Analysis of Ancestry in Genetic Programming with a Graph Database

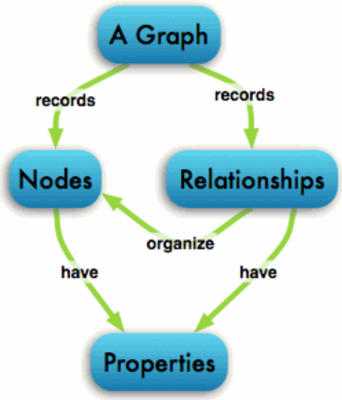
David Donatucci
M. Kirbie Dramdahl
Nicholas Freitag McPhee

Division of Science and Mathematics
University of Minnesota, Morris
Morris, Minnesota, USA

25 April 2014
MICS, Verona, WI

The Big Picture

- Genetic programming demonstrated to be effective for a variety of applications.
- Difficult to determine how this process works.
- Databases allow examination of the internal interactions of a run.
- Graph databases more efficient at this task than relational databases.
- This knowledge may be used to improve genetic programming algorithms.



Neo4j
http://www.neo4j.org/learn/graphdatabase

Outline

1. Genetic Programming
2. Graph Database
3. Experimental Setup
4. Results
5. Conclusions

Outline

Genetic Programming Overview

Roger Alsing
http://io9.com/5106124/a-computer-program-that-taught-itself-to-draw-the-mona-lisa

- Genetic Programming is based upon biological principles.
- Individuals form a population.
- Transformations
  - Crossover (XO)
  - Mutation
  - Reproduction
  - Elitism
- Transformations occur over a specified number of generations.
- Individuals are rated by their fitness.

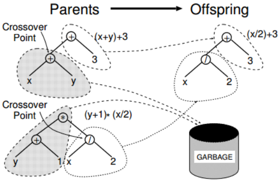
Transformations

Crossover sexual reproduction (root and non-root)

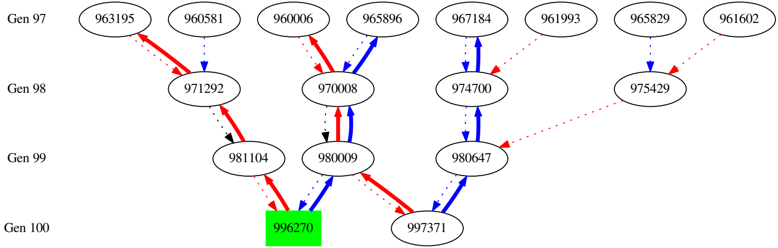
Mutation subtrees altered

Reproduction asexual reproduction

Elitism reproduction based on fitness



Richard Poli, William B. Langdon, Nicholas F. McPhee
`http://dces.essex.ac.uk/staff/rpoli/gp-field-guide/A_Field_Guide_to_Genetic_Programming.pdf`



Symbolic Regression and Fitness

We are focusing on symbolic regression problems.

- Collection of test points as input.
- Evolve mathematical formula to fit data.

Fitness determines individual's distance from target function.

- Lower the fitness, the better the individual.
- A fitness of zero would exactly match test data.

The goal of GP is to evolve an individual with as low a fitness as possible.

Outline

Neo4j

Neo4j is a graph database.

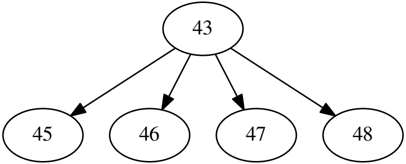
- relatively new tool
  - initial release 2007
  - popularized in 2010
- information is stored using a graph
- nodes and relationships
- efficient recursive queries compared with traditional databases

Cypher

Neo4j's query language is Cypher.

Fundamental elements of Cypher queries:

- START
- RETURN
- MATCH
- WHERE



START parent=node(43)
MATCH (parent)-[:PARENTOF]->(child)
RETURN parent, child;

Outline

Run Configurations

Target Function	sin(x)
Variables	x (range 0.0 to 6.2, incremented by steps of 0.1)
Constants	range between -5.0 and 5.0
Operations	addition (+), subtraction (-), multiplication (*), protected division (/)
Generation Number	100
Population Size Per Gen	1000 (6 runs) and 10000 (1 run)
Transform Percentages	crossover (90%), mutation (1%), reproduction (9%)
Elitism	best 1%
Fitness	absolute error between target function and individual function

Outline

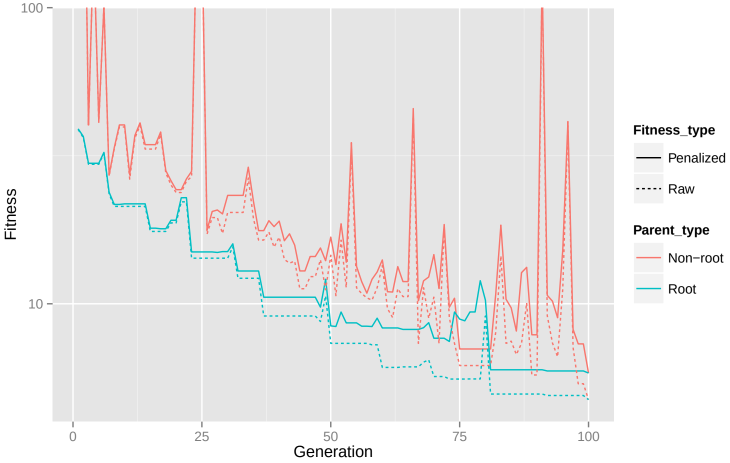
1. Genetic Programming
2. Graph Database
3. Experimental Setup
4. Results
   - Questions Asked
   - Fitness Over Time
   - Improved Transformations
   - Common Ancestor
5. Conclusions

Questions Asked

1. *What does the fitness of the "winning" root parent ancestry line look like over time?*
2. *How often do mutations improve fitness? Also, how often do crossovers improve fitness, where the root parent is more fit than the non-root parent, and vice versa?*
3. *Do a group of individuals have a common root parent ancestor and what is the latest generation where such an ancestor occurs?*
4. *How many individuals in the initial generation have any root parent descendants in the final generation?*

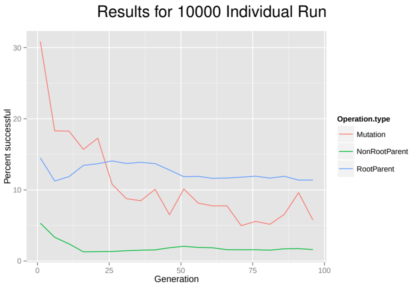
Fitness Over Time

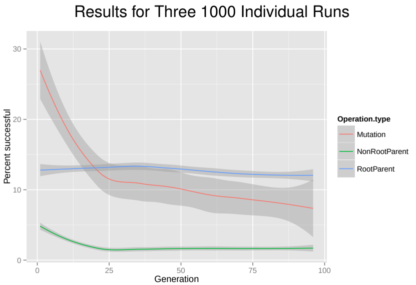
What does the fitness of the "winning" root parent ancestry line look like over time?



Percentage of Improved Transformations

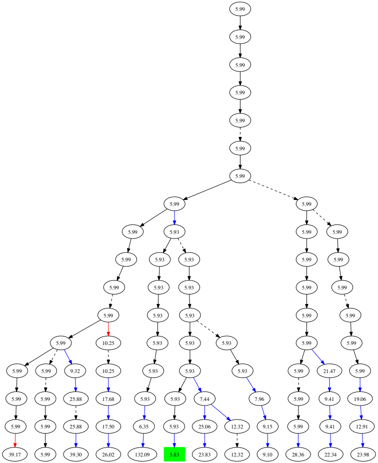
How often do mutations and crossovers improve fitness?





Common Ancestor

Do a group of individuals have a common root parent ancestor and what is the latest generation where such an ancestor occurs?



Outline

Conclusions

- We can gather internal data.
- Provides more in depth information than statistical summaries.
- Support for hypotheses.

Future Work

- Trying different setup configurations.
- Enforcing the root parent to have better fitness in XO.
- Dynamically change parameters.

Thanks!

Thank you for your time and attention!

Contacts:

- donat056@morris.umn.edu
- dramd002@morris.umn.edu
- mcphee@morris.umn.edu

Questions?

References

LUKE, S.
Essentials of Metaheuristics, second ed.
Lulu, 2013.
Available for free at http://cs.gmu.edu/$\sim$sean/book/metaheuristics/.

MCPHEE, N. F., AND HOPPER, N. J.
Analysis of genetic diversity through population history.
In *Proceedings of the Genetic and Evolutionary Computation Conference* (1999), vol. 2, Citeseer, pp. 1112–1120.

POLI, R., LANGDON, W. B., AND MCPHEE, N. F.
A Field Guide to Genetic Programming.
Published via `http://lulu.com` and freely available at `http://www.gp-field-guide.org.uk`, 2008.
(With contributions by J. R. Koza).

ROBINSON, I., WEBBER, J., AND EIFREM, E.
Graph Databases.
O'Reilly Media, Inc., 2013.