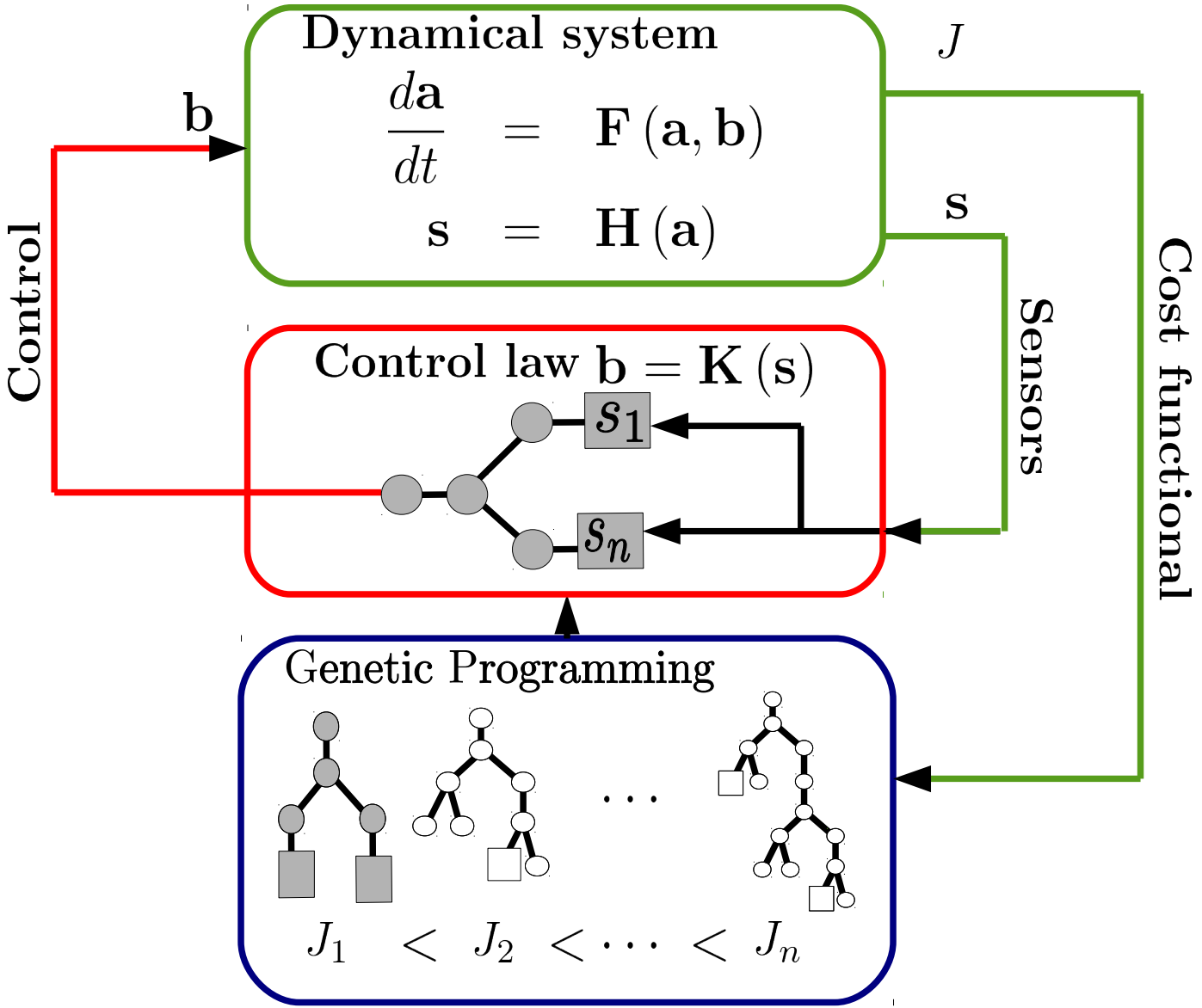
Genetic Programming Control



Genetic programming

- Bio-inspired evolutive algorithm.
- Largely developed by Koza (books, 1994, 1999).
- Regression method which optimizes a function with respect to an objective functional.
- Used in micro-controllers, robotics, programming, weather forecast, fish harvesting, … --- *almost everywhere except in fluid mechanics.*

Genetic Programming Control 1

MIMO control problem:

$$\begin{aligned} \frac{d\mathbf{a}}{dt} &= \mathbf{F}(\mathbf{a}, \mathbf{b}) \\ \mathbf{s} &= \mathbf{H}(\mathbf{a}) \end{aligned}$$

Find $b = K(s)$

to minimize $J(\mathrm{a}, \mathrm{b})$

Genetic Programming Control 2

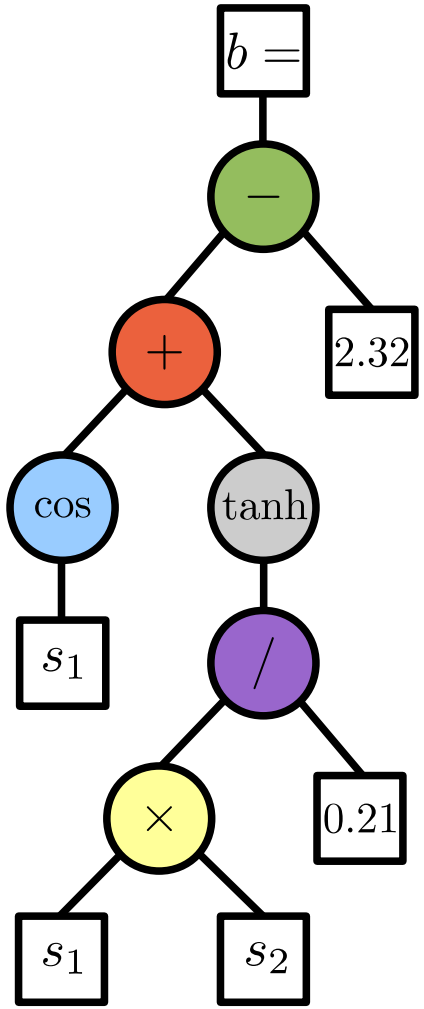
MIMO control problem:

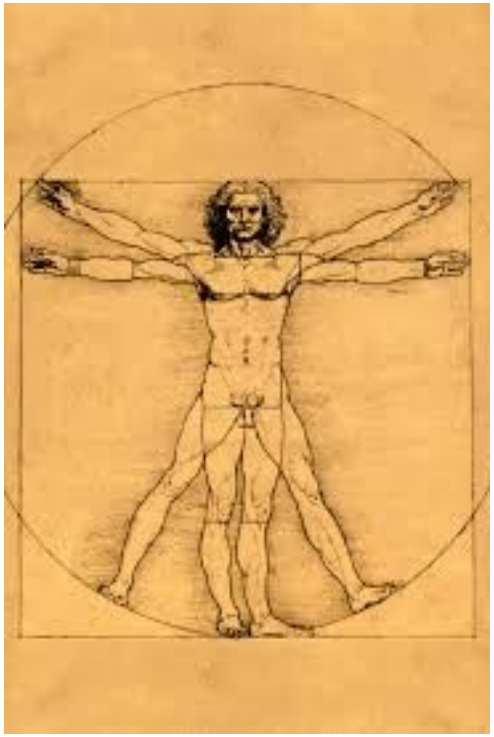
$$\frac{d\mathbf{a}}{dt} = \mathbf{F}(\mathbf{a}, \mathbf{b})$$
$$\mathbf{s} = \mathbf{H}(\mathbf{a})$$

Find $b = K(s)$
to minimize $J(\mathrm{a}, \mathrm{b})$

Genetic Programming Control 3

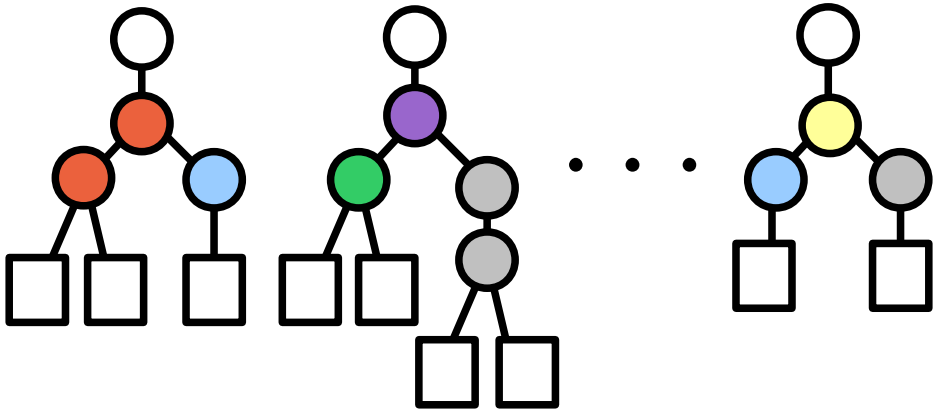
Individual:





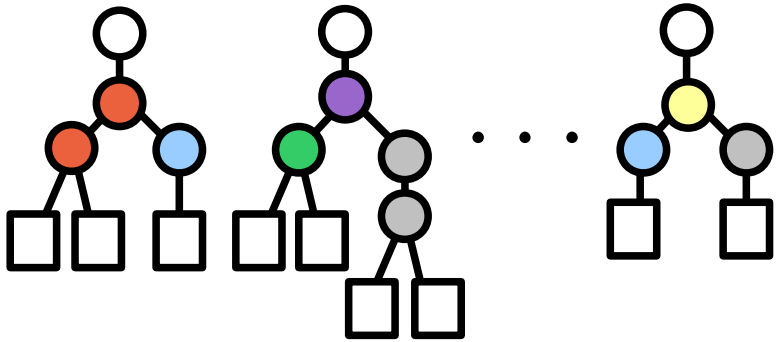
Genetic Programming Control 4

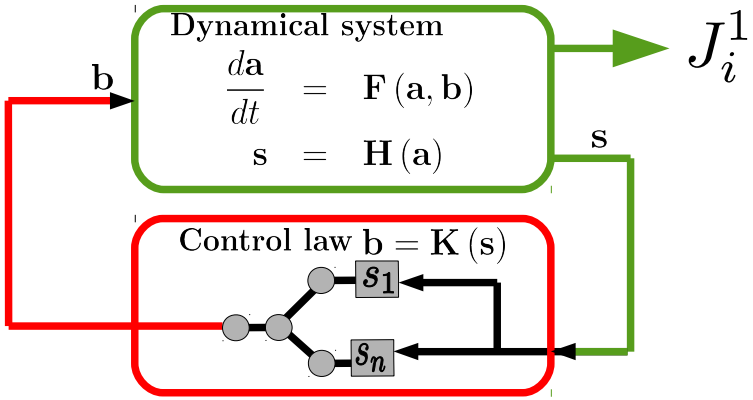
We start with an initial random population:



Genetic Programming Control 5

And evaluate how they solve the problem:



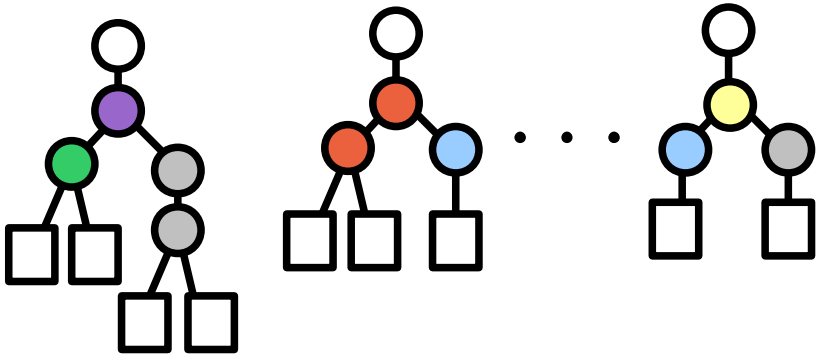


VS

$= 17\,\mathrm{s}$

Genetic Programming Control 6

Until we have one evaluated population.



$$J_1^1 < J_2^1 < \cdots < J_n^1$$

We need to evolve the population.

Genetic Programming Control 7

We use three genetic operations:

- Replication: copy one individual in the next generation

  (memory).
- Crossover: change a pair of individals

  (exploitation).
- Mutation: change a single individual

  (exploration).

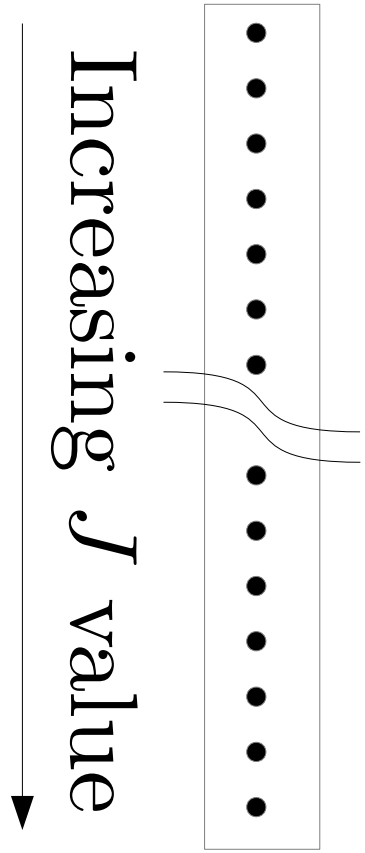
Genetic Programming Control 8

Which individuals get replicated, mutated, crossed?

- The operation gets decided probabilistically.
- The concerned individuals are decided through a random access tournament procedure.
- p individuals are randomly chosen, the best individuals among those are chosen.

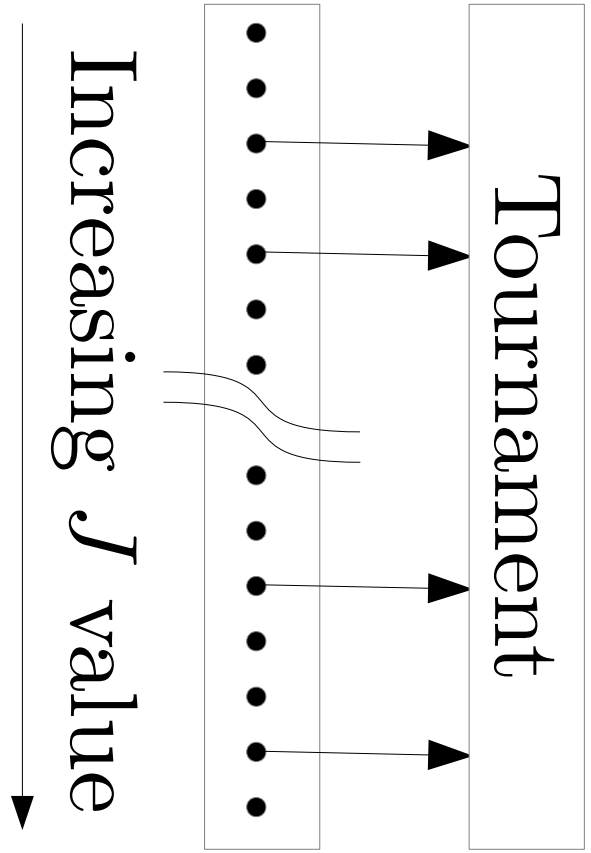
Genetic Programming Control 9

Selection:



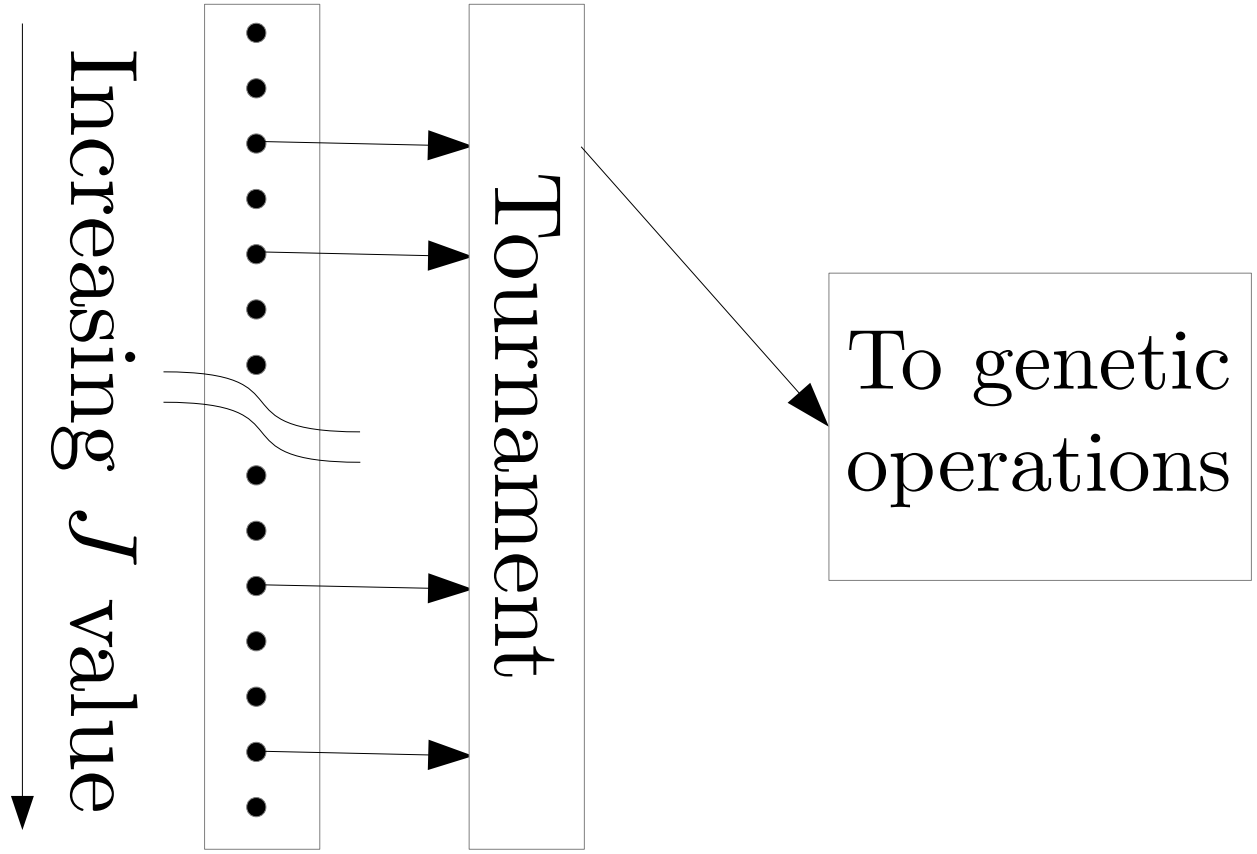
Genetic Programming Control 10

Selection:



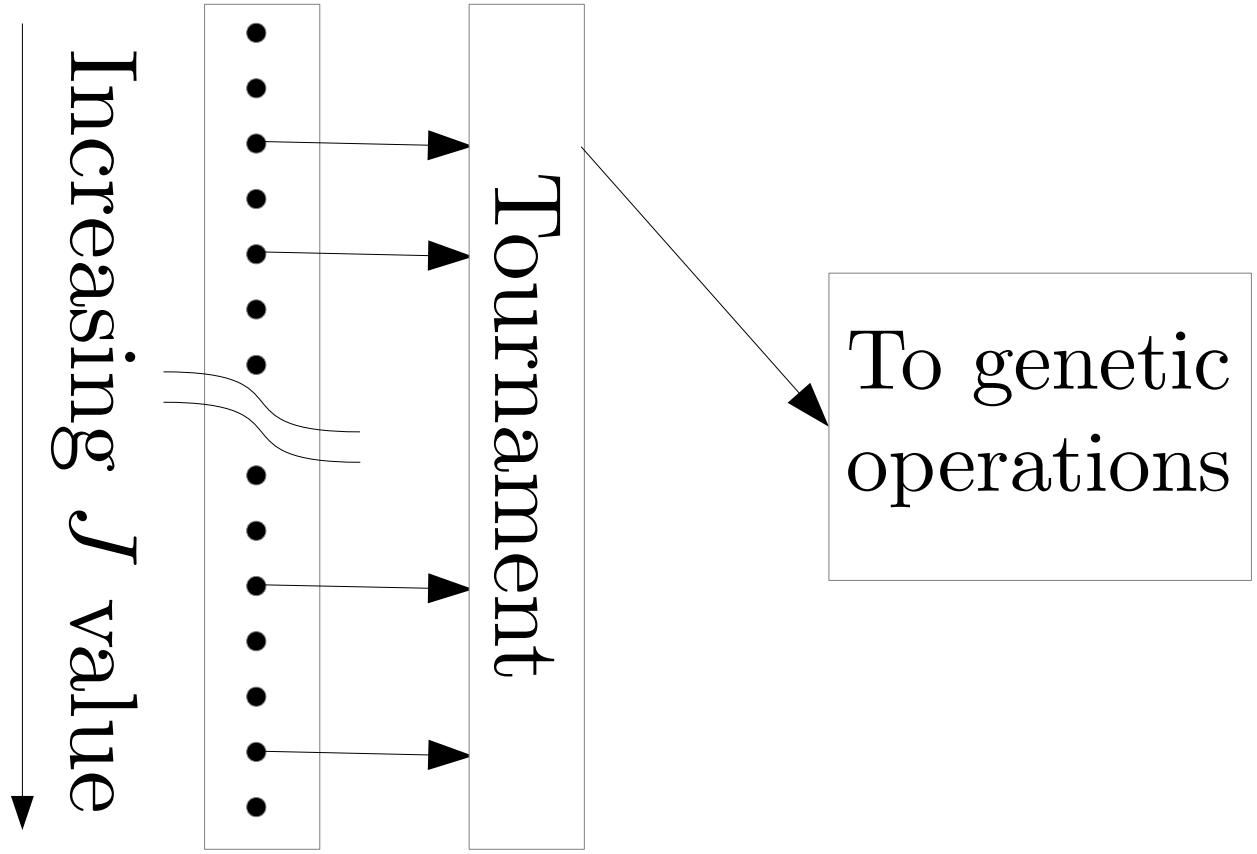
Genetic Programming Control 11

Selection:



Genetic Programming Control 12

Sélection:

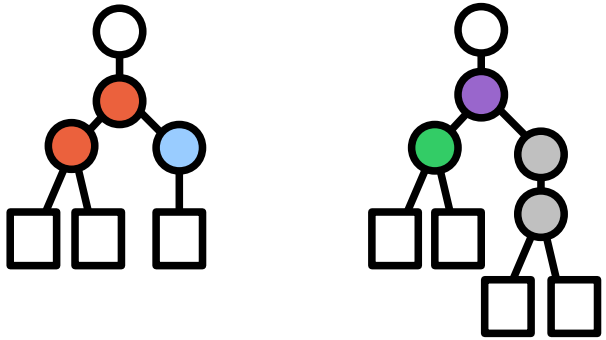


- n individuals
- p individuals in the tournament
- probability for individual i to be selected:

$$P_s(i) = \left(\frac{n-i}{n-1}\right)^{p-1}$$

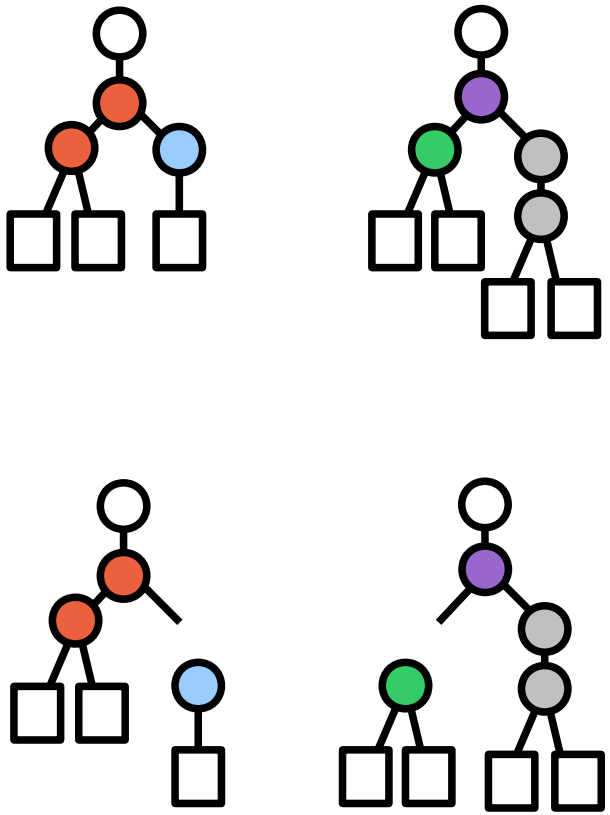
Genetic Programming Control 13

Crossover:



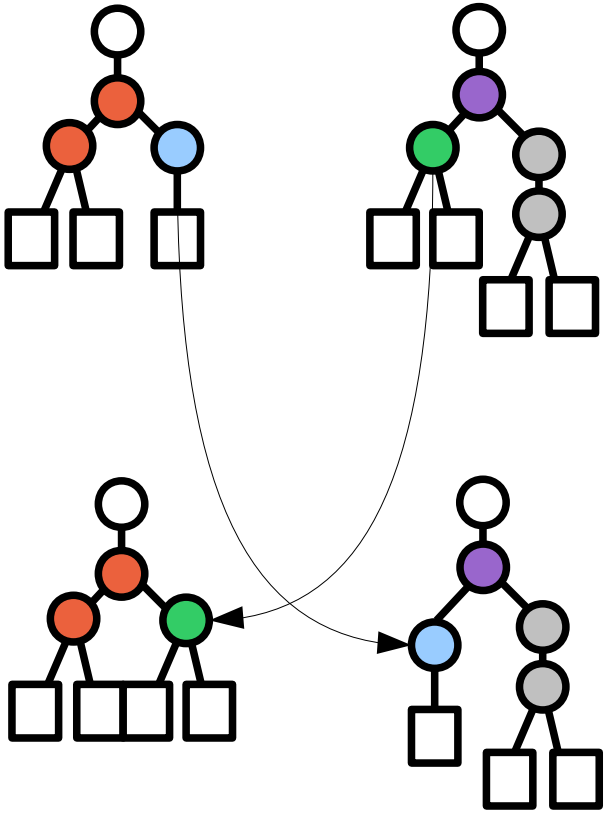
Genetic Programming Control 14

Crossover:



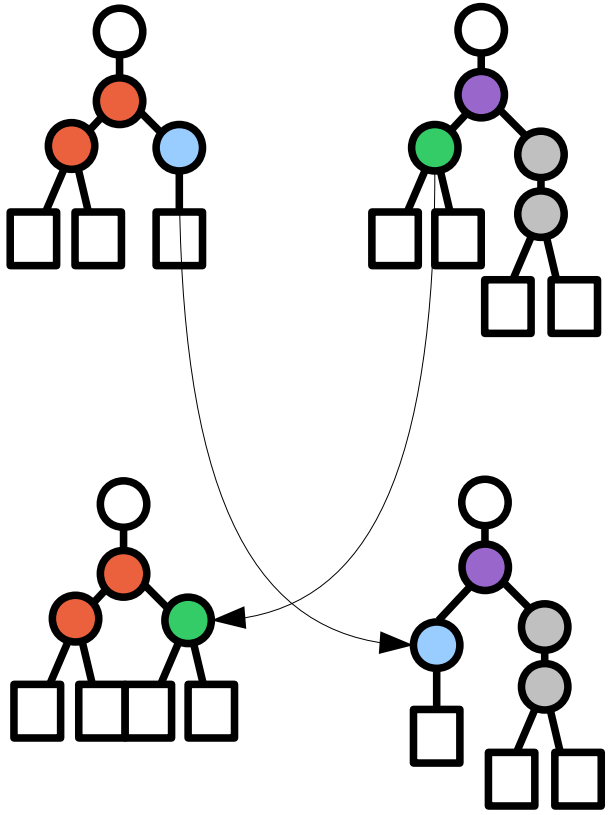
Genetic Programming Control 15

Crossover:



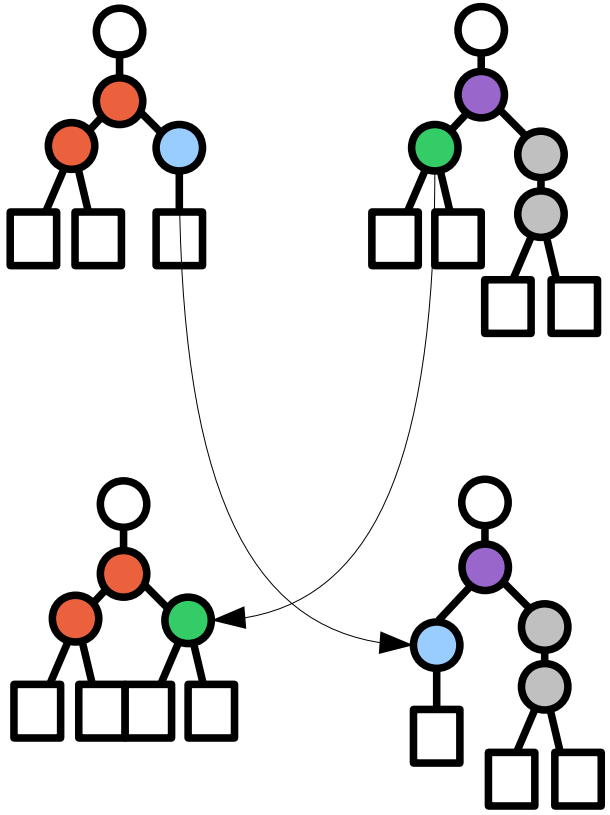
Genetic Programming Control 16

Crossover:



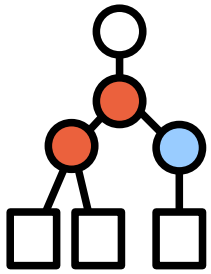
Genetic Programming Control 17

Crossover:



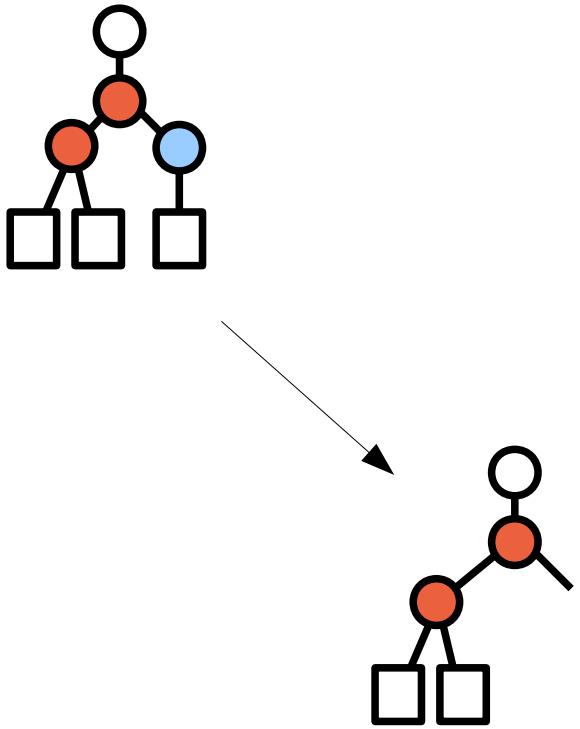
Genetic Programming Control 18

Mutation:



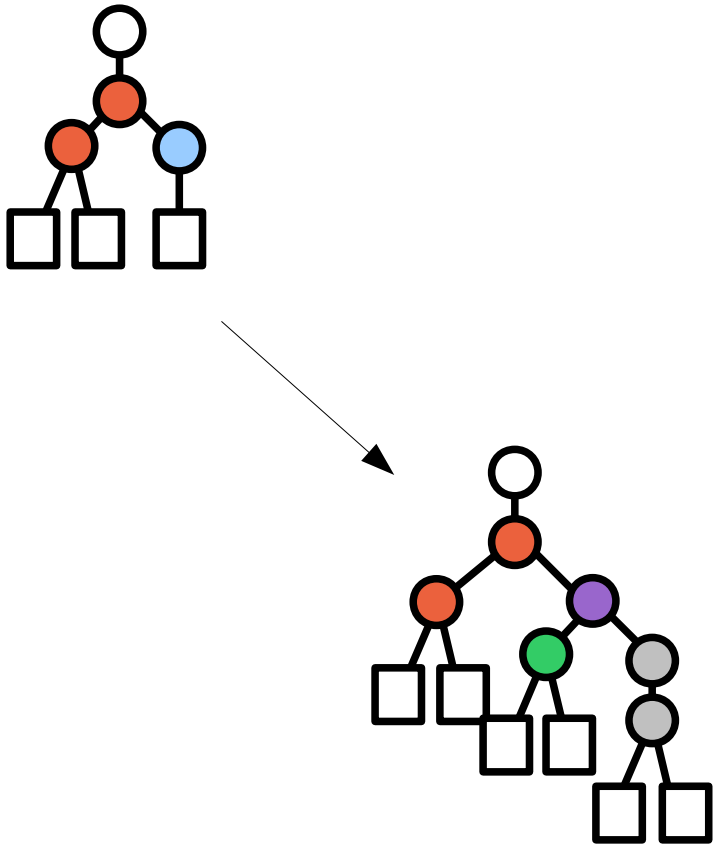
Genetic Programming Control 19

Mutation:



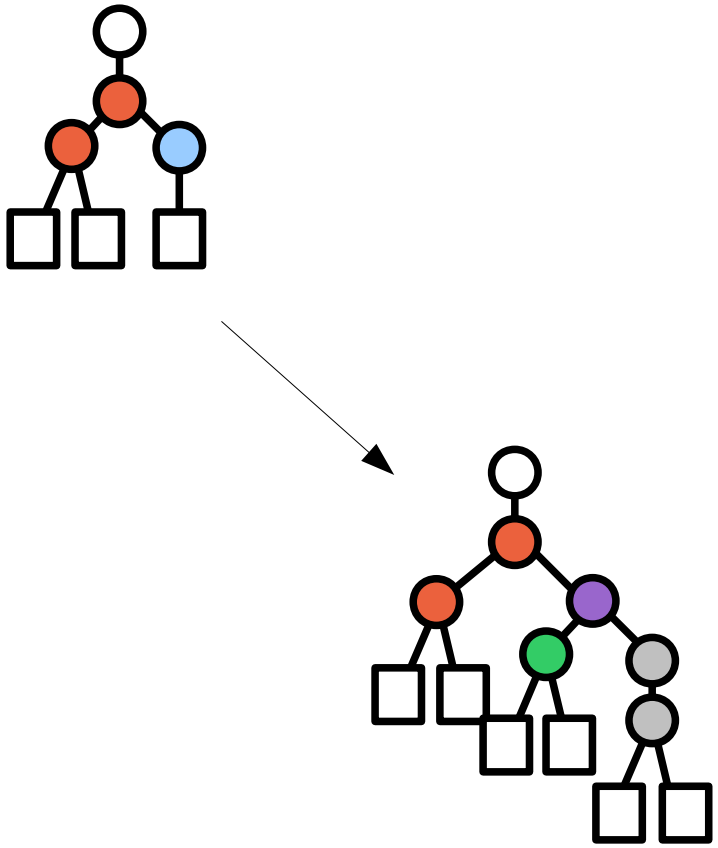
Genetic Programming Control 20

Mutation:



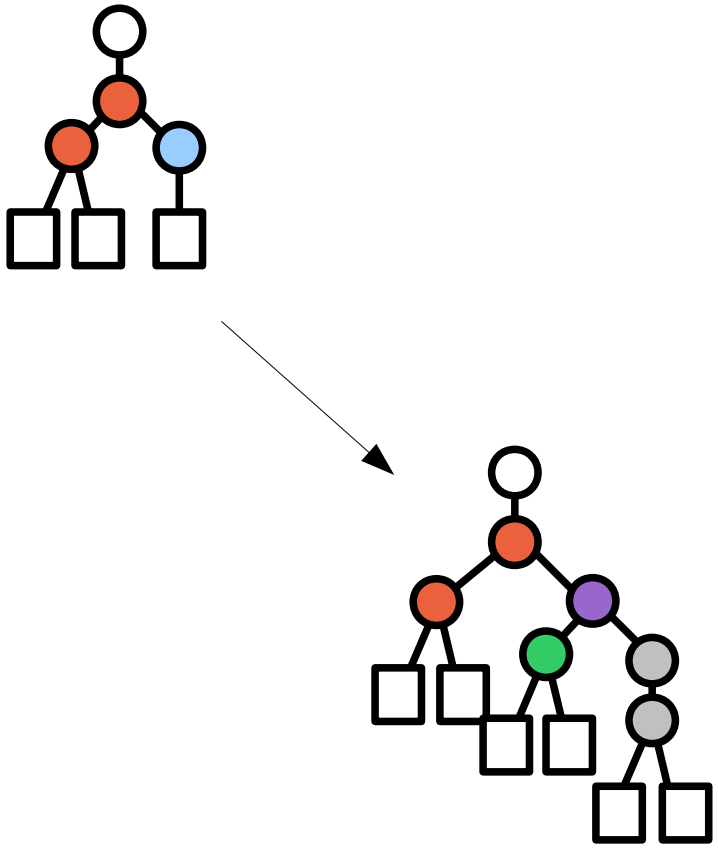
Genetic Programming Control 21

Mutation:

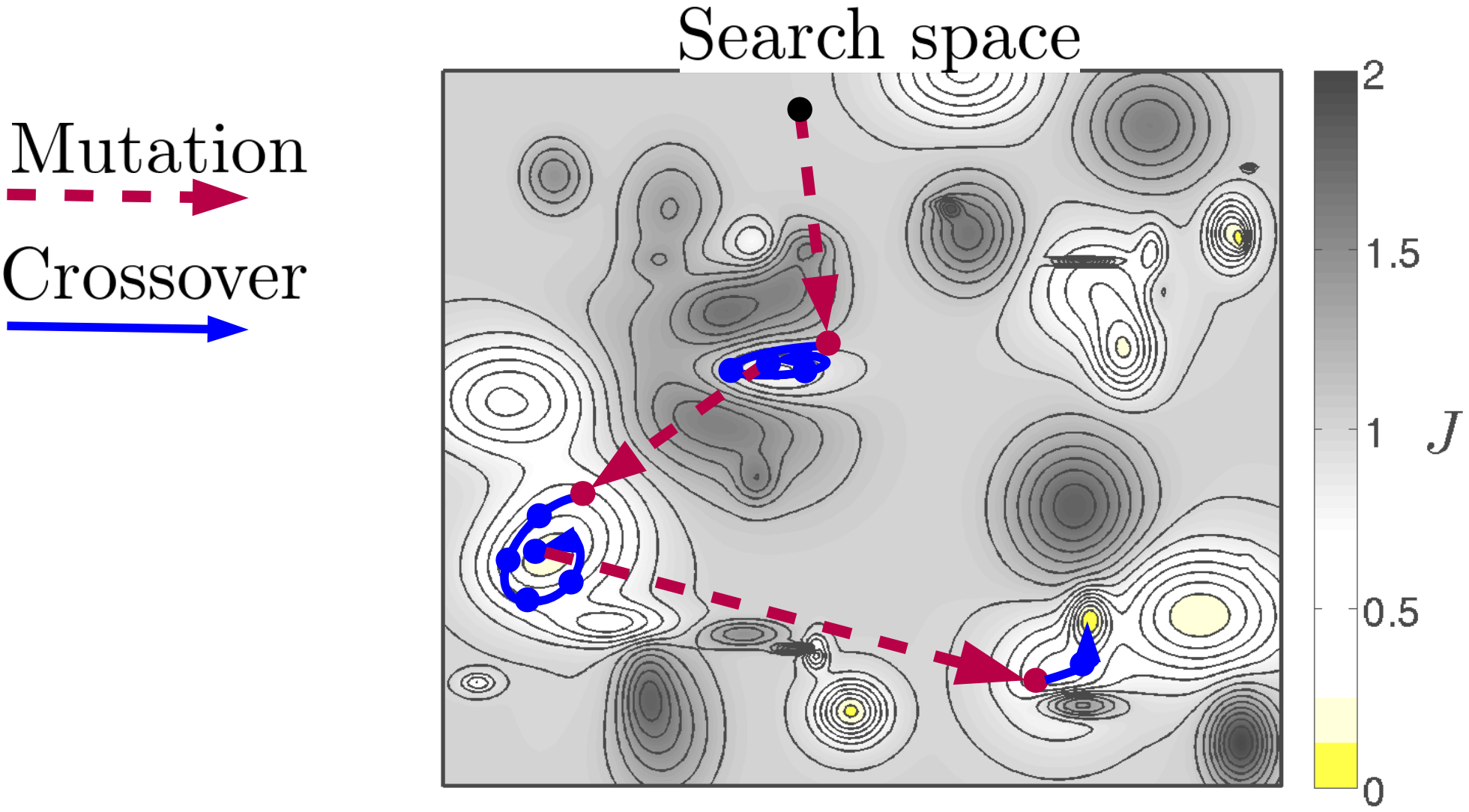


Genetic Programming Control 22

Mutation:

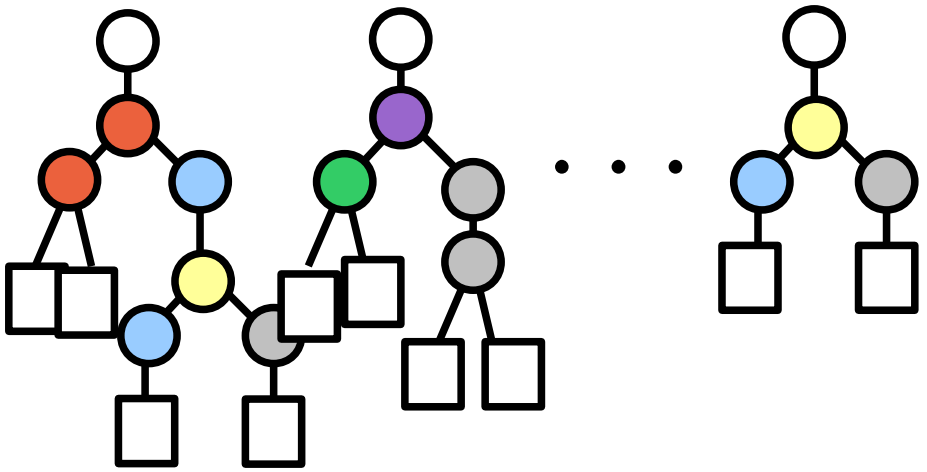


Genetic Programming Control 23



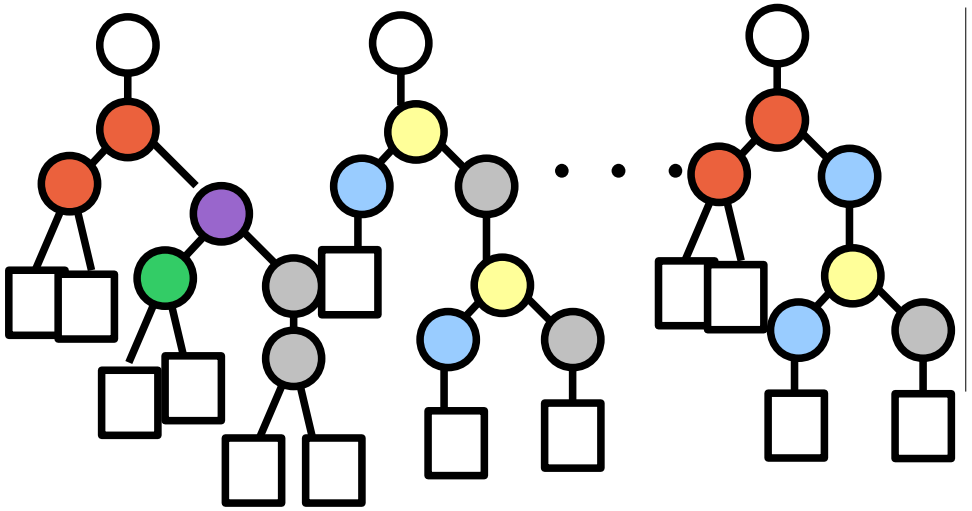
Genetic Programming Control 23

We have a new generation:



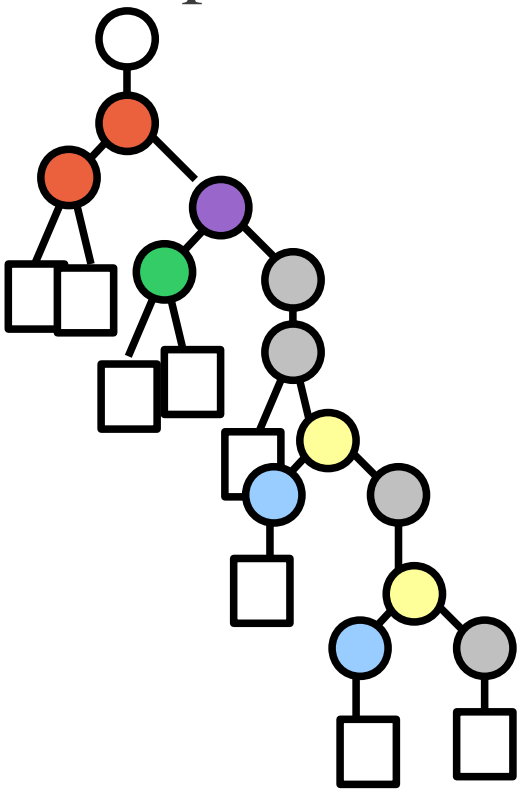
Genetic Programming Control 24

We get increasingly betters generations:



Genetic Programming Control 25

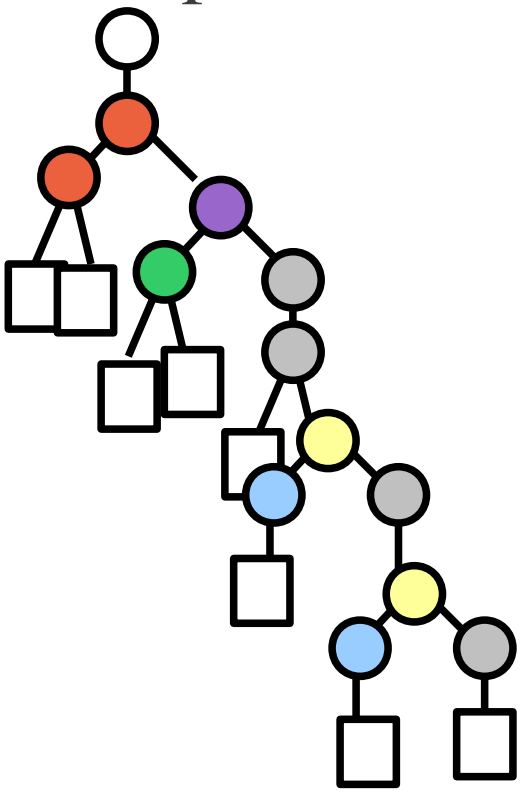
Until the problem is solved



Low enough J value

Genetic Programming Control 26

Until the problem is solved



Low enough J value

Genetic Programming Control 27