

# 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.

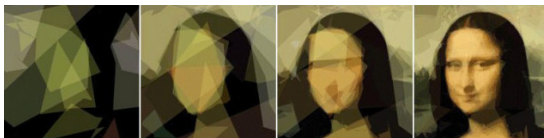
# Outline

- 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://goo.gl/kqsEP>

- 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.

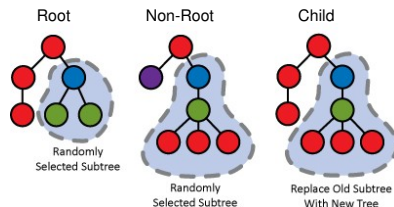
# Transformations

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

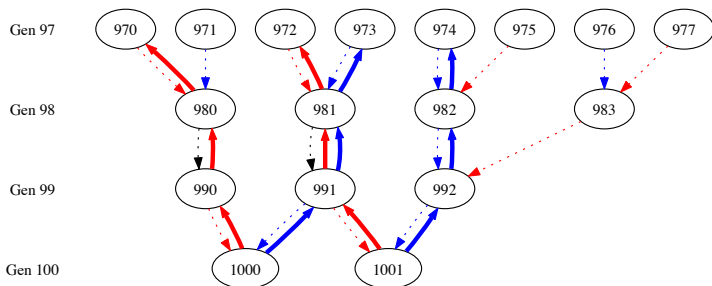
**Mutation** subtrees altered

**Reproduction** asexual reproduction

**Elitism** reproduction based on fitness



geneticprogramming.us



# 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.

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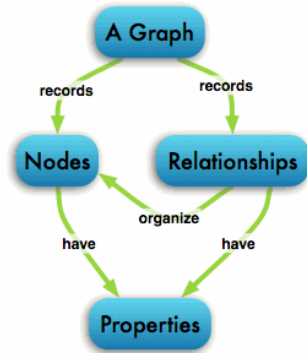
- 1 Genetic Programming
- 2 Graph Database
  - Neo4j
  - Cypher
- 3 Experimental Setup
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# Neo4j

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



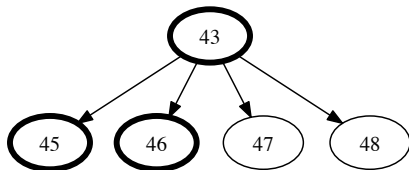
Neo4j <http://goo.gl/nzRWSV>

# Cypher

Neo4j's query language is Cypher.

Fundamental elements of  
Cypher queries:

- START
- RETURN
- MATCH
- WHERE



```
START parent=node(43)  
MATCH (parent)-[:PARENTOF]->(child)  
WHERE id(child) < 47  
RETURN parent, child;
```

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1 Genetic Programming

2 Graph Database

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- Configurations

4 Results

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# 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 1,000 (3 runs) and 10,000 (1 run)

Transform Percentages crossover (90%), mutation (1%), reproduction (9%)

Elitism best 1%

Fitness absolute error between target function and  
individual function

# Outline

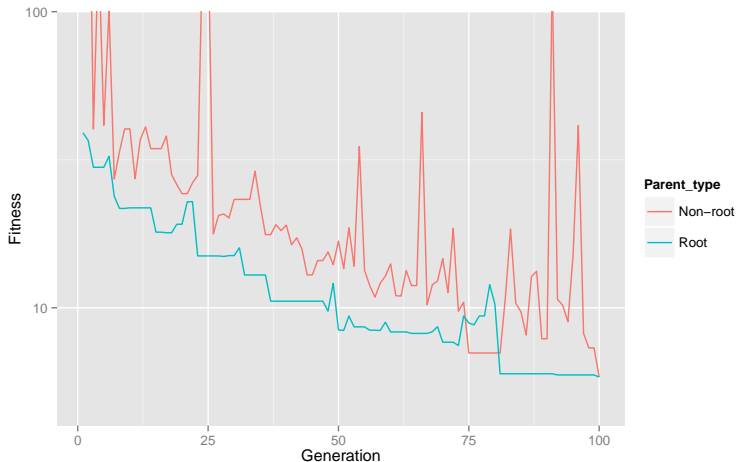
- 1 Genetic Programming
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  - Questions Asked
  - Fitness Over Time
  - Improved Transformations
  - Common Ancestor
- 5 Conclusions

# Questions Asked

- 1 *What does the fitness of the “winning” individual’s ancestry line look like over time?*
- 2 *How often does mutation improve fitness? Also, how often does crossover improve fitness, where the root parent is more fit than the non-root parent, and vice versa?*
- 3 *Does 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” individual’s ancestry line look like over time?*



# Percentage of Improved Transformations

*How often does mutation and crossover improve fitness?*

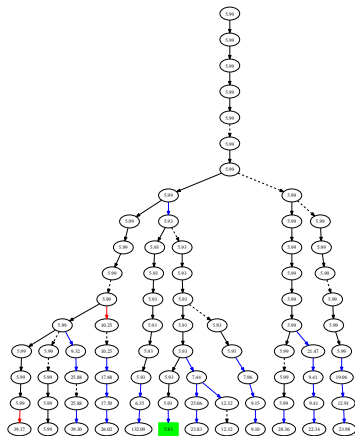
Results for Three 1,000 Individual Runs and One 10,000 Individual Run





# Common Ancestor

*Does a group of individuals have a common root parent ancestor and how many initial generation individuals have descendants in the final generation?*



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# Conclusions

- We can gather internal data efficiently.
- 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