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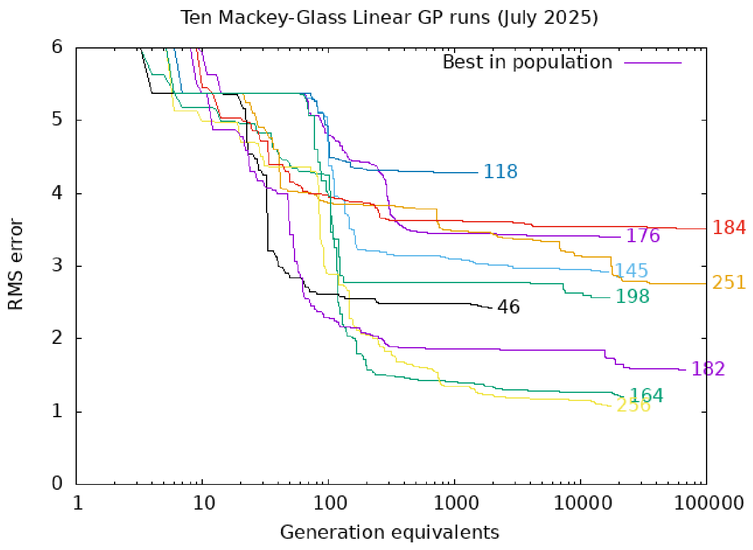
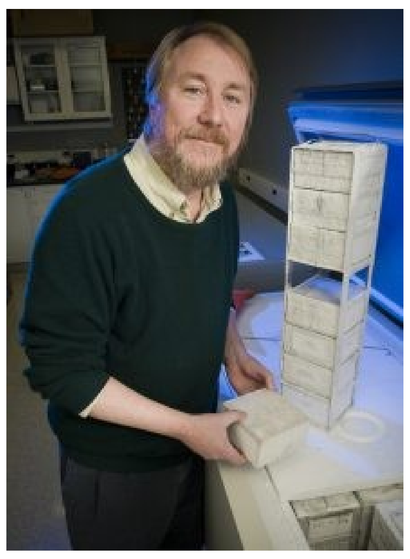
Open-Ended Evolution with Linear Genetic Programming

1 Long Term Evolution Experiment

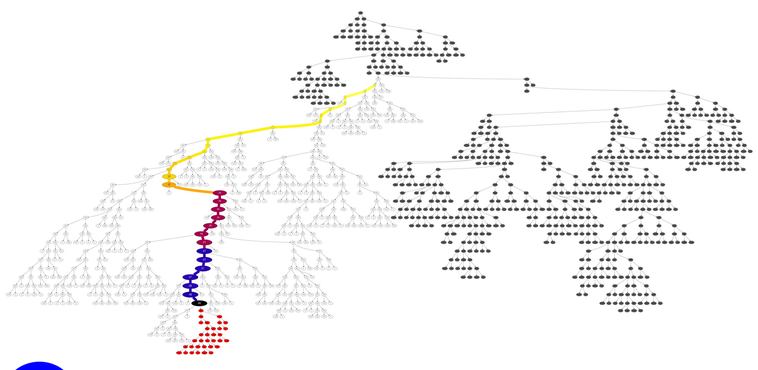




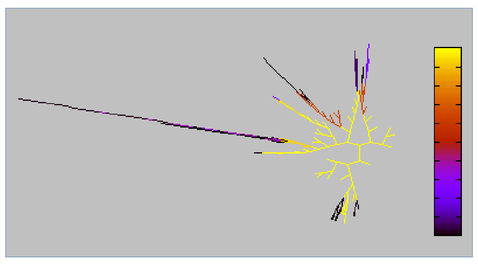
Richard Lenski pulls frozen bacteria cultures out of a freezer 15 Oct 2009.

August 2024 LTEE 80,000 generations.

2 Disruption hidden by depth

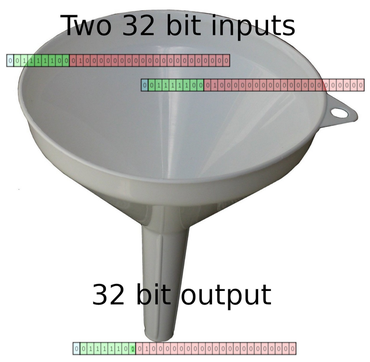


3 Population Convergence



500 trees after 2000 generations

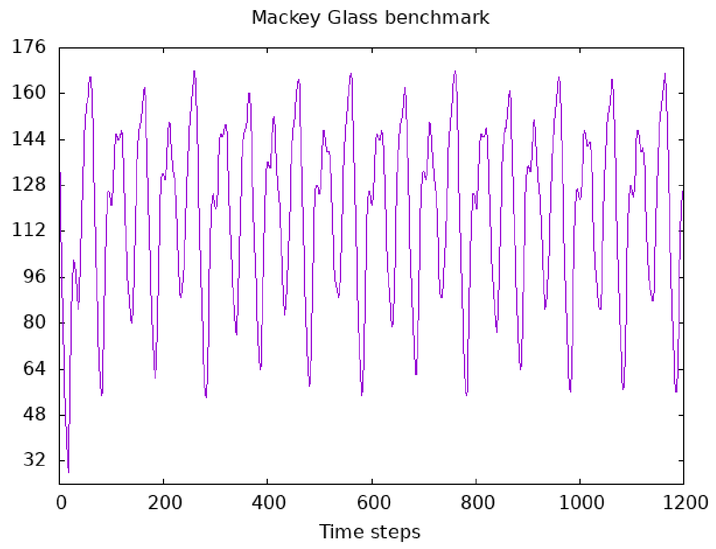
4 Information Theory



In digital computing all operations are irreversible. Meaning loss of information.

The funnel adds two 32 bit numbers (≤64bits information) and generates one 32 bit answer (≤32 bits of information).

5 IEEE chaotic time series Benchmark



6 Linear Genetic Programming

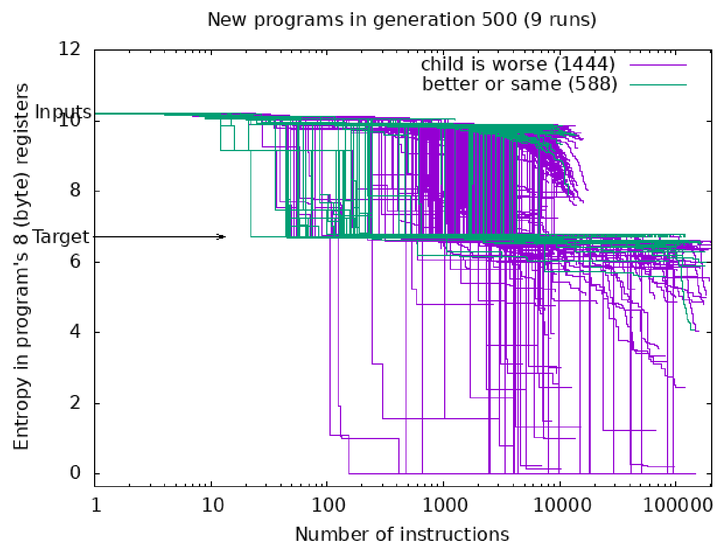
Table 1: Mackey-Glass prediction with Linear GP

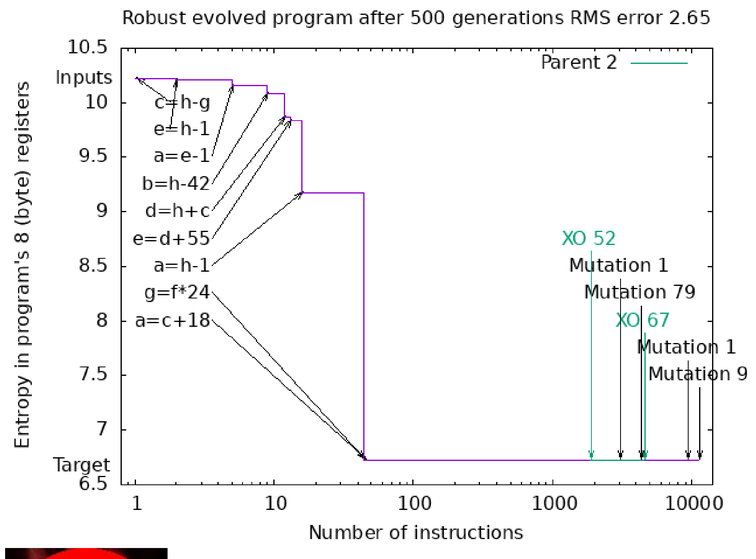
Terminal set:	Unsigned 8 bit integers. Variables R0, R1, R2, R3, R4, R5, R6, R7. Constants 0 to 127.
Function set:	$+ - \times$ DIV
Fitness cases:	1201 Mackey-Glass examples. Given 8 prior values (-1, -2, -4, ... -128 before) predict next y
Selection:	Tournament(2), fit = $\sum_{i=0}^{1201} \lvert \mathrm{GP}(\vec{x_i}) - y_i \rvert^2$
Population:	500, panmictic, steady state.
Parameters:	100 000 generations. Random initial population (500) size between 1 and 14 instructions. 90% two point 2 child crossover, 40% chance both XO children subjected to random point mutation 4 times. 10% reproduction.

DIV is protected division `(y!=0)? x/y : 0`

7 Information Entropy

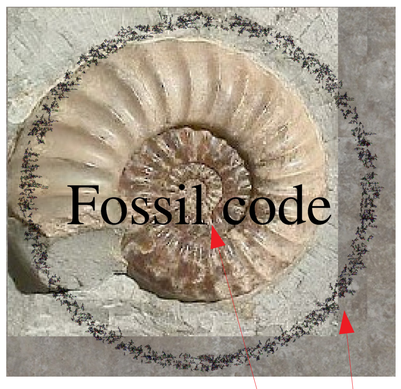
Entropy = -Σ p $\log_2$ p





Software is robust not chaotic

8 Evolve large complex code



Large dead center

Thin evolving crust

AVOID dead code

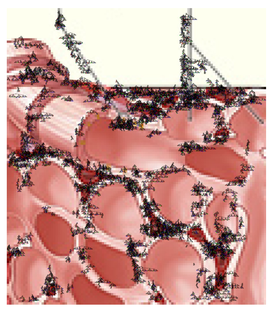
With deep code most crossovers and mutations make no difference.

To avoid dead center evolving code must be near environment.

9 Evolve many linked shallow codes

Bali barat mangroves

Many many trees, so most code close to fitness environment.



Lung like open complex evolving system composed of 1300 individual functions. Compute element are placed side-by-side to form an open structure. The gaps promote short cut side effects between functions input and outputs and the environment.

sponge Coral Pumice Zeolite

Be shallow, be close to the environment

10 References

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