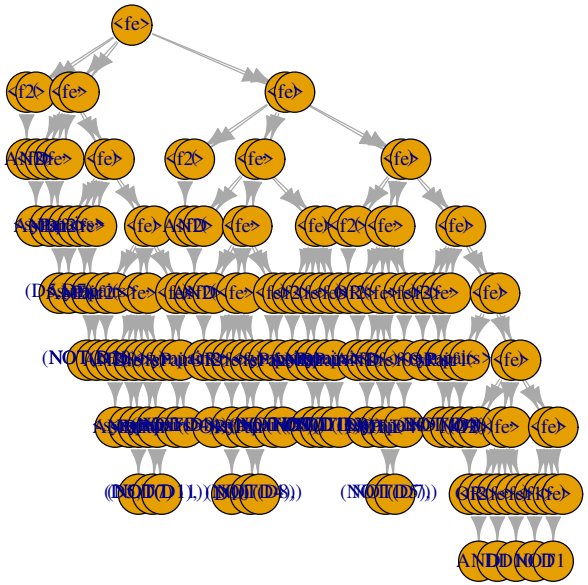
Table: Treatment: BoolT5sgp11k

The Solution Table of Treatment BoolT5sgp11k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

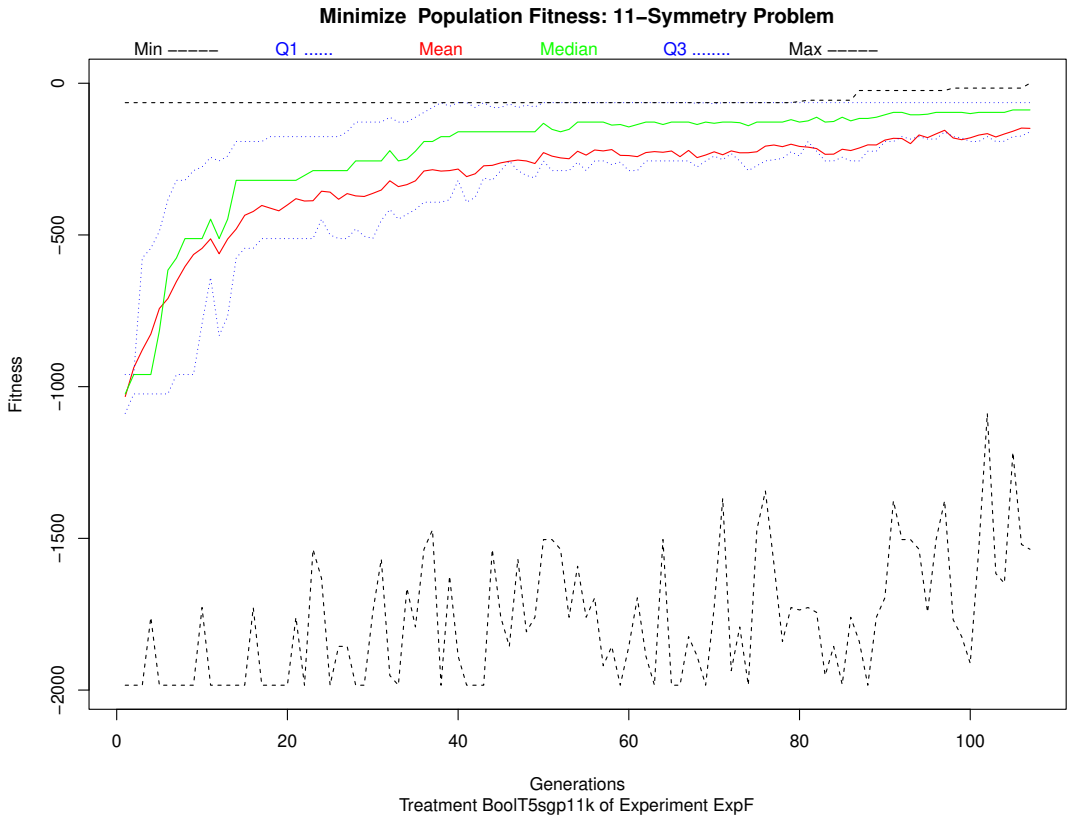
	Solution
1	AND(sPair(NOT(D4), NOT(D8)), AND(AND(sPair(NOT(D2), NOT(D10)), AND(sPair(D3, D9), sPair(D5, D7))), sPair(D1, D11)))

Table: The Solution Table of Treatment BoolT5sgp11k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 40.

The Derivation Tree of a Solution of Treatment BoolT5sgp11k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp11k of Experiment ExpF



Parameters of treatment: BoolT5sgp12k

	Parameter Values
tRNG	L'Ecuyer-CMRG Inversion Rejection
tReplay	0
experimentName	EE
treatmentName	BoolT5sgp12k
trials	15
everyK	5
outpath	data
batchPath	.
tVerbose	1

Table: Parameters of treatment: BoolT5sgp12k

Parameters of treatment BoolT5sgp12k passed to xegaRun

	Parameter Values
penv	12-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
replay	0
algorithm	sgp
maxdepth	7
max	FALSE
worstFitness	-4096
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
ivmutrate	Const
mutrate2	0.8
ivcrossrate	Const
crossrate2	0.4

Table: Parameters of treatment BoolT5sgp12k passed to xegaRun (Part 1)

Parameters of treatment BoolT5sgp12k passed to xegaRun

	Parameter Values
scalefactor	Uniform
genemap	Bin2Dec
initgene	InitGene
selection	SUS
mateselection	SUS
replication	Kid2
crossover	Cross2Gene
mutation	MutateGene
accept	All
reportEvalErrors	TRUE
codons	480
codonPrecision	LCM
terminationEps	-0.1
terminationCondition	AbsoluteError
evalmethod	Deterministic

Table: Parameters of treatment BoolT5sgp12k passed to xegaRun (Part 2)

Parameters of treatment BoolT5sgp12k passed to xegaRun

	Parameter Values
executionModel	MultiCore
verbose	1
batch	FALSE
semantics	byValue
path	.

Table: Parameters of treatment BoolT5sgp12k passed to xegaRun (Part 3)

Treatment: BoolT5sgp12k

	Treatment	Trials	Variable	min	mean	sd	n
44	BoolT5sgp12k	40	Evaluations	16000.00	113680.00	86630.47	400000
41	BoolT5sgp12k	40	Fitness	0.00	0.80	5.06	32
43	BoolT5sgp12k	40	Generations	40.00	284.20	216.58	1000
42	BoolT5sgp12k	40	Seconds	470.98	4376.96	3895.03	19775

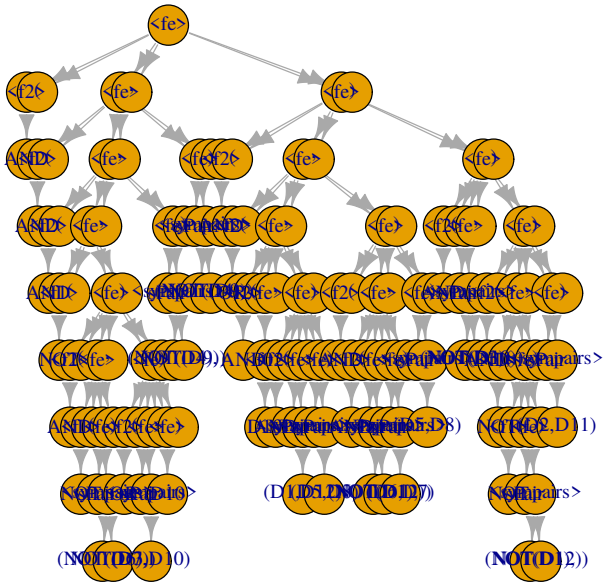
Table: Treatment: BoolT5sgp12k

The Solution Table of Treatment BoolT5sgp12k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 39.

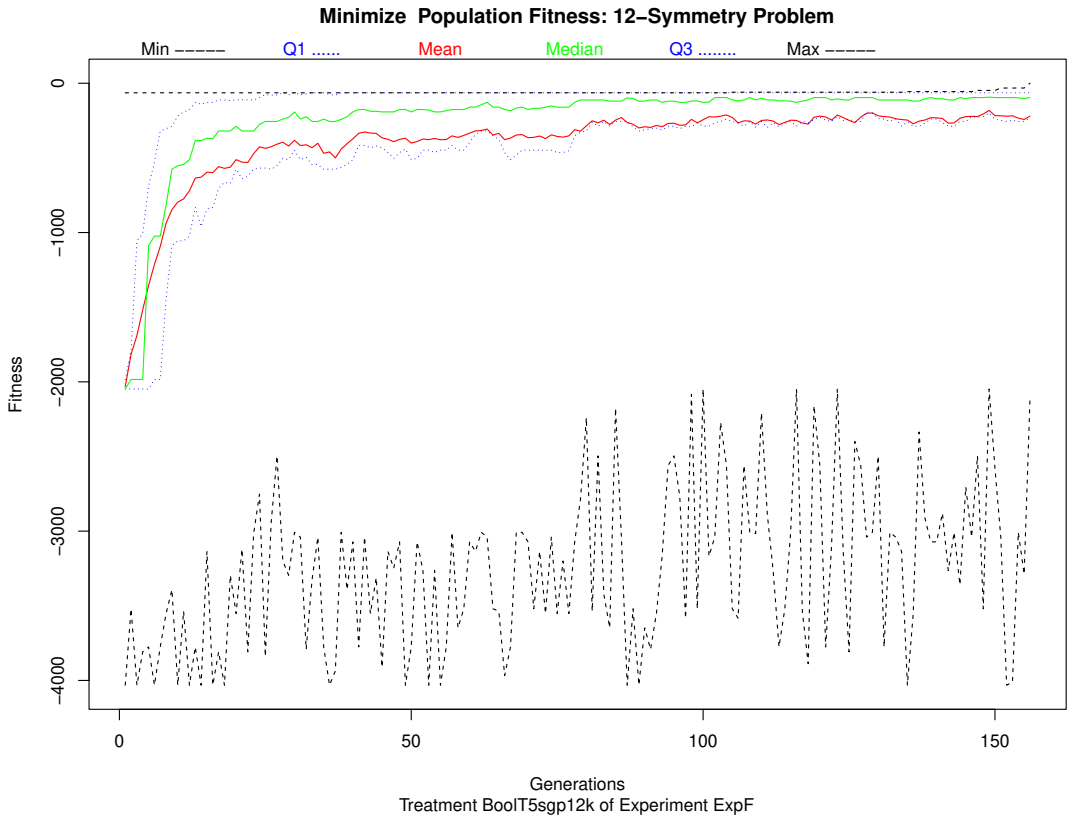
	Solution
1	AND(AND(sPair(NOT(D2), NOT(D11)), AND(sPair(D4, D9), AND(sPair(NOT(D5), NOT(D8)), sPair(NOT(D6), NOT(D7))))), AND(sPair(D3, D10), sPair(NOT(D1), NOT(D12))))

Table: The Solution Table of Treatment BoolT5sgp12k of Experiment ExpF. Fit: 0. Unique Shortest Solutions: 39.

The Derivation Tree of a Solution of Treatment BoolT5sgp12k of Experiment ExpF



Plot of last xegaRun for Treatment BoolT5sgp12k of Experiment ExpF



All parameters of xegaRun of treatment BoolT5sgp02k

	Parameter Values
penv	2-Symmetry Problem
grammar	/home/dj2333/dev/cran/kSymmetry/BNF/AndOrNotTuned5.txt
max	FALSE
algorithm	sgp
popsize	400
generations	1000
crossrate	0.2
mutrate	0.4
elitist	TRUE
replay	0
maxdepth	7
maxtrials	5
codons	80
codonBits	0
codonPrecision	LCM

Table: All parameters of xegaRun of treatment BoolT5sgp02k (Part 1)

All parameters of xegaRun of treatment BoolT5sgp02k

	Parameter Values
maxPBias	0.01
evalmethod	Deterministic
evalrep	1
reportEvalErrors	TRUE
genemap	Bin2Dec
decoder	DecodeGene
crossrate2	0.4
ivcrossrate	Const
crossover	Cross2Gene
uCrossSwap	0.2
mincrossdepth	1
maxcrossdepth	7
ivmutrate	Const
mutrate2	0.8
bitmutrate	0.005

Table: All parameters of xegaRun of treatment BoolT5sgp02k (Part 2)

All parameters of xegaRun of treatment BoolT5sgp02k

	Parameter Values
bitmutrate2	0.01
maxmutdepth	3
minmutinsertiondepth	1
maxmutinsertiondepth	7
lambda	0.05
max2opt	100
scalefactor1	0.9
scalefactor2	0.3
scalefactor	Uniform
cutoffFit	0.5
mutation	MutateGene
replication	Kid2
initgene	InitGene
offset	1
eps	0.01

Table: All parameters of xegaRun of treatment BoolT5sgp02k (Part 3)

All parameters of xegaRun of treatment BoolT5sgp02k

	Parameter Values
tournamentSize	2
selectionBias	1.5
maxTSR	1.5
selection	SUS
mateselection	SUS
selectionContinuation	TRUE
scaling	NoScaling
scalingThreshold	0
scalingExp	1
scalingExp2	1
rdmWeight	1
drMax	2
drMin	0.5
dispersionMeasure	var
scalingDelay	1

Table: All parameters of xegaRun of treatment BoolT5sgp02k (Part 4)

All parameters of xegaRun of treatment BoolT5sgp02k

	Parameter Values
accept	All
alpha	0.99
beta	2
cooling	ExponentialMultiplicative
coolingPower	1
temp0	40
tempN	0.01
verbose	1
logevals	FALSE
allsolutions	FALSE
early	FALSE
terminationCondition	AbsoluteError
terminationEps	-0.1
terminationThreshold	0
worstFitness	-4

Table: All parameters of xegaRun of treatment BoolT5sgp02k (Part 5)

All parameters of xegaRun of treatment BoolT5sgp02k

	Parameter Values
PACdelta	0.01
fSpace	Hilbert
cores	
executionModel	MultiCore
uParApply	NULL
Cluster	NULL
profile	FALSE
batch	FALSE
path	.
semantics	byValue

Table: All parameters of xegaRun of treatment BoolT5sgp02k (Part 6)