The Relationship Between Evolvability and Bloat

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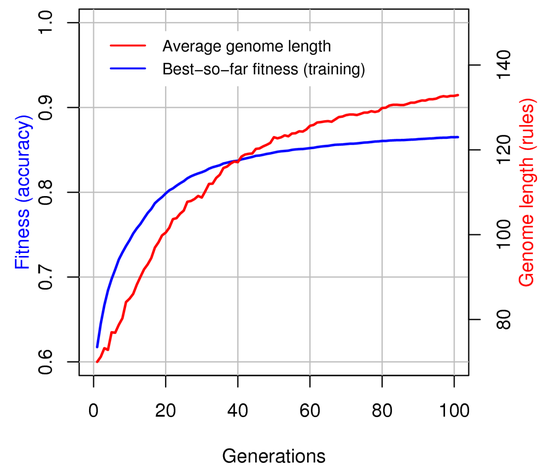
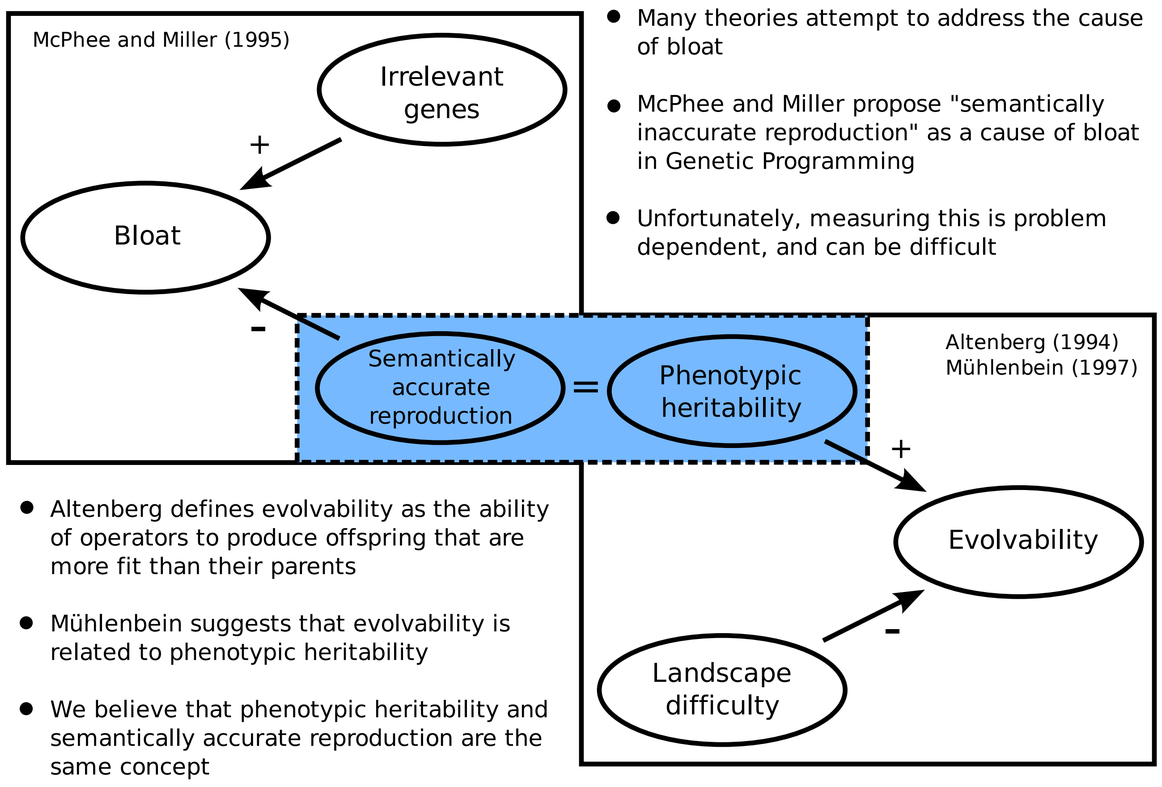
The Problem

- **Bloat** occurs when the size of genomes in a population grow uncontrollably, even after a solution is found
- Most variable length representations suffer from bloat
- There are some reproductive operators that cause little to no bloat at all
- But there is little guidance for designing such an operator



Proposed Solution



- Many theories attempt to address the cause of bloat
- McPhee and Miller propose "semantically inaccurate reproduction" as a cause of bloat in Genetic Programming
- Unfortunately, measuring this is problem dependent, and can be difficult

- Altenberg defines evolvability as the ability of operators to produce offspring that are more fit than their parents
- Mühlenbein suggests that evolvability is related to phenotypic heritability
- We believe that phenotypic heritability and semantically accurate reproduction are the same concept

Hypothesis:

Reproductive operators with high evolvability will produce less bloat

- If so, evolvability will provide a useful metric for guiding the design process

A Demonstration

- Develop a new crossover operator for Pittsburgh Approach rule systems
  - Design Principle: improve phenotypic heritability
  - Phenotype = mapping from feature space (inputs) - to classifications (outputs)
  - The Nearest Neighbor representation offers an opportunity
    - Rule conditions identify points in feature space
    - The relationship between genotype and phenotype is very clear
  - "Feature space crossover"
    - Perform gene swaps based on a rule's location in feature space
    - See next frame
- Compare our operator to a standard Pittsbugh Approach crossover operator
  - Test suite: several common concept learning problems
  - Evolvability = Correlation(Fp, Fc)
    - Fp = Fitness of mid-parent, Fc = Fitness of child

References

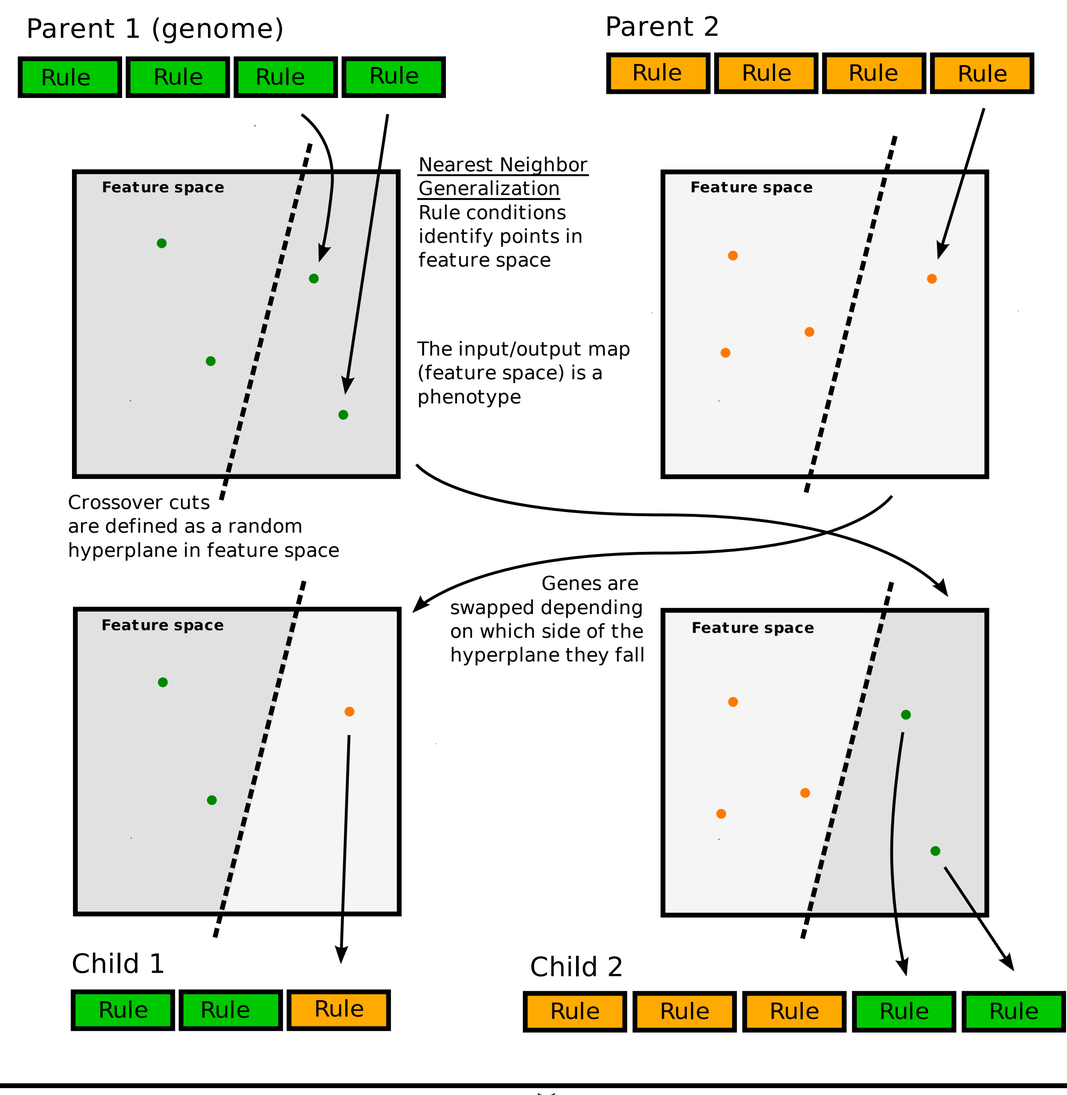
Altenberg, L. (1994) The Evolution of Evolvability in Genetic Programming. In Kenneth E. Kinnear Jr., editor, Advances in Genetic Programming, pages 47–74. MIT Press.

McPhee, N.F. and Miller, J.D. (1995) Accurate Replication in Genetic Programming. In L. J. Eshelman, editor, Proceedings of the Sixth Int. Conf. on Genetic Algorithms, pages 303–309, Morgan Kaufmann.

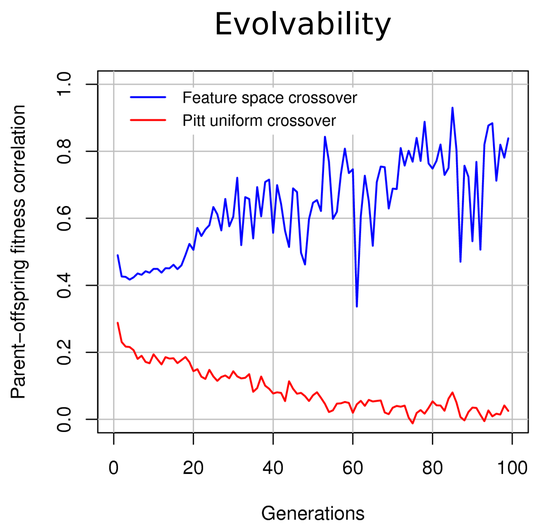
Mühlenbein, H. (1996) The Equation for the Response to Selection and Its Use for Prediction. Evolutionary Computation, 5(3):303-346, MIT Press.

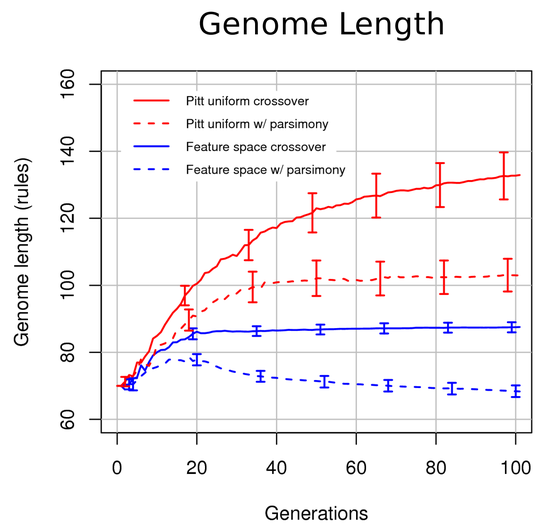
Improving Phenotypic Heritability

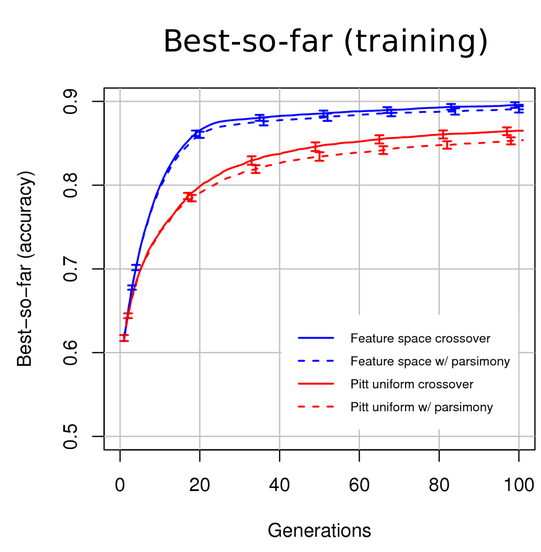
"Feature space crossover"
for Pittsburgh Approach rule systems

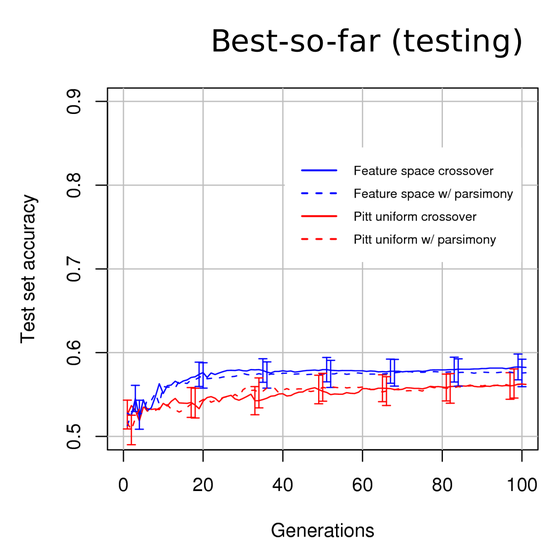


Results









Conclusions

- In all experiments, feature space crossover produced significantly less bloat at no cost to fitness
- Evolvability metrics can aid in the development of customized reproductive operators that cause less bloat