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Evolving Better Software Parameters

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Evolving Better Software Parameters

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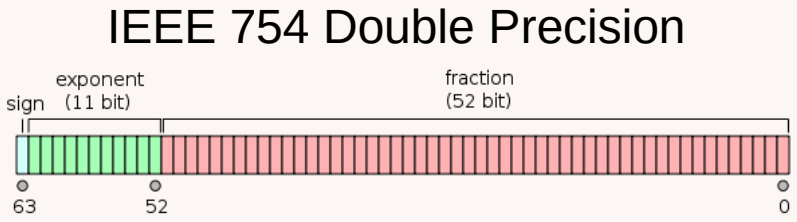
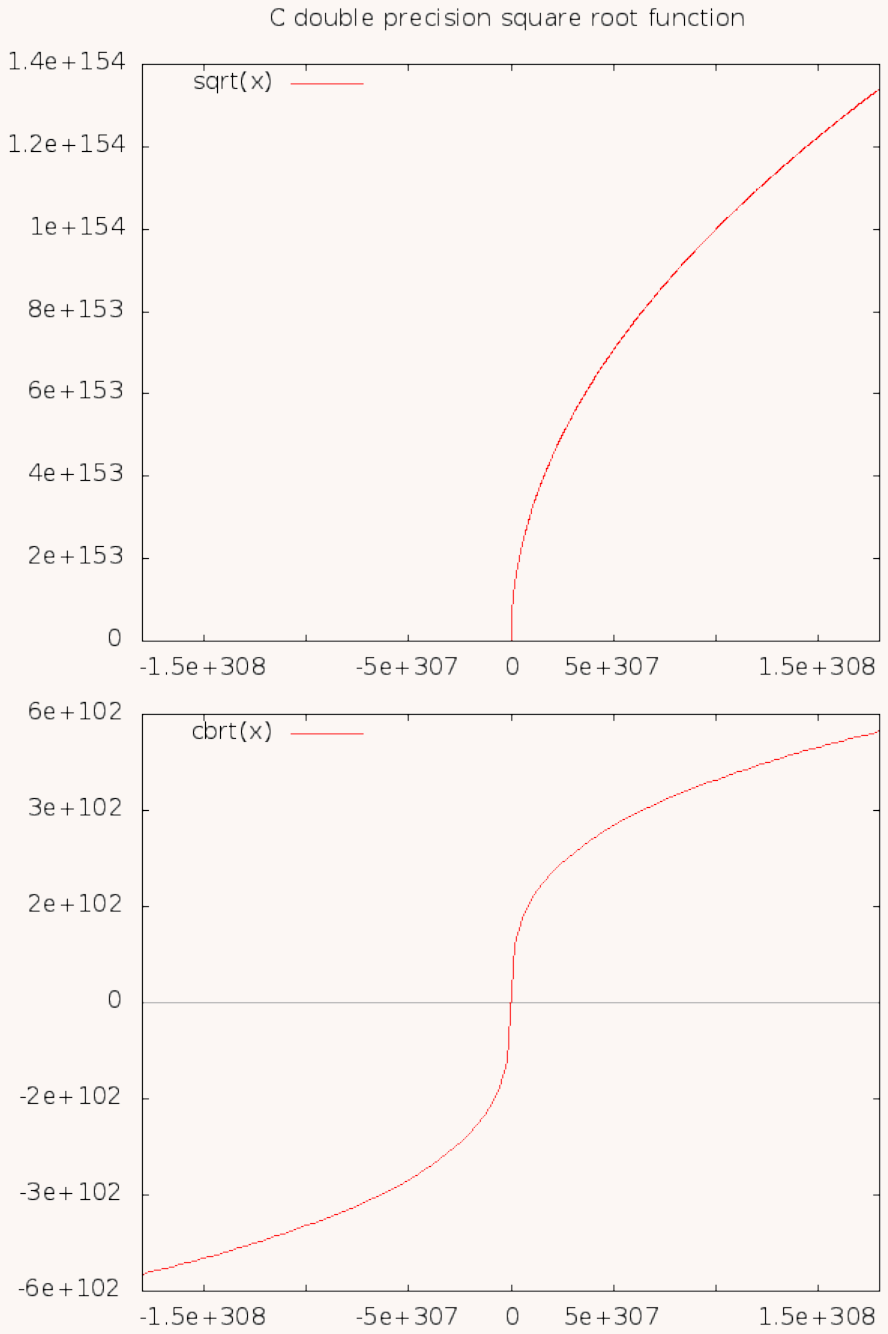
Maintaining Embedded Constants

- EuroGP 2018
  - RNAfold 7000 lines of code 50000 numbers
  - On average better predictions of RNA folding.
  - Shipped since 2.4.7
- GNU C library sqrt converted to cube root
  - New functionality, double precision accuracy
- RN/18/05 square root converted to $\log_2$
  - Demonstrate duplicating existing functionality using CMA-ES on square root data.
  - Gives double precision accuracy

Use CMA-ES to convert sqrt into cbrt

By updating table of 512x2 floats





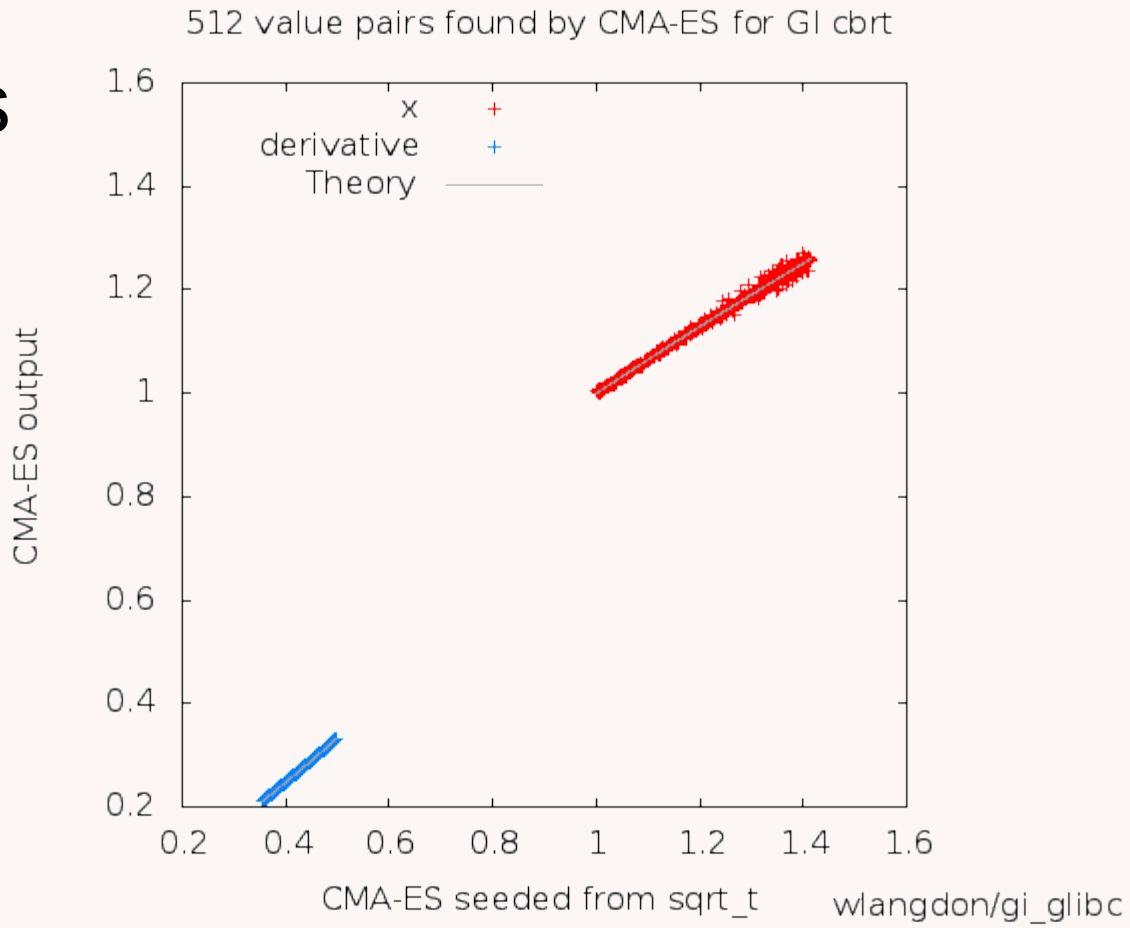
GNU C library sqrt converted to cbrt

- Chosen implementation of sqrt divides normalised input into 512 bins.
- Each bin holds start point for Newton-Raphson and initial derivative (two floats)
- Run CMA-ES per table element:
  - Seed with square root values
  - Run code with CMA-ES generated test pair
  - Fitness = log |c*c*c - x| where c=‘cbrt’(x)
    - x takes three test values: smallest, mid, max in bin
  - Random restart if search fails to find pair of values for which 3 diffs are smallest possible

CMA-ES

sqrt seed values close to cbrt

Evolved value very close to theory.



Evolved cube root

Evolved cbrt tested many thousands of times

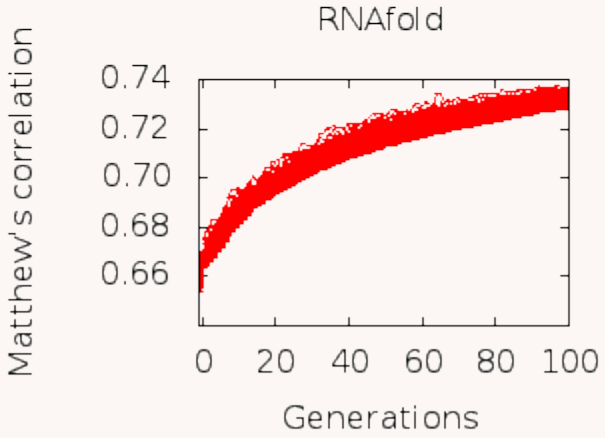
- Almost always exact (double precision)
- Usually same precision as sqrt ($\leq 4.4\ 10^{-16}$)
- Worst case $6.6\ 10^{-16}$ (last bit double precision $2.2\ 10^{-16}$)
- Worst case probably due to additional rounding error in least significant bit of double during manual code.

Automatic Software Maintenance

- In a world addicted to software, maintenance is the dominant cost of computing.
- Need to keep parameters up to date. Eg:
  - New science, new laws or regulations, new users, new user expectations
  - Change of load, new hardware (eg bigger RAM), automatic porting
  - Search can be fast (cbrt < five minutes)
- Little SBSE research
- Great scope for automation

Summary

- Problem of maintaining data in code ignored
- SBSE to optimize them
  - suitable training data
  - treat code as a black box.



- Rapidly generated new maths (cbrt, $\log_2$)
- Need research on Automatic Data and Parameter Tuning via Genetic Improvement
- Software is not fragile

END

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Genetic Programming

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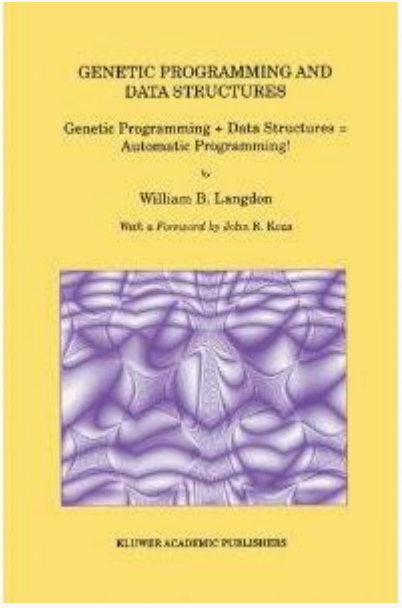
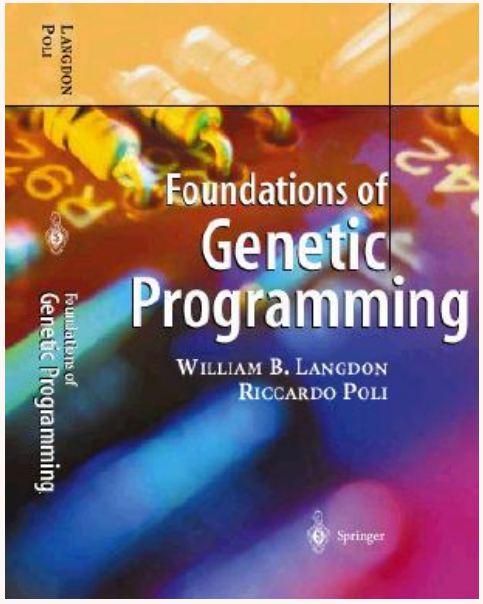
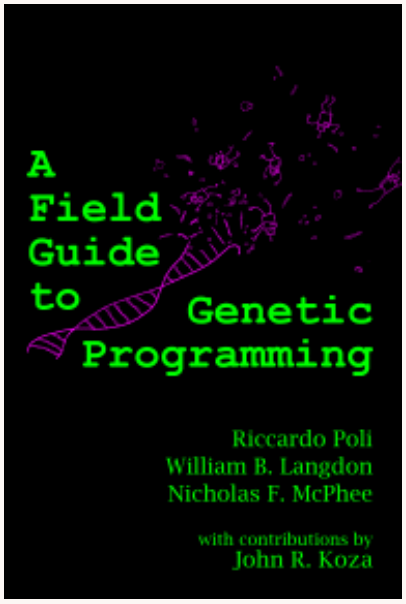






Improving RNAfold parameters

EuroGP-2018

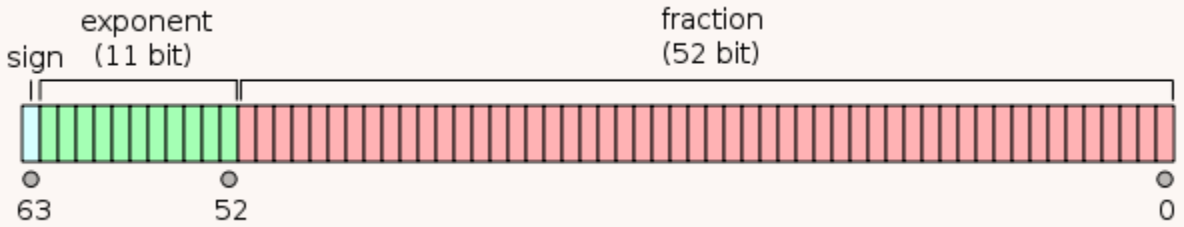
- RNAfold 7100 lines of C source code, 51521 parameters.
- Fitness correlation between prediction and true structure (MCC).
- Post evolution tidy
- 14732 (29%) parameters changed
- Holdout set significant increase in MCC
- Also better than constrained optimisation
- GI parameters rna_langdon2018.par shipped with ViennaRNA since 13 Jun 2018

Manual Changes I

- Most implementations of square root use hardware support.
- GNU C library glibc 2.27 also includes Newton-Raphson iterative solution
- Trap bad values, e.g. negative
- Normalise double input to 0.5 .. 2.0
- Guaranteed convergence in three steps:
  - Update both estimate of $\sqrt{x}$ and derivative
- Apply square root to exponent, ie divide by 2

Cube Root Code Changes II

- Remove trap for negative values
- Normalise double precision input to 1.0..2
  - Update both estimate of cube root $x^{⅓}$ and its derivative $⅓x^{-⅔}$
- Apply cube root to exponent, ie divide by 3

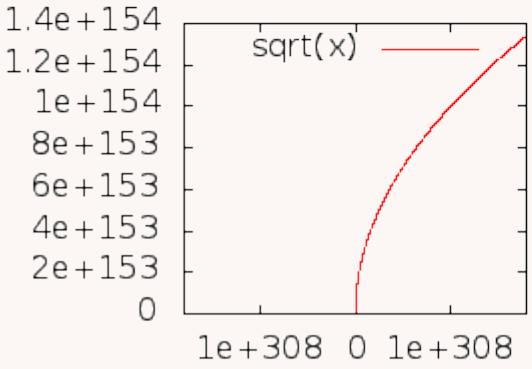


Square root to binary log RN/18/05

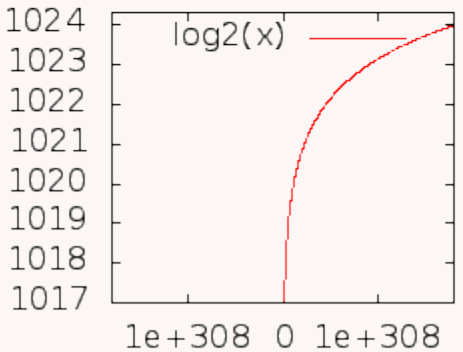
Frame work as sqrt to cbrt but

- Derivative known
- CMA-ES one dimension at a time (512 times) very easy

C double precision square root function



C double precision binary logarithm function



RN/18/05

The Genetic Programming Bibliography

http://www.cs.bham.ac.uk/~wbl/biblio/

12579 references, 11000 authors

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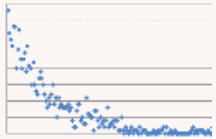
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