

# Analysis of Ancestry in Genetic Programming with a Graph Database

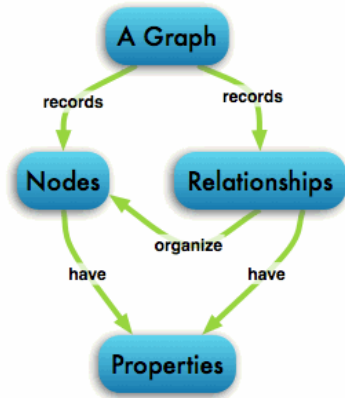
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25 April 2014  
MICS, Verona, WI

# 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>

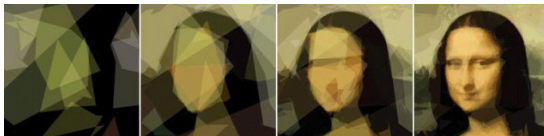
# Outline

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

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- 1 Genetic Programming
  - GP Overview
  - Symbolic Regression and Fitness
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# 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.

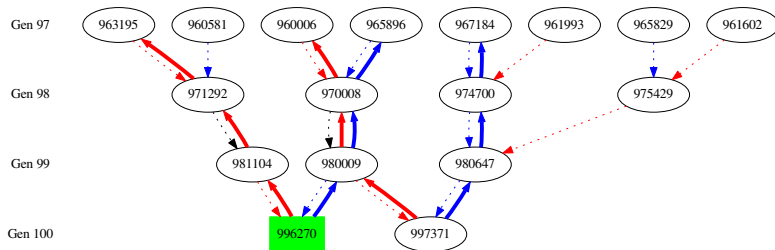
# Transformations

Crossover (XO) sexual reproduction (root and non-root)

Mutation subtrees altered

Reproduction asexual reproduction

Elitism reproduction based on fitness



# 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

1 Genetic Programming

2 Graph Database

- Neo4j
- Cypher

3 Experimental Setup

4 Results

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# Neo4j

Neo4j is a graph database.

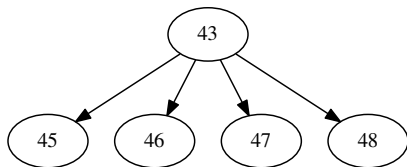
- relatively new tool
  - initial release 2007
  - popularized in 2010
- information is stored using a graph
- nodes and relationships
- efficient recursive queries compared with traditional databases

# 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;
```

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# Run Configurations

**Target Function**  $\sin(x)$

**Variables**  $x$  (range from 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 Generation** 1000 (6 runs) and 10000 (1 run)

**Transformation Percentages** Crossover (90%), Mutation (1%),  
Reproduction (9%)

**Elitism** best 1%

**Fitness** Absolute error between target function and individual function.

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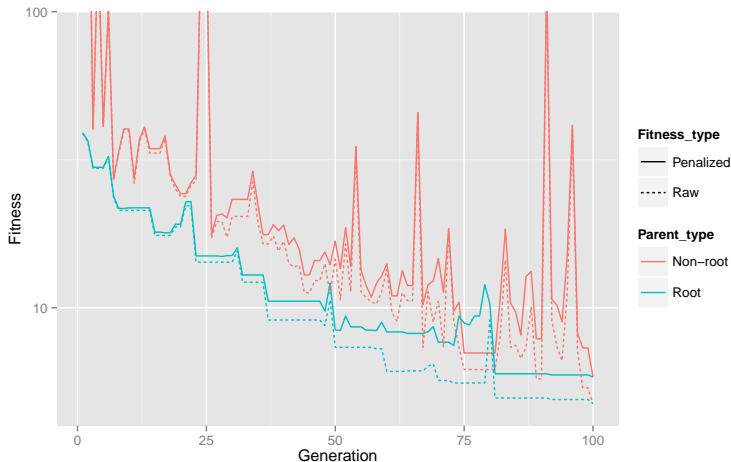
- 1 Genetic Programming
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- 4 Results**
  - Questions Asked
  - Fitness Over Time
  - Improved Transformations
  - Common Ancestor
- 5 Conclusions

# 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?*



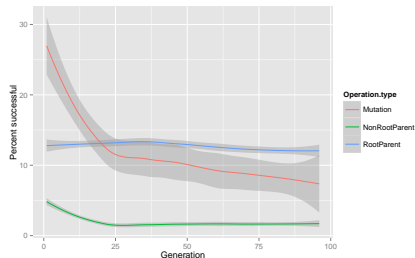
# Percentage of Improved Transformations

*How often do mutations and crossovers improve fitness?*

Results for 10000 Individual Run



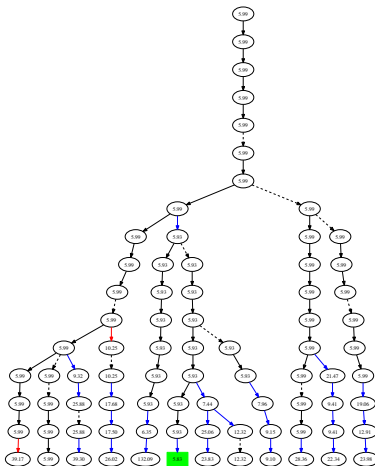
Results for Three 1000 Individual Runs





# Common Ancestor

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



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# 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?

# References



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