Applying Genetic Improvement to MiniSAT

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Summary (from SSBSE'13 talk)

Genetic Improvement Programming:

Automatically improves system behaviour

According to some desired criteria using GP

(Relies on a set of test cases)

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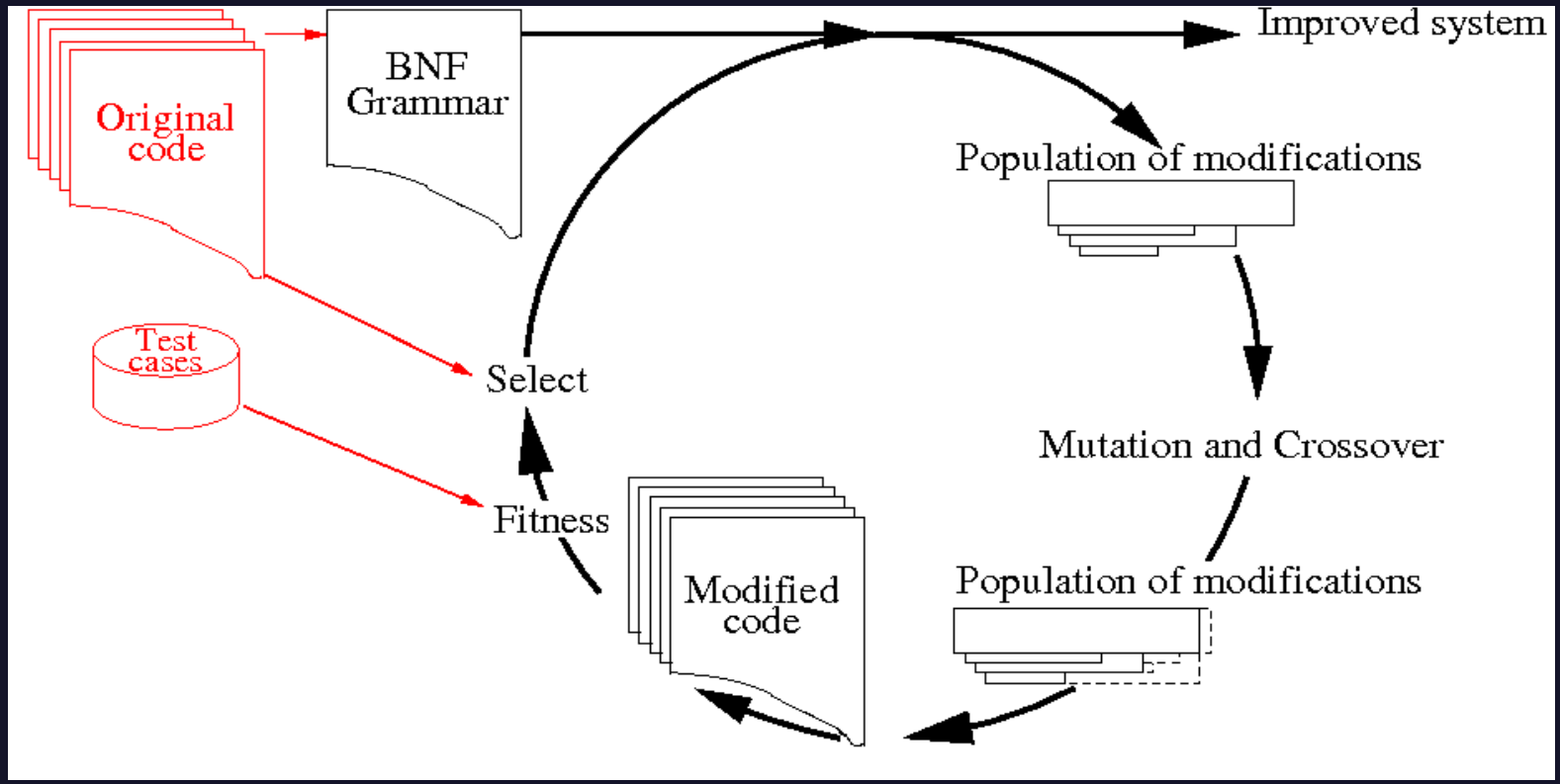
Bowtie2 : big runtime improvement ("Optimising Existing Software with Genetic Programming", W.B.Langdon & M.Harman, IEEE Transact. on Evol. Comp.)

MiniSAT : up to $\sim$2.5% runtime improvement (SSBSE'13)

GP Improvement



Motivation for choosing a SAT solver

Bounded Model Checking

Planning

Software Verification

Automatic Test Pattern Generation

Combinational Equivalence Checking

Combinatorial Interaction Testing

and many other applications..

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Benchmarks available from SAT solver competitions

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MiniSAT hack track in SAT solver competitions

Research directions (from SSBSE'13 talk)

Specialise test sets for GP

Change population and generation size

Allow to inject lines of code from other SAT solvers

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Trying an older version of MiniSAT

Comparing random vs. fitness-based selection strategy

Allowing changes within expressions by using GenProg

(http://dijkstra.cs.virginia.edu/genprog/)

Experiments: Setup

Solvers used:

MiniSAT1.14 and MiniSAT2-070721

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Test cases used:

from SAT competitions (application track)

from Combinatorial Interaction Testing field (generated)

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MiniSAT1.14 and MiniSAT2-070721

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Scoring:

200 points for returning the correct answers

0-50 points for runtime improvement

MiniSAT1.14: Fitness Strength

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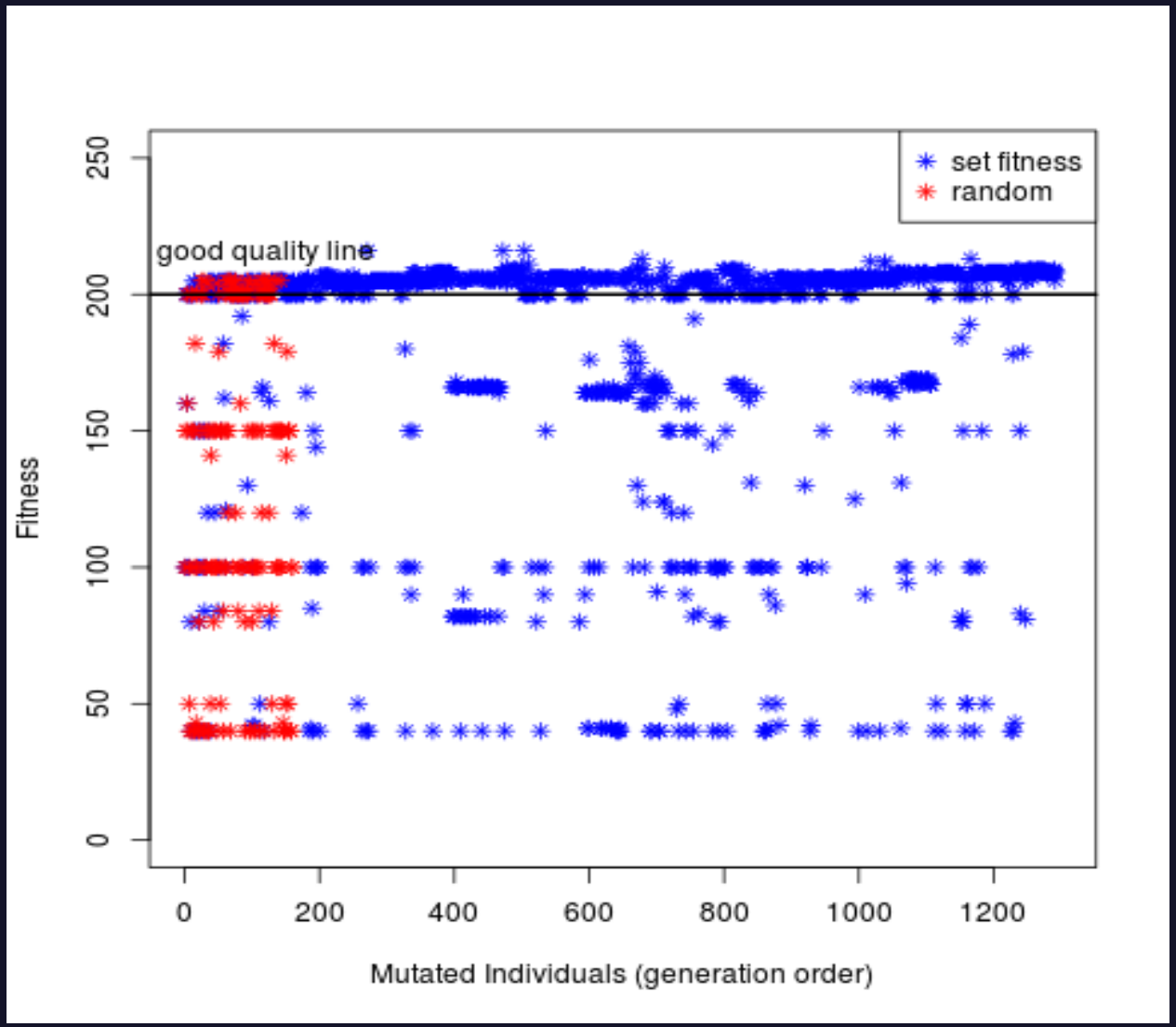

population size: 100, generations: 20, Application benchmarks

MiniSAT1.14: Specialised Test Set

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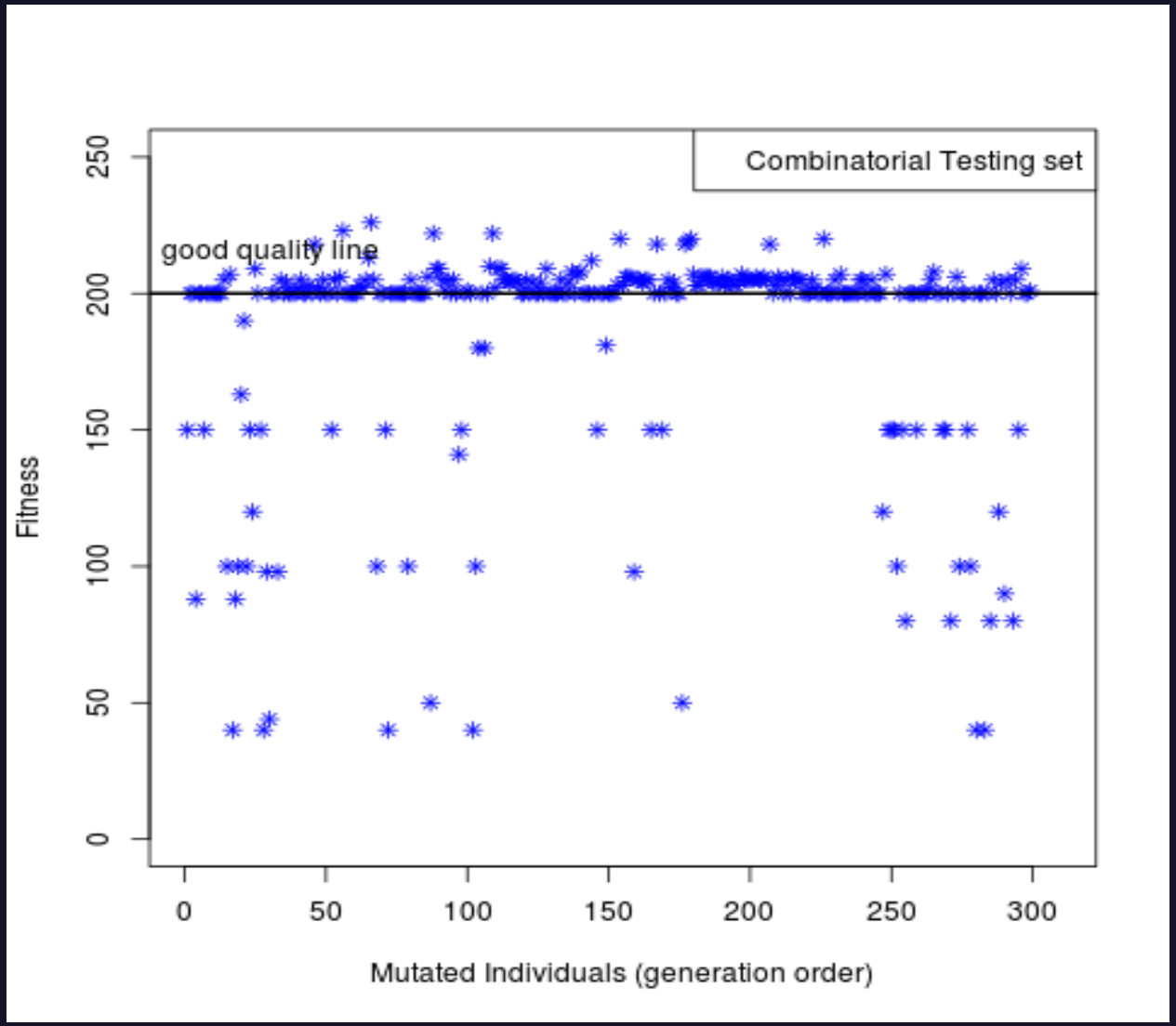

population size: 100, generations: 10, Combinatorial Testing benchmarks

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Test Cases from the Application track of SAT competitions:

65% produced non-zero fitness (47% of good quality)

highest fitness: 216

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Test Cases from Combinatiorial Testing application:

30% produced non-zero fitness (24% of good quality)

highest fitness: 226

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improved on around 60% tests

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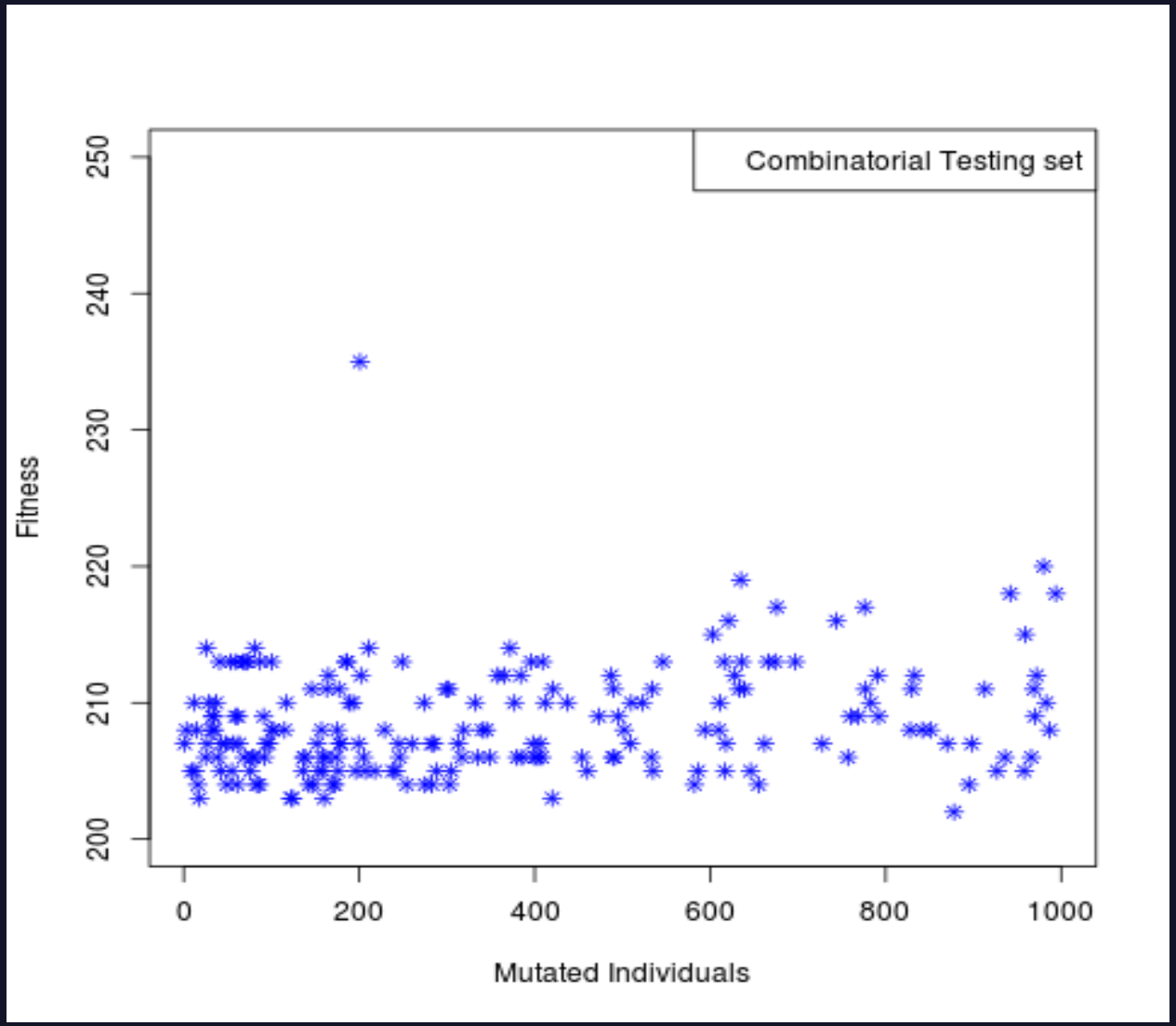

population size: 100, generations: 10, Combinatorial Testing benchmarks

MiniSAT1.14: Modifying Expressions

Test Cases from Combinatiorial Testing application:

Original framework:

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changes: $<$ *IF_Solver*_632 $><$ *IF_Solver*_985 $>$

MiniSAT1.14: Modifying Expressions

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Original framework:

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changes: $<$ *IF_Solver*_632 $><$ *IF_Solver*_985 $>$

GenProg:

20% produced non-zero fitness (20% of good quality)

highest fitness: 235

changes: s(992,1031) d(1082)

MiniSAT2-070721: Adding New Code

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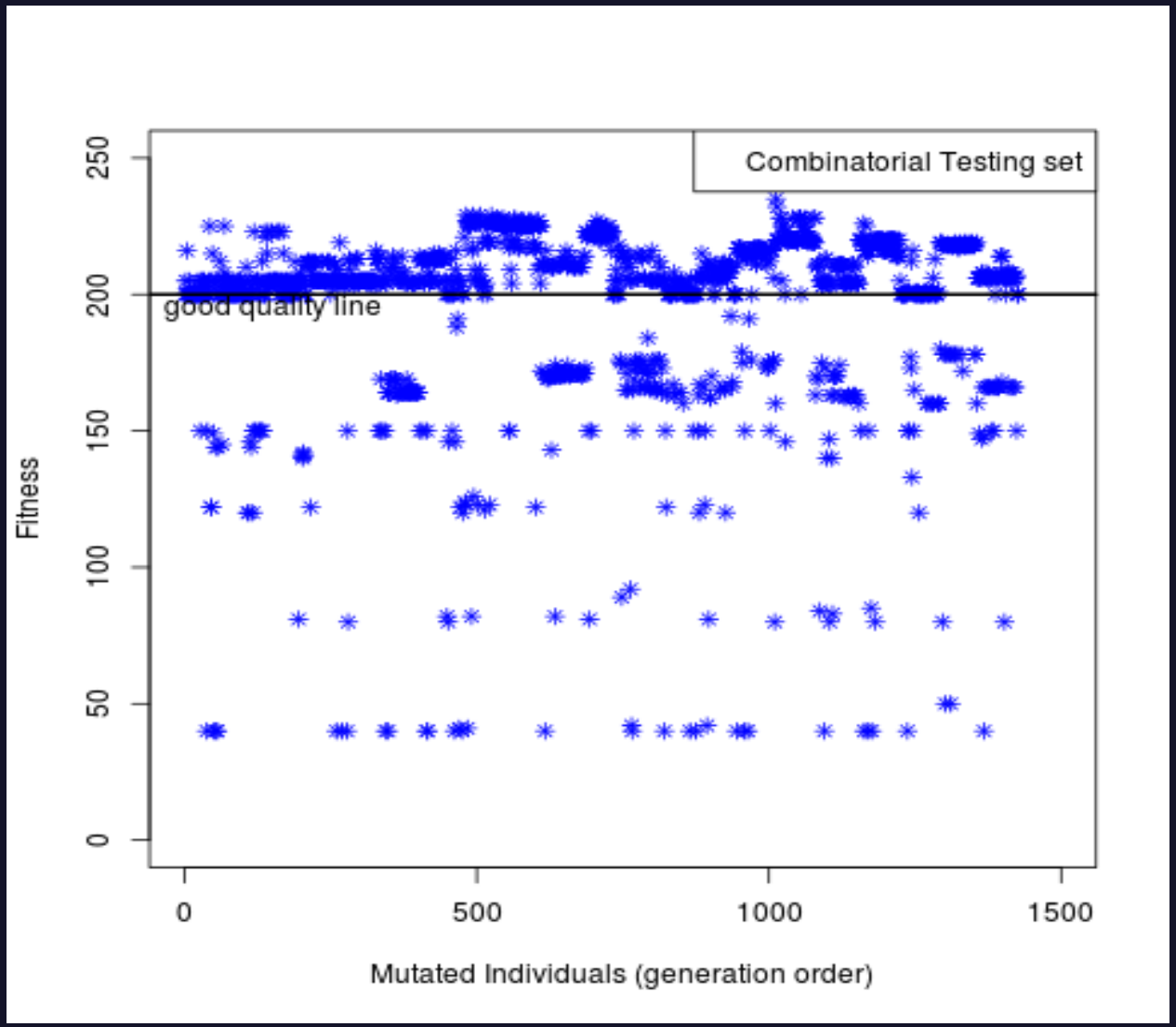

population size: 100, generations: 20, Combinatorial Testing benchmarks

MiniSAT2-070721: Adding New Code

Test Cases from Combinatiorial Testing application:

71% produced non-zero fitness (55% of good quality)

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New code used in generations 5, 8-20

None of the new code used in the ‘best’ individuals

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Best individuals found in early generations

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Combining all ‘best ’ individuals gives:

Improvement of 4.9% in terms of CPU time

Improvement of 7.9% in terms of lines of code executed

40 changes in total

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Better than a winning solver from MiniSAT hack track 2009

(which was worse than MiniSAT2-070721 on Combinatorial Testing set)

Summary

Applied genetic improvement to a SAT solver

By specialising the training set:

Achieved 4.9% improvement in terms of CPU time

Achieved 7.9% improvement in tems of lines of code executed

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Fitness vs. Random:

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Fitness vs. Random: fitness provides good guidance

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Non-specialised vs. Specialised:

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Modify fitness