Analysis of Ancestry in Genetic Programming with a Graph Database

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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.
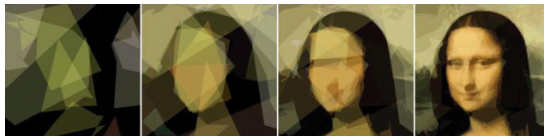- This knowledge may be used to improve genetic programming algorithms.

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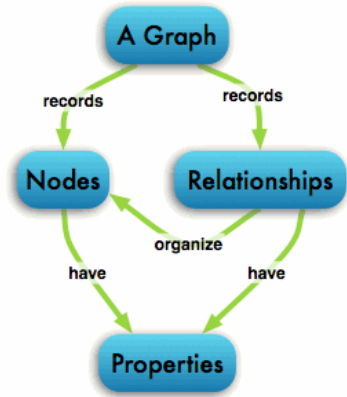
Outline

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.
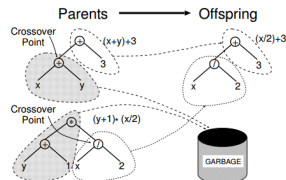- Individuals are rated by their fitness.

Transformations

Crossover   sexual reproduction (root and non-root)
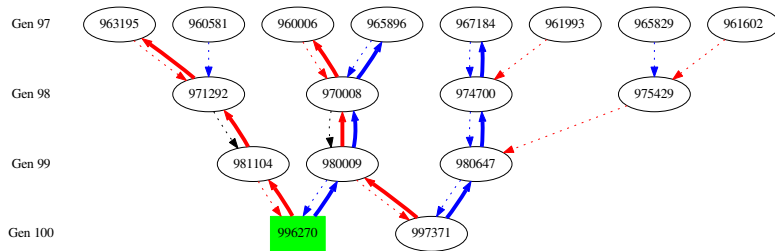
Mutation   subtrees altered

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.

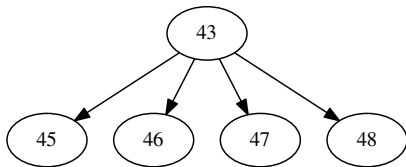# Outline

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

Donatucci, Dramdahl, McPhee (UMM)   Analysis of GP Ancestry in Neo4j   April '14, MICS, Verona, WI   13 / 21

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?*
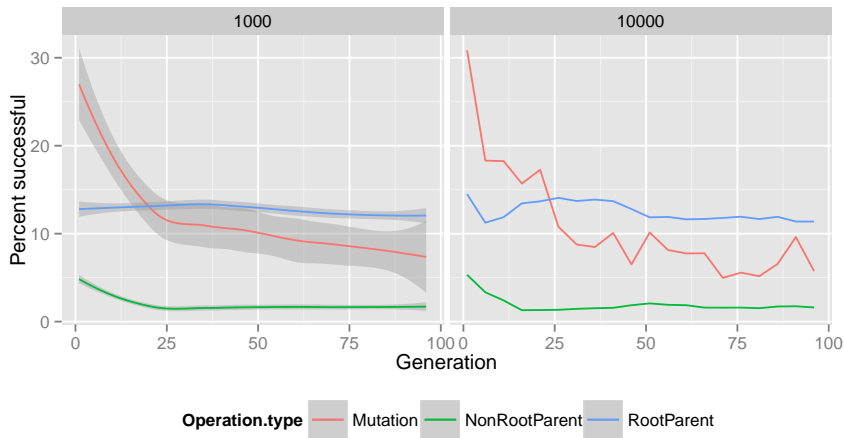
Fitness Over Time

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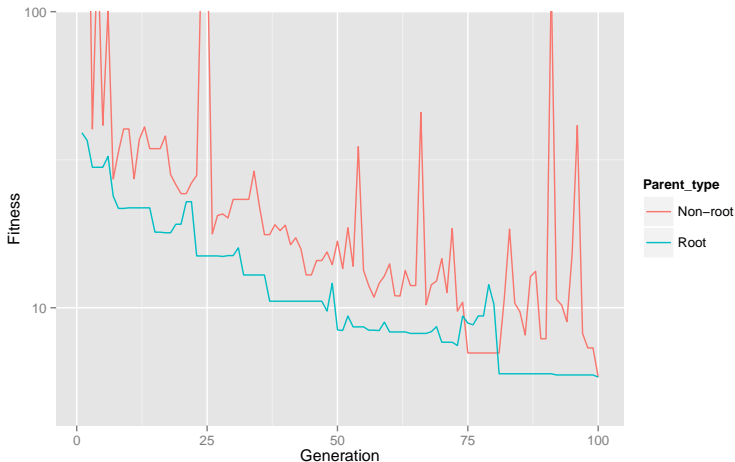
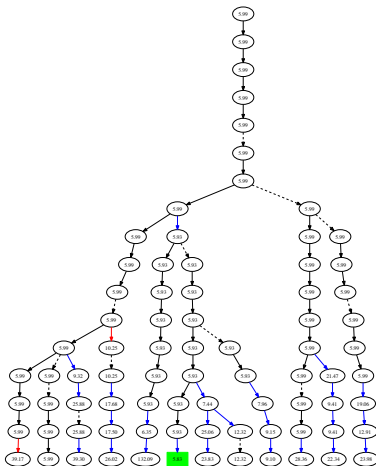# Percentage of Improved Transformations

How often do mutations and crossovers improve fitness?

Results for Three 1,000 Individual Runs and One 10,000 Individual Run

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!

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Questions?

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