CSE/ECE 848 Introduction to Evolutionary Computation

Module 3 - Lecture 11 - Part 3

Genetic Programming - Tree Representation

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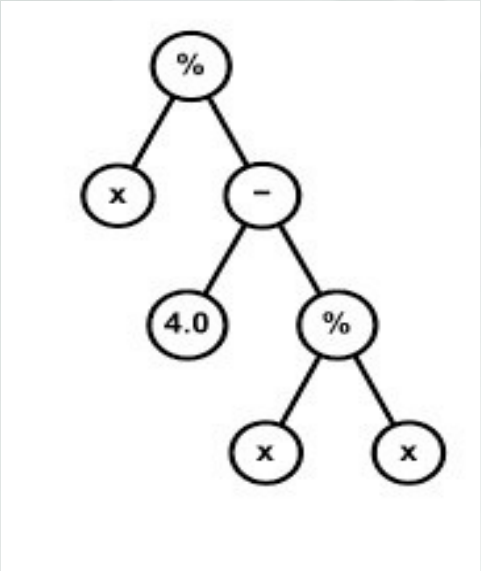
Representations

- Tree GP
- AIM GP
- Linear GP
- Graph GP (PADO example)
- Cellular Encoding
- CF Grammar GP

Tree GP

- Individuals are expression or parse trees
- Trees consist of functions and terminals (variables, constants)
- Trees are evaluated in a depth-first fashion
- Functions are protected to provide functional closure
- Trees are modified by different types of mutation and crossover operators.

Sample Tree

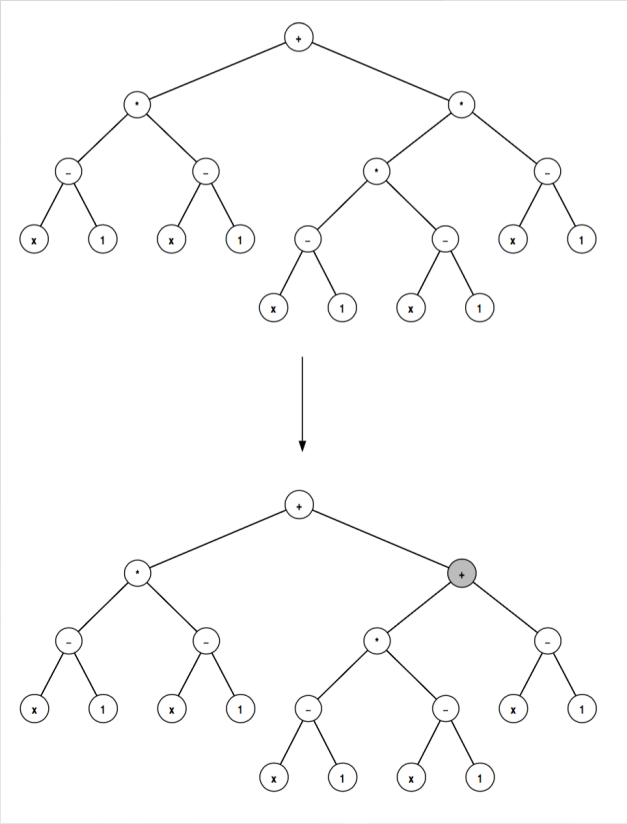


How you read it?

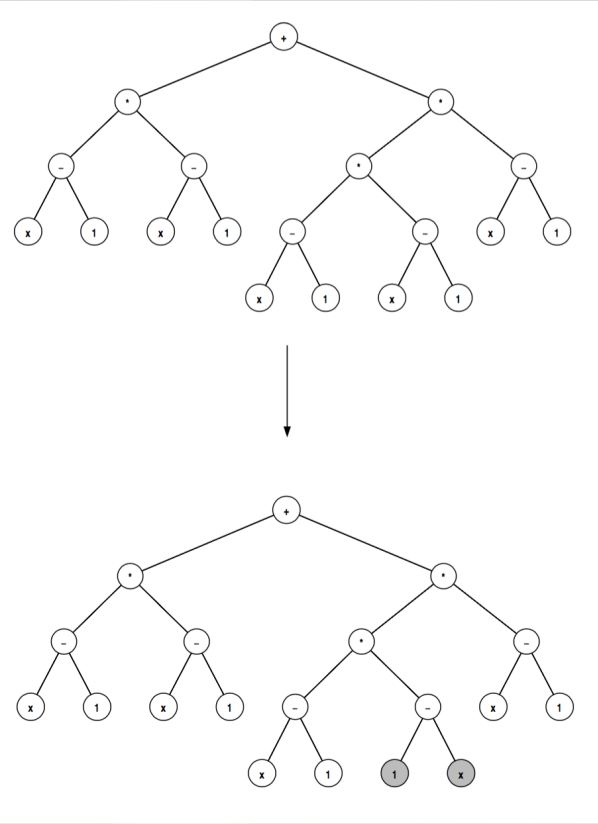
x / (4 - x / x) = x / 3

%: Protected division

Tree GP: Mutation

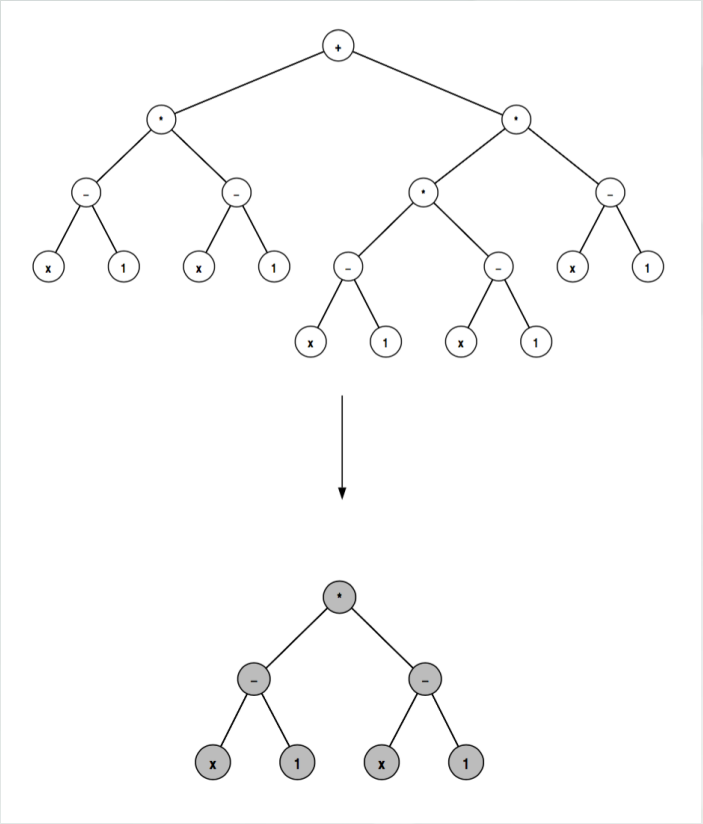


Point Mutation

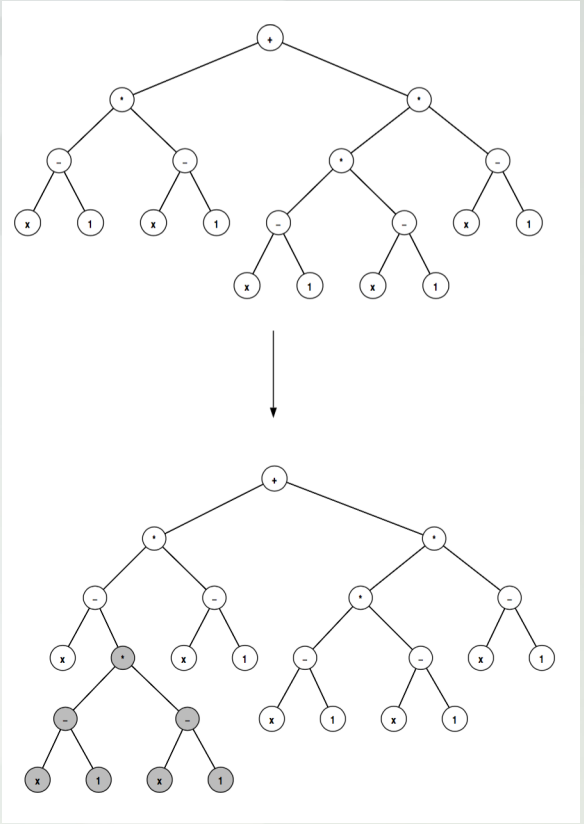


Permutation

Tree GP: Mutation

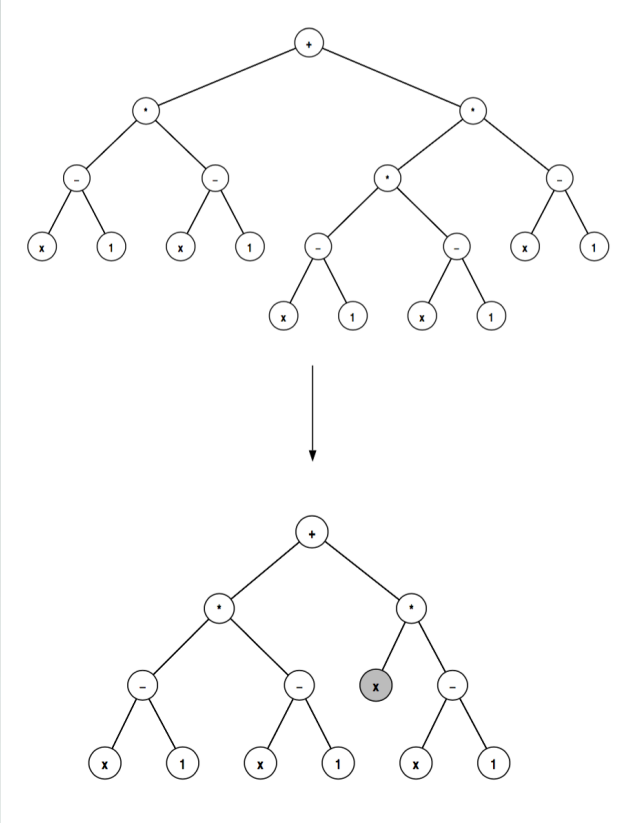


Hoist Mutation

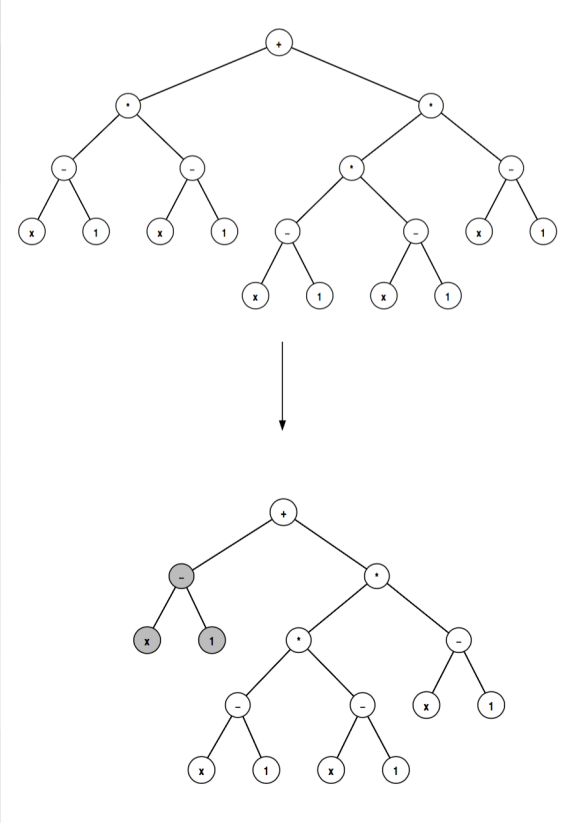


Expansion mutation

Tree GP: Mutation

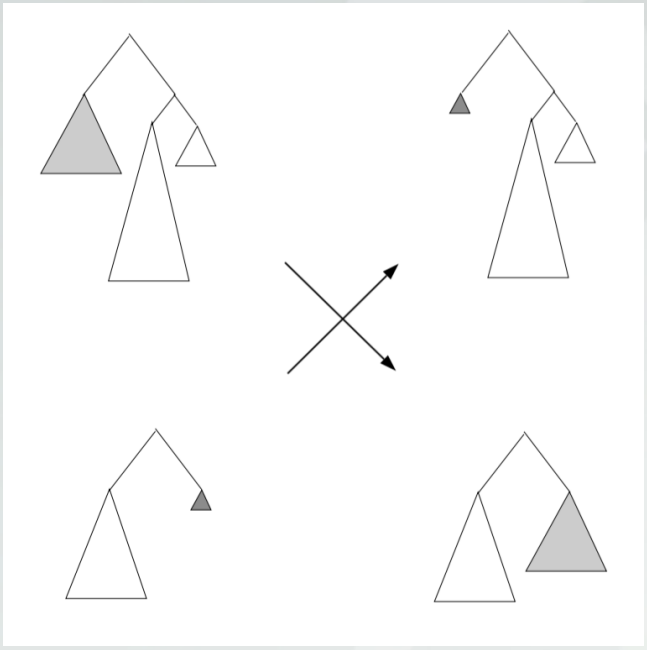


Collapse Subtree-Mutation

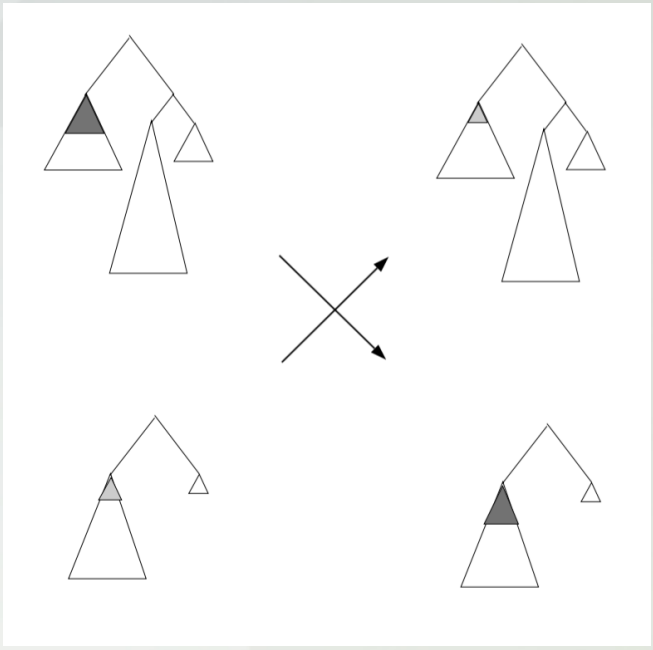


Subtree mutation

Tree GP: Xover

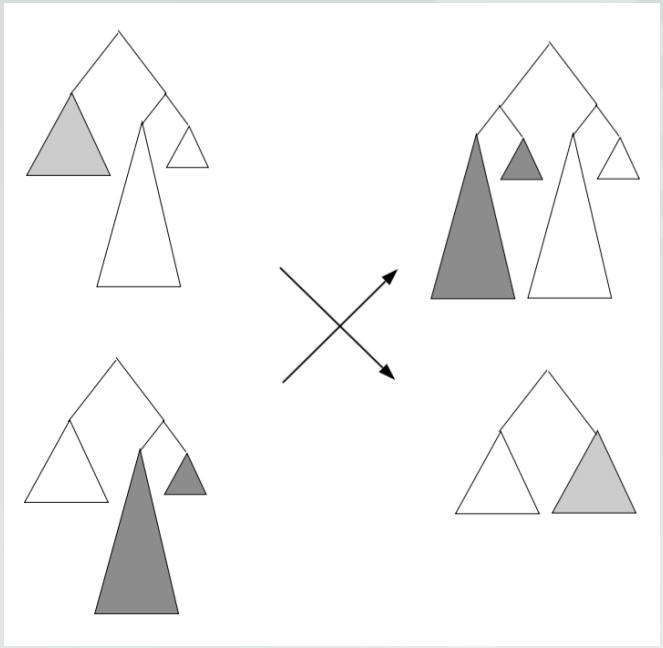


Subtree Crossover

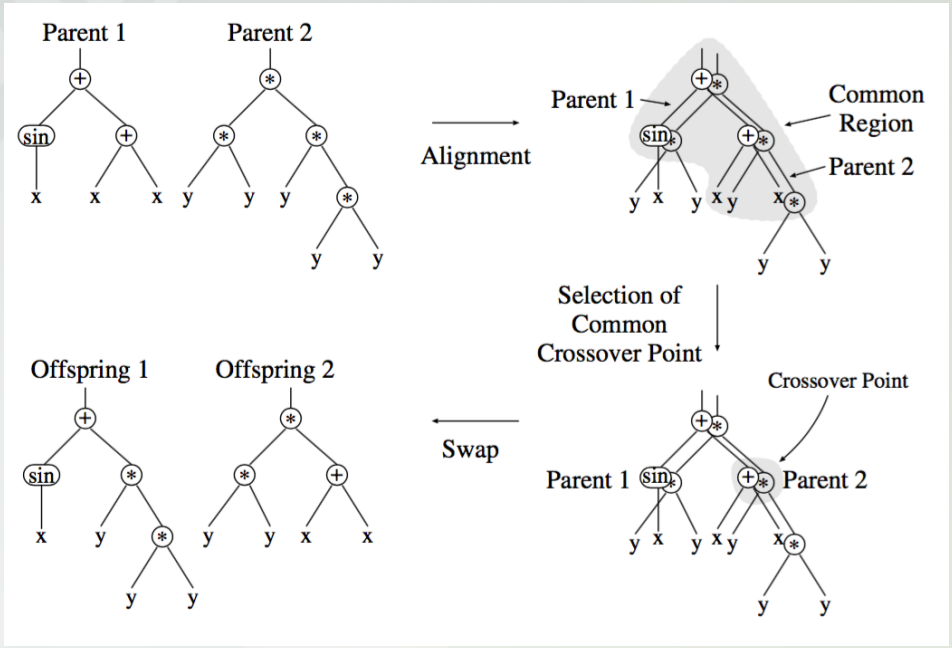


Module Crossover

Tree GP: Xover



Self Crossover



Homologous Crossover

From: Poli et al, Field Guide

Tree GP: Sample Run

- Fix terminal and function set
  - Variable x, integer constants in interval [-5,+5]
  - Arithmetic operations: +, -, *, %
- Determine Fitness Function
  - Root mean square error over the fitness cases
- Fix GP run parameters, see Koza tableau

Koza Tableau

Parameters	Values
Objective:	Evolve function fitting the values of the fitness case table
Terminal set:	x, Integers from -5 to +5
Function set:	ADD, SUB, MUL, DIV
Population size:	600
Crossover probability:	90 percent
Mutation probability:	5 percent
Selection:	Tournament selection, size 4
Termination criterion:	None
Maximum number of generations:	100
Maximum depth of tree after crossover:	200
Maximum mutant depth:	4
Initialization method:	Grow

Initialization

Full

Depth of Trees: D

Choose until D-1:

Nodes ∈ {Function set}

On level D:

Nodes ∈ {Terminal set}

Grow

Depth of Trees: D

Choose until D:

Nodes ∈ {Function set} OR {Terminal set}

Ramped Half-and-Half

Depth of Trees: D

For each depth until D choose:

Half of assigned individuals according to Full

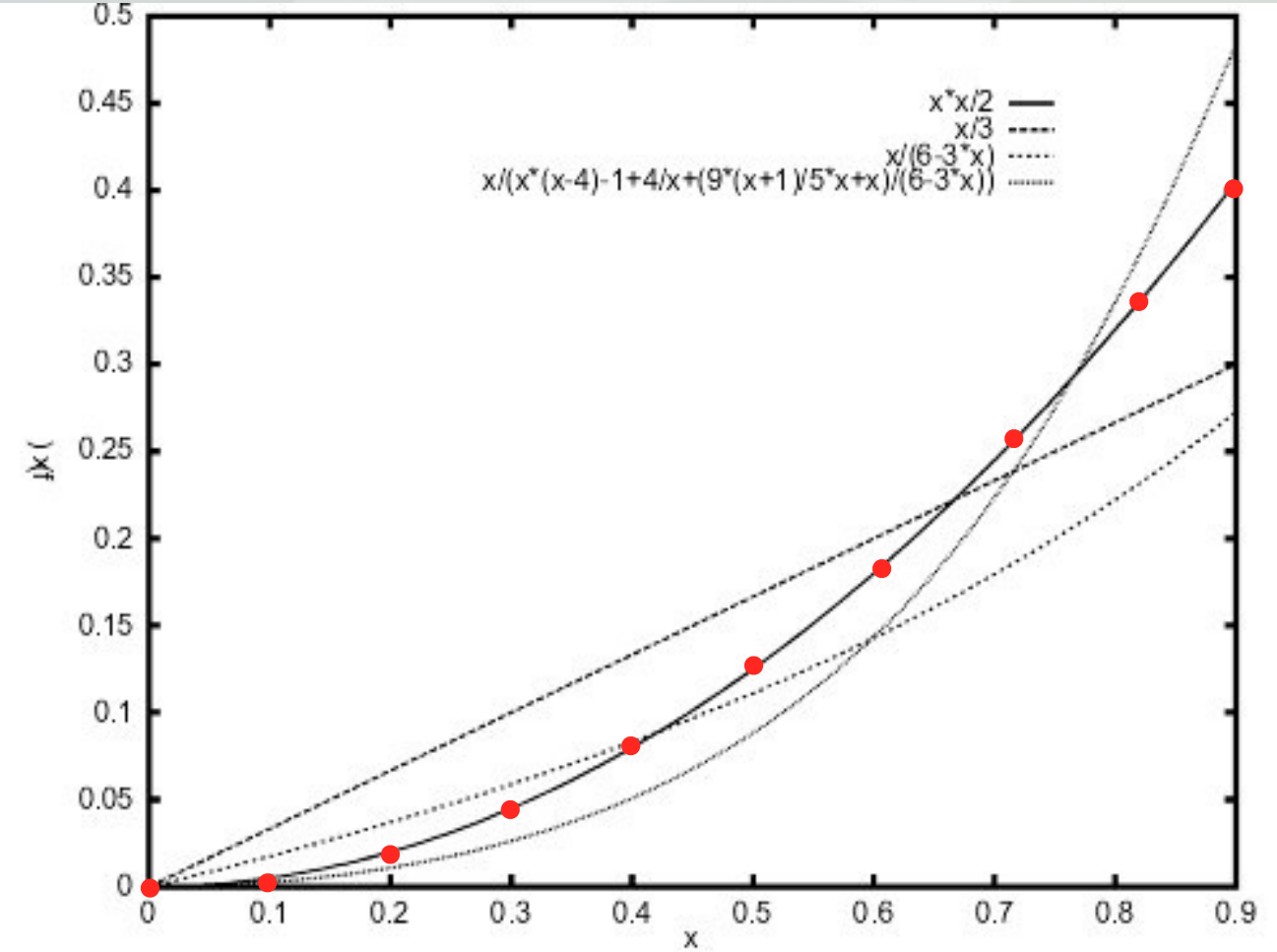
Half of assigned individuals according to Grow

Example: Regression Problem Fitness Cases shown during training

	Input	Output
Fitness Case 1	0	0
Fitness Case 2	0.1	0.005
Fitness Case 3	0.2	0.02
Fitness Case 4	0.3	0.045
Fitness Case 5	0.4	0.08
Fitness Case 6	0.5	0.125
Fitness Case 7	0.6	0.18
Fitness Case 8	0.7	0.245
Fitness Case 9	0.8	0.32
Fitness Case 10	0.9	0.405

Example of GP for Symbolic Function Regression

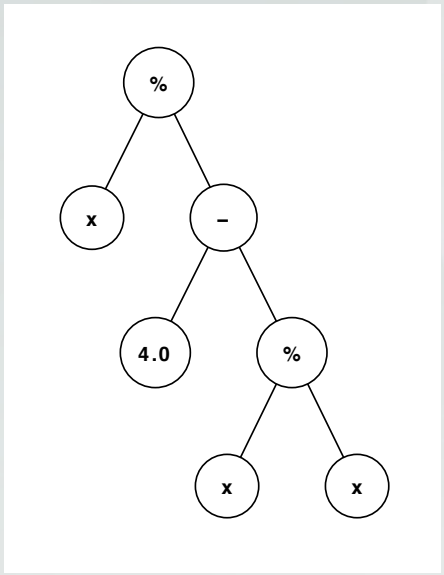
$$y = \frac{x^2}{2}$$



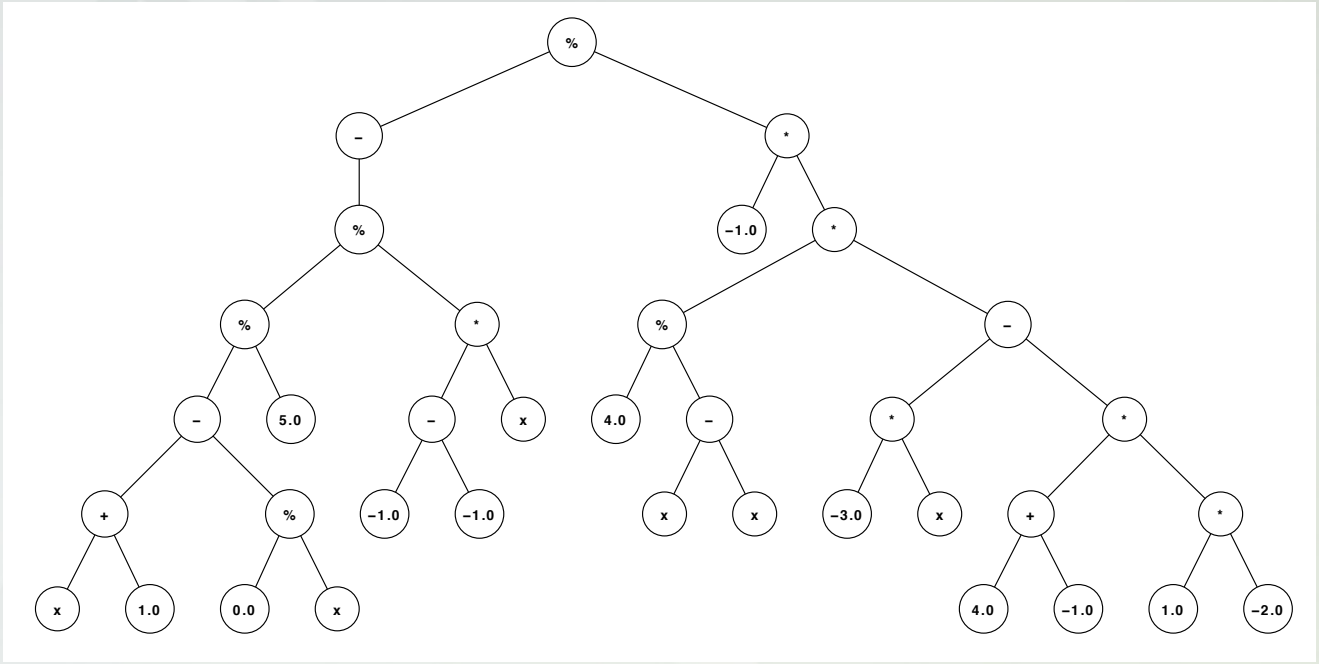
Snapshots from sample run of GP

$$y = \frac{x^2}{2}$$

- Function regression problem:



Best individual of generation 0

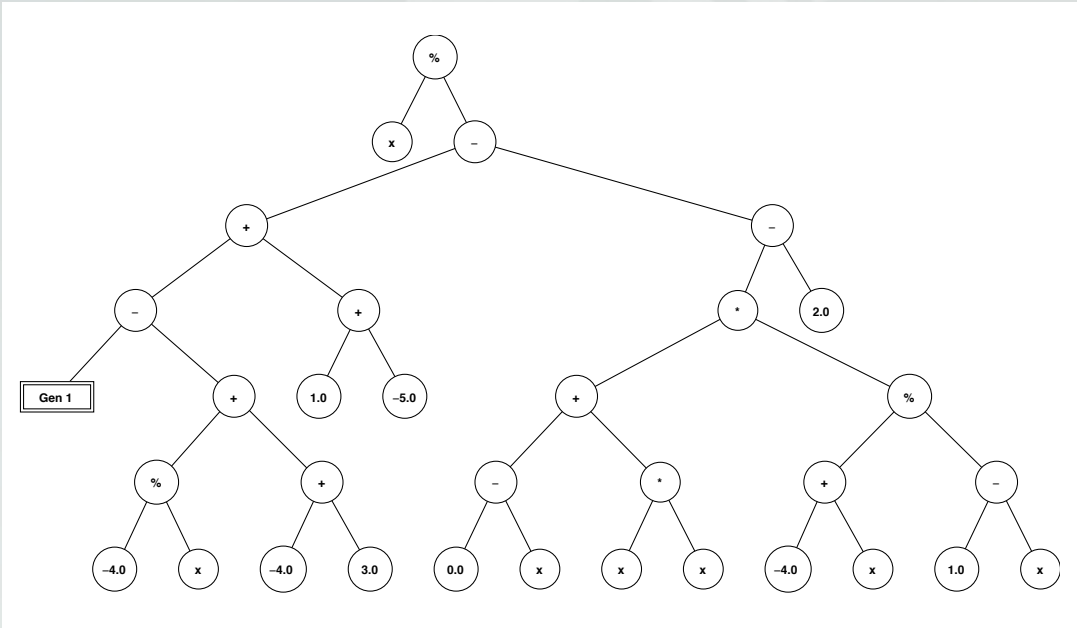


Best individual of generation 1

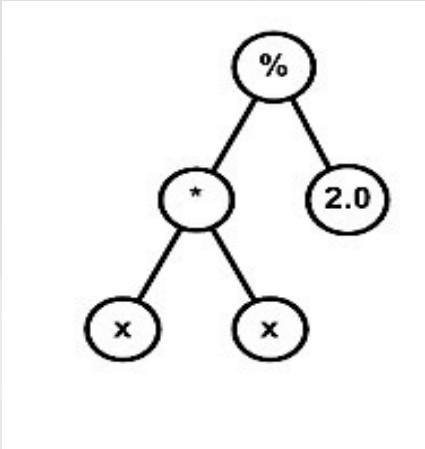
Tree-GP: Example

$$y = \frac{x^2}{2}$$

- Function regression problem:

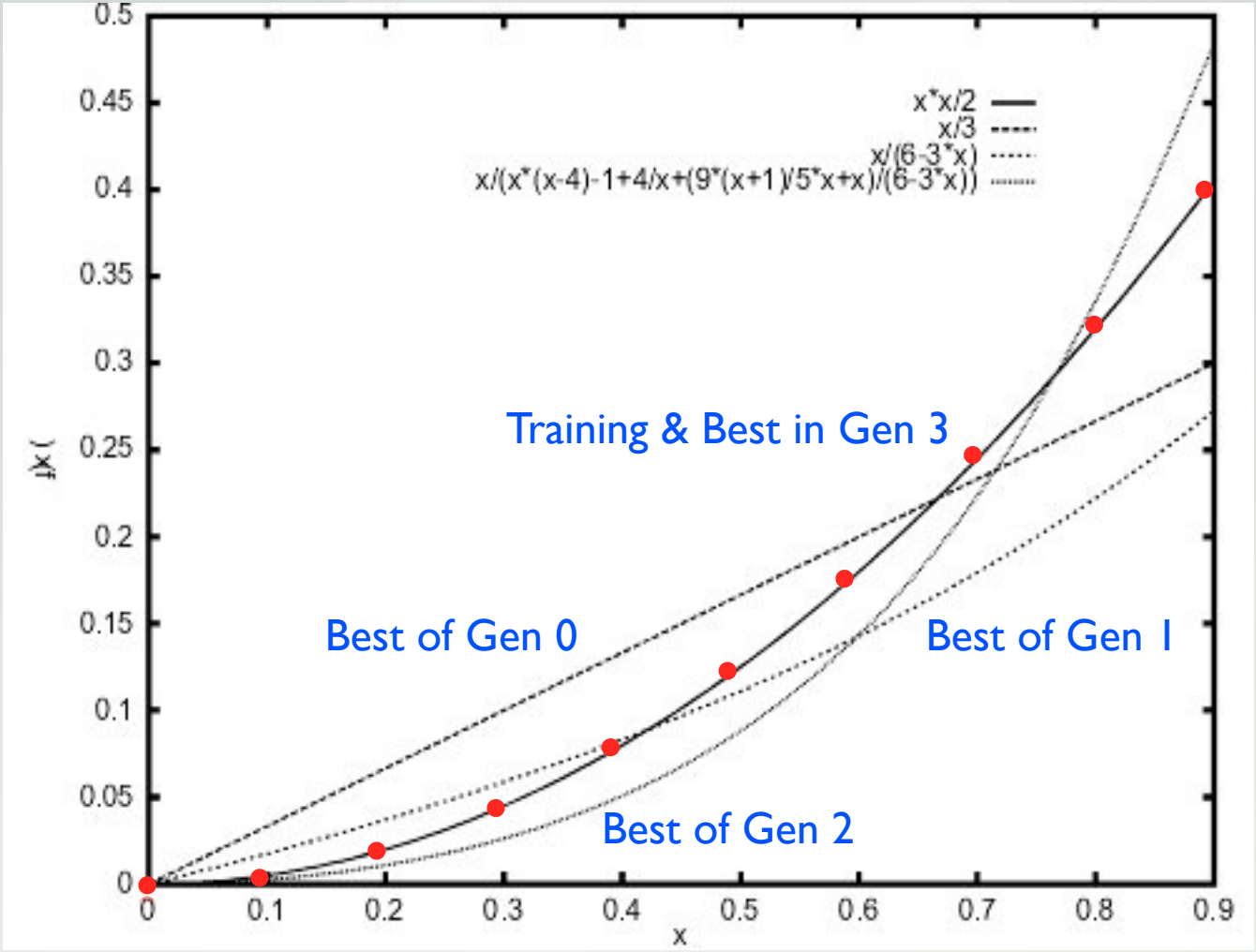


Best individual of generation 2



Best individual of generation 3

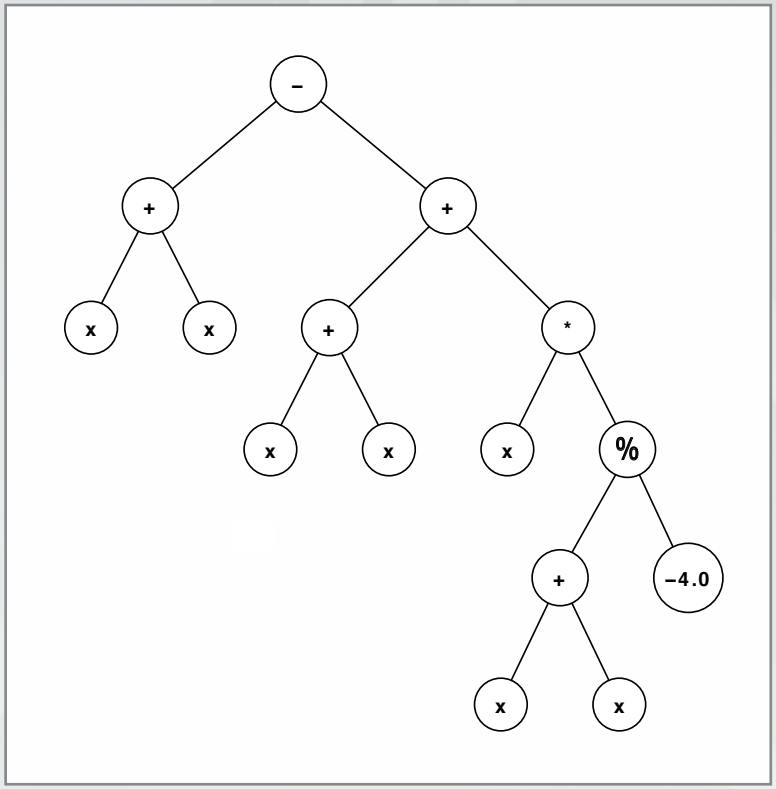
Tree-GP: Example



$$y = \frac{x^2}{2}$$

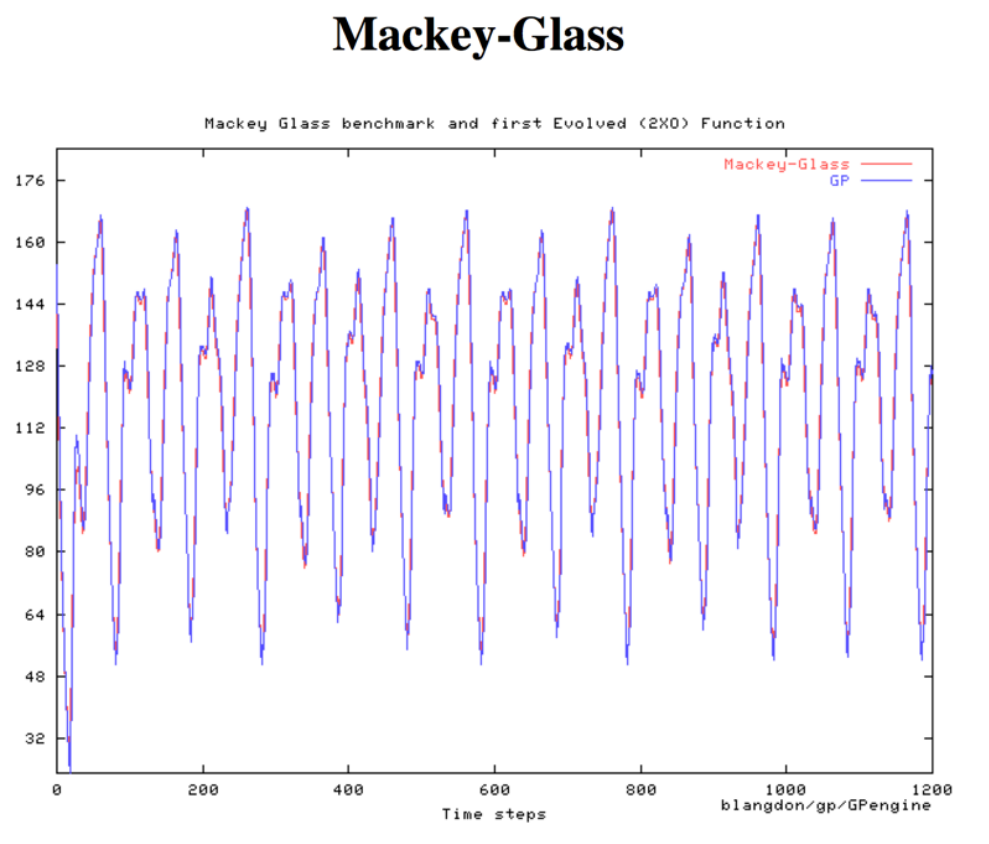
Example of Tree GP

- After perfect solution has been found: Evolution continues



Best individual of generation 5

Mackey-Glass Chaotic Time Series



Want to know more?