Introduction to Evolutionary Computation

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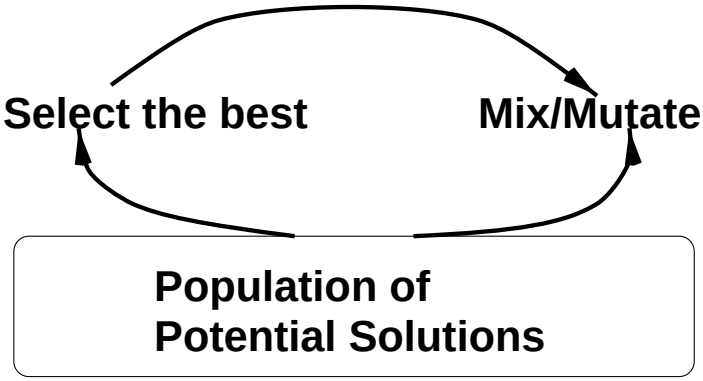
Outline

- What is evolutionary computation (EC): Genetic Algorithms (GA) and Genetic Programming (GP)
- How does EC work?
- What good is EC?
- What are the open problems?
- What are we doing about them?

What is Evolutionary Computation?

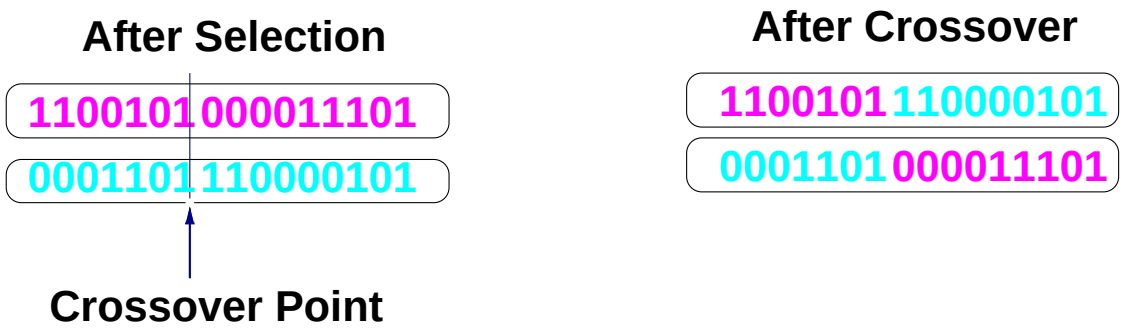


- *Chromosomes* represent *individuals*: either solutions (GA) or programs which provide solutions (GP)
- A *Fitness function* evaluates individuals; highly fit individuals represent better solutions to the *objective function*
- Individuals are *selected* for *mating* at random, with a bias toward fitter individuals
- *Crossover* mixes information from selected individuals
- *Mutation* randomly alters individuals
- Iterate until *population converges* or meets the *termination condition*

What are Genetic Algorithms? (GA)

Representation Chromosomes: binary strings

Crossover Swap substrings



Mutation Randomly change a bit

This Session

- Strategies for game playing (Lam)
- Stock Portfolios (Foster, Shoaf)
- Selections of songs (Weinberg)
- Two-Stroke Engines (Danielson)
- Subgraphs of a graph (Soule, Foster)

What is Genetic Programming? (GP)

Representation Chromosomes: syntax trees with *terminal* and *non-terminal* nodes

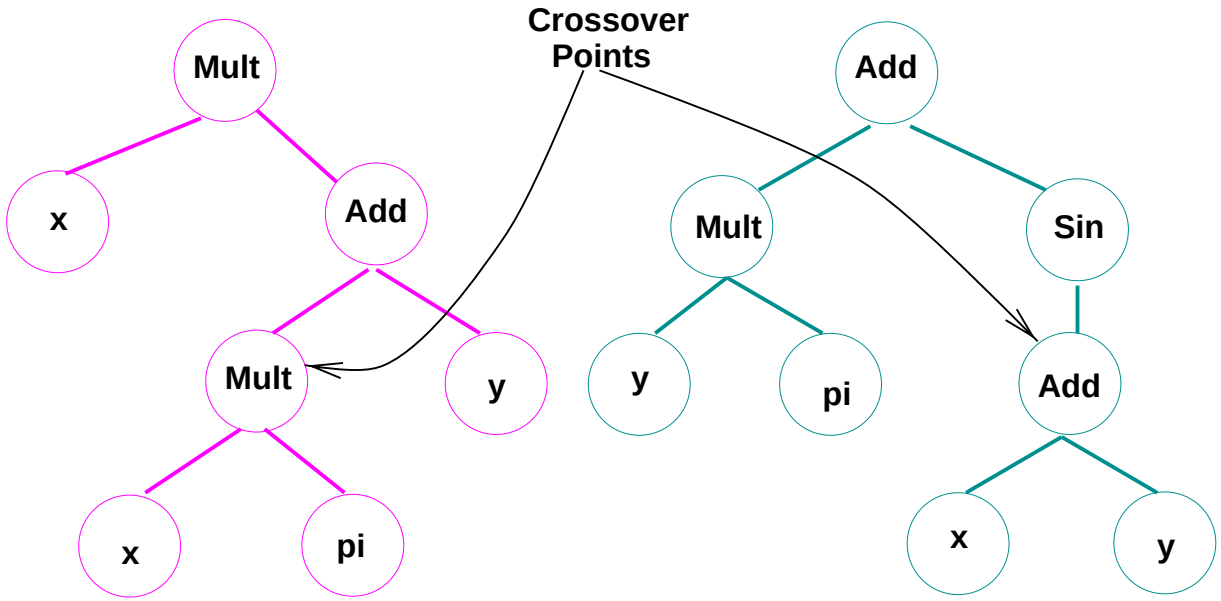
Crossover Swap subtrees

Mutation Randomly change a node

This Session Robot motion control (Soule, Foster)

Illustrations on next slide.

GP After Selection, Before Crossover



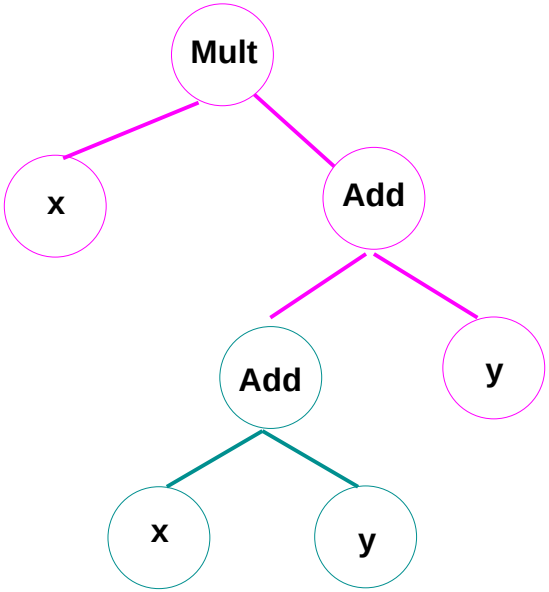
(Mult x (Add (Mult x pi) y))

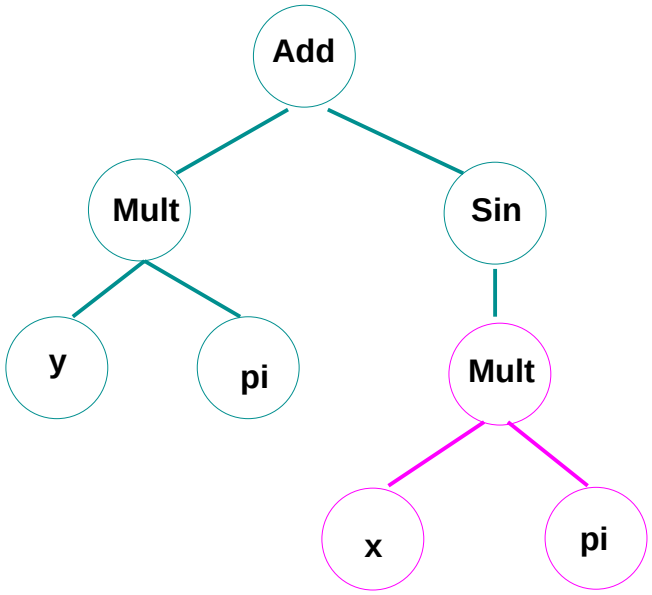
x * ((x * pi) + y)

(Add (Mult y pi) (Sin (Add x y)))

(y * pi) + sin (x + y)

GP After Crossover





(Mult x (Add (Add x y) y))

x * ((x + y) + y)

(Add (Mult y pi) (Sin (Mult x pi)))

(y * pi) + Sin(x*pi)

How does EC work?

Schema Theorem Chromosomes with above average fitness are sampled with exponentially increasing frequency

Building Block Hypothesis Short, highly fit parts of individuals are combined to improve solutions

EC works surprisingly well for complicated, large, multi-dimensional search spaces.

What good is EC?

Areas in which EC has been successfully applied:

- Game playing (chess, go, tic tac toe, tic tac dough)
- Economics and politics (prisoner's dilemma, evolution of co-operation)
- Planning (robot control, air traffic control)
- Scheduling (job shop, precedence-constrained problems, workload distribution)
- Machine vision
- Manufacturing
- VLSI design
- Many, many more

Student projects for GA class

Student	*Status*	*Topic*
Paul Alderman	Grad	Robot Motion Planning
Susan Armitage	Grad	Optimal Mutual Funds Split
Todd Avery	Grad	Pilot Scheduling
Keith Bechard	Grad	The game of Go
Matt Cenis	UG	Salmon Migration
Jonas Champion	UG	Optimal Firing of a V8
Bill Danielson	Grad	Optimization of Dynamic Systems
Phillip Erwin	UG	The Lawn Mower Problem
Richard Ess	Grad	Robot Motion Planning
Victor Fanberg	Grad	Locksmith Sequences
David Gray	UG	Experimental Economics
Clay Hopkins	UG	Robot Motion Planning
William Hegedusich	Grad	Three Processor Scheduling
Wesley Hu	Grad	Troubleshooting Telephony Line
Alvin Hui	UG	Chromatic Number
Wesley Ireland	UG	Vertex Cover problem
Fong Shing Lam	Grad	The game of Go
Jeremy S. Leon	UG	Robot Motion Problem
Michael Lopez	Grad	GAs and Finite Element Analysis
Kevin Lussie	Grad	Graph Coloring

Student projects for GA class (cont'd)

Student	*Status*	*Topic*
Jason McMunn	UG	Poker Solitaire
Mark Meysenburg	Grad	Pseudo-Random Number Generators
Steve Newton	Grad	Evolving Robotic Behavior
Moncif Ouazzani	UG	Neural Network Design
Kevin Pearson	UG	A Perfect Golfer
Mark Pokorny	Grad	Neural Net Design
Greg Raab	UG	Robot Motion Planning
Joel Rieke	UG	Satellite Control
Ray Saxe	UG	Poker Solitaire
Robert Shepherd	Grad	Airlift Payload Optimization
Jacqueline Shoaf	Grad	Investment Portfolio
Terry Soule	Grad	Code Optimization
Andreas Suryawan	UG	Rubik's Cube
Cristos Vasilas	Grad	Scheduling Students
Carl D. Weinberger	UG	Song Archiving

Open problems/current work

- When does EC *not* work? (Soule)
- How to solve specific problems with EC? (Soule, Shoaf, Leon)
- How to keep GP chromosomes small? (Soule)
- What are effects of pseudorandom numbers? (Meysenberg)