Automating Algorithm Design through Genetic Programming Hyper-Heuristicss

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Morris, MN

What does the title mean?

- Reducing the human component in algorithm design

https://scratch.mit.edu/discuss/m/topic/200574/

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- Reducing the human component in algorithm design
- More work at the beginning, more possibilities
- Genetic programming hyper-heuristics as a method to the madness

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Outline

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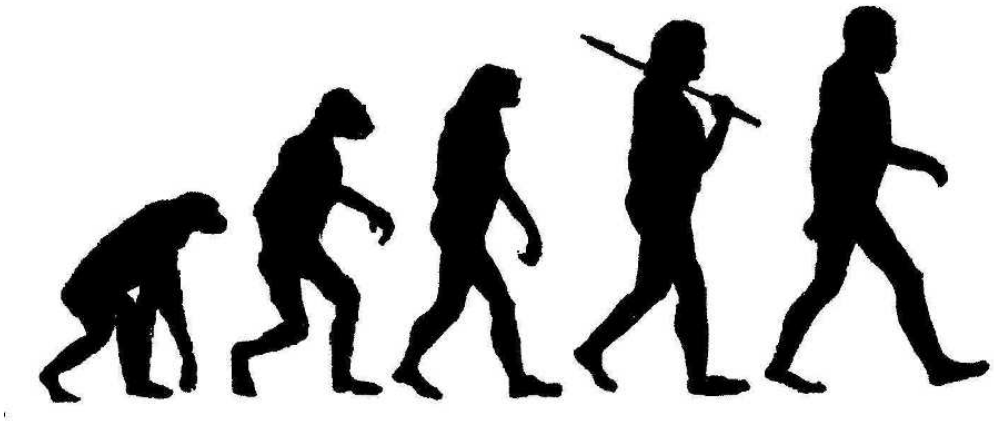
Evolutionary Computation



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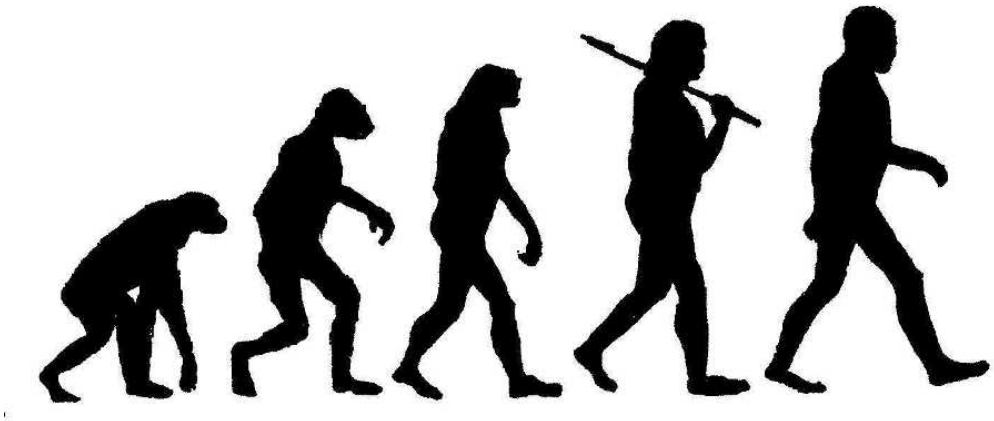
- Subfield of Artificial Intelligence

Evolutionary Computation



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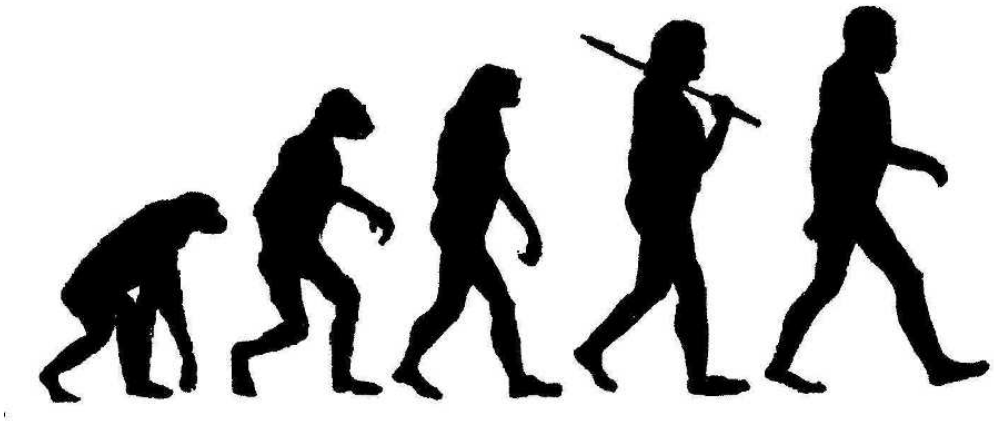

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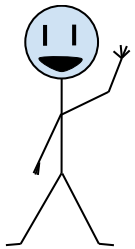
- Subfield of Artificial Intelligence
- Algorithms based on biological evolution
- Uses lots of terminology from biology, doesn't always mean same thing as term means in biology.

Evolutionary Computation – Terminology



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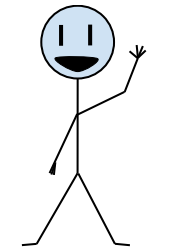

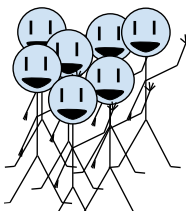

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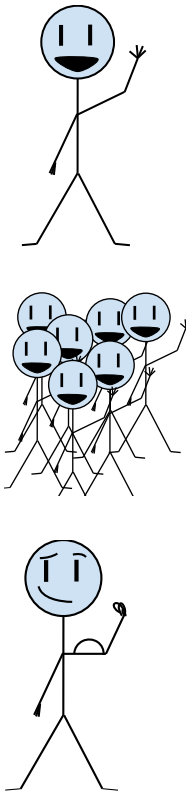

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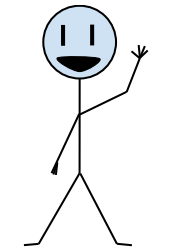
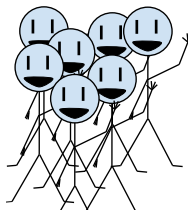
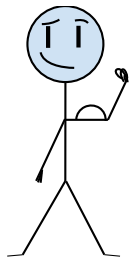
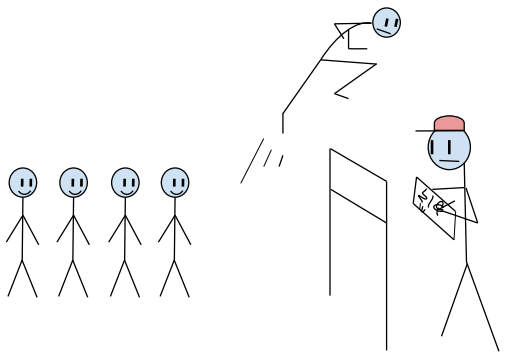
- **Fitness Test** – a set of tests to determine how fit an individual is.









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- **Global optima** – best solution (or solutions) possible

Evolutionary Computation – Terminology

If individual A experiences a mutation to create individual B, then:

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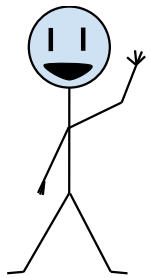
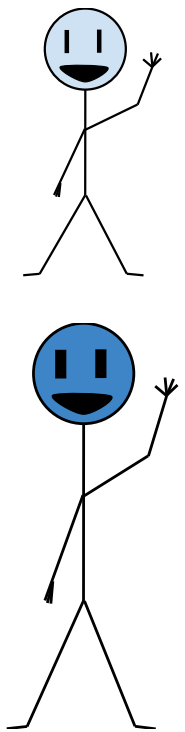


- **Parent** – Individual A

Evolutionary Computation – Terminology

If individual A experiences a mutation to create individual B, then:

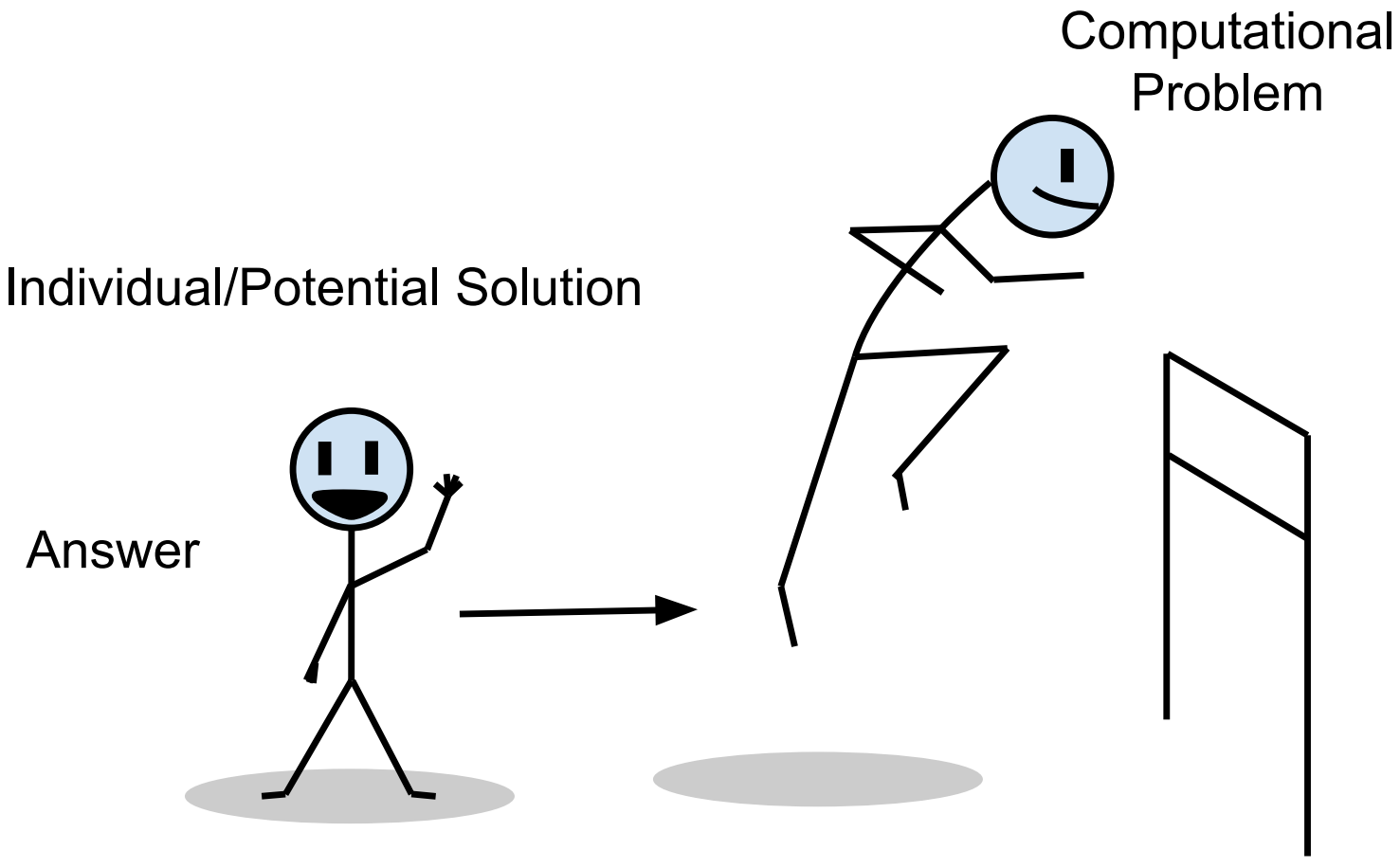
- **Parent** – Individual A
- **Child** – Individual B



Genetic Programming

A family of algorithms in Evolutionary Computation that uses biological techniques to create programs to solve computational problems.

Genetic Programming



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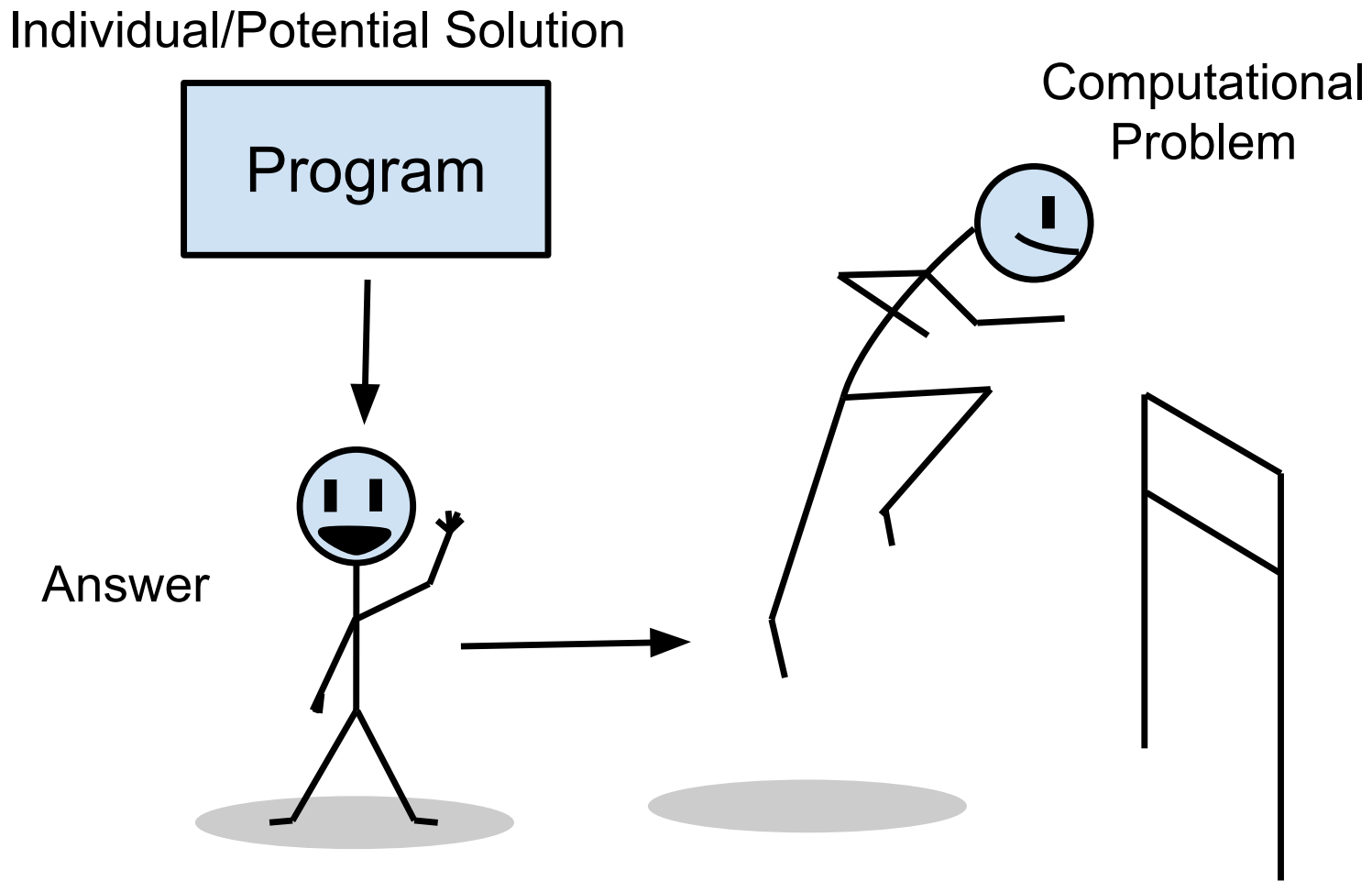

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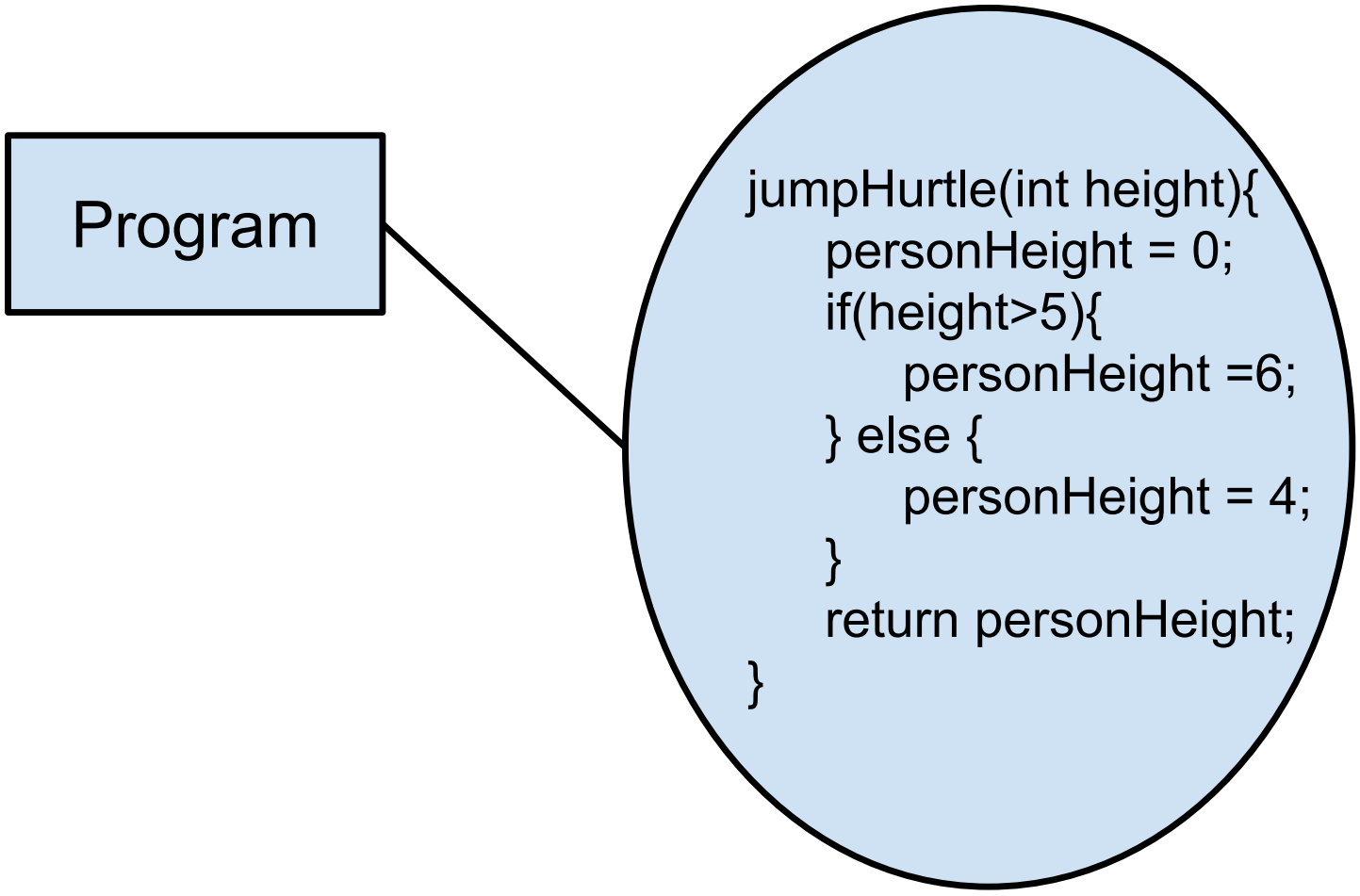

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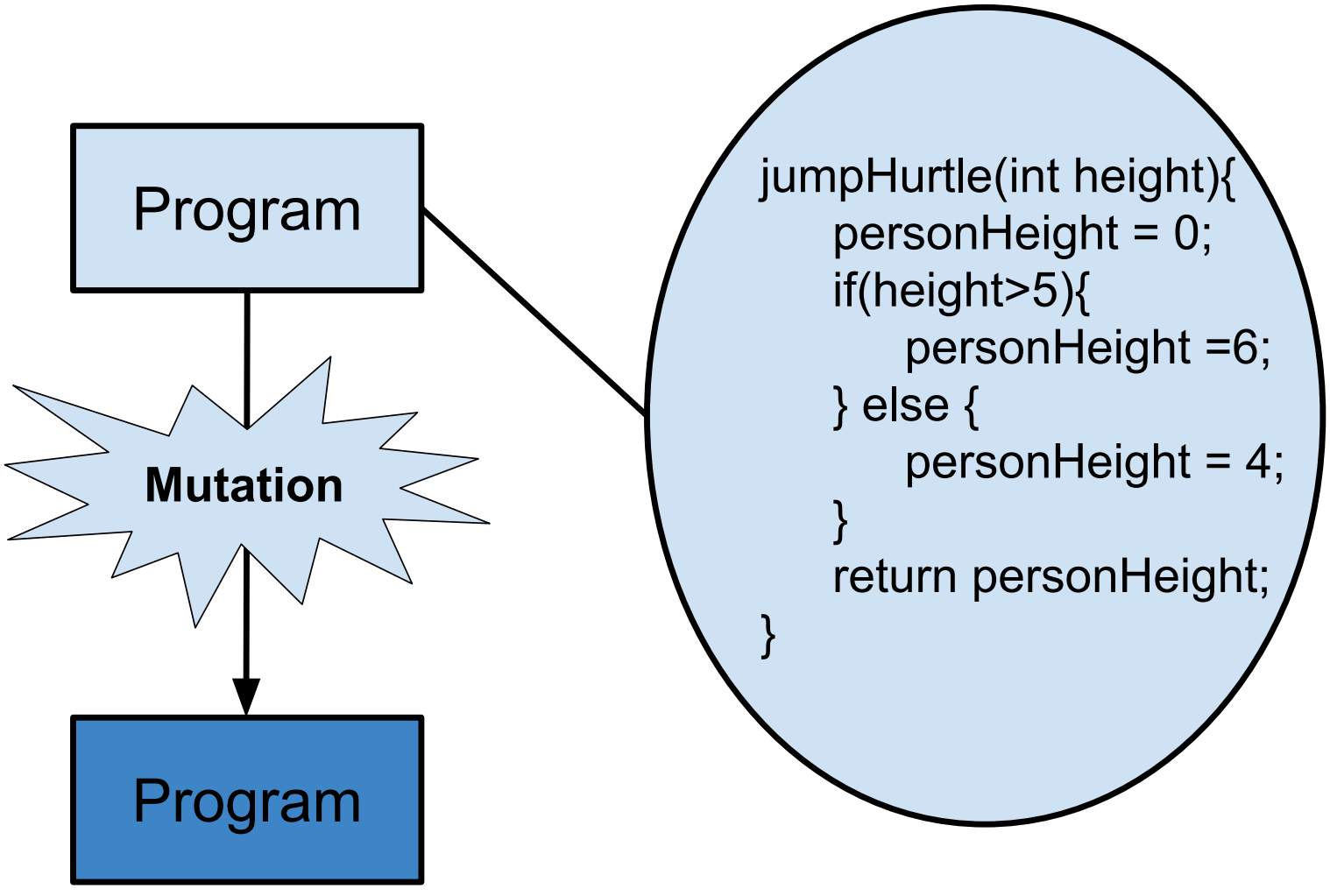

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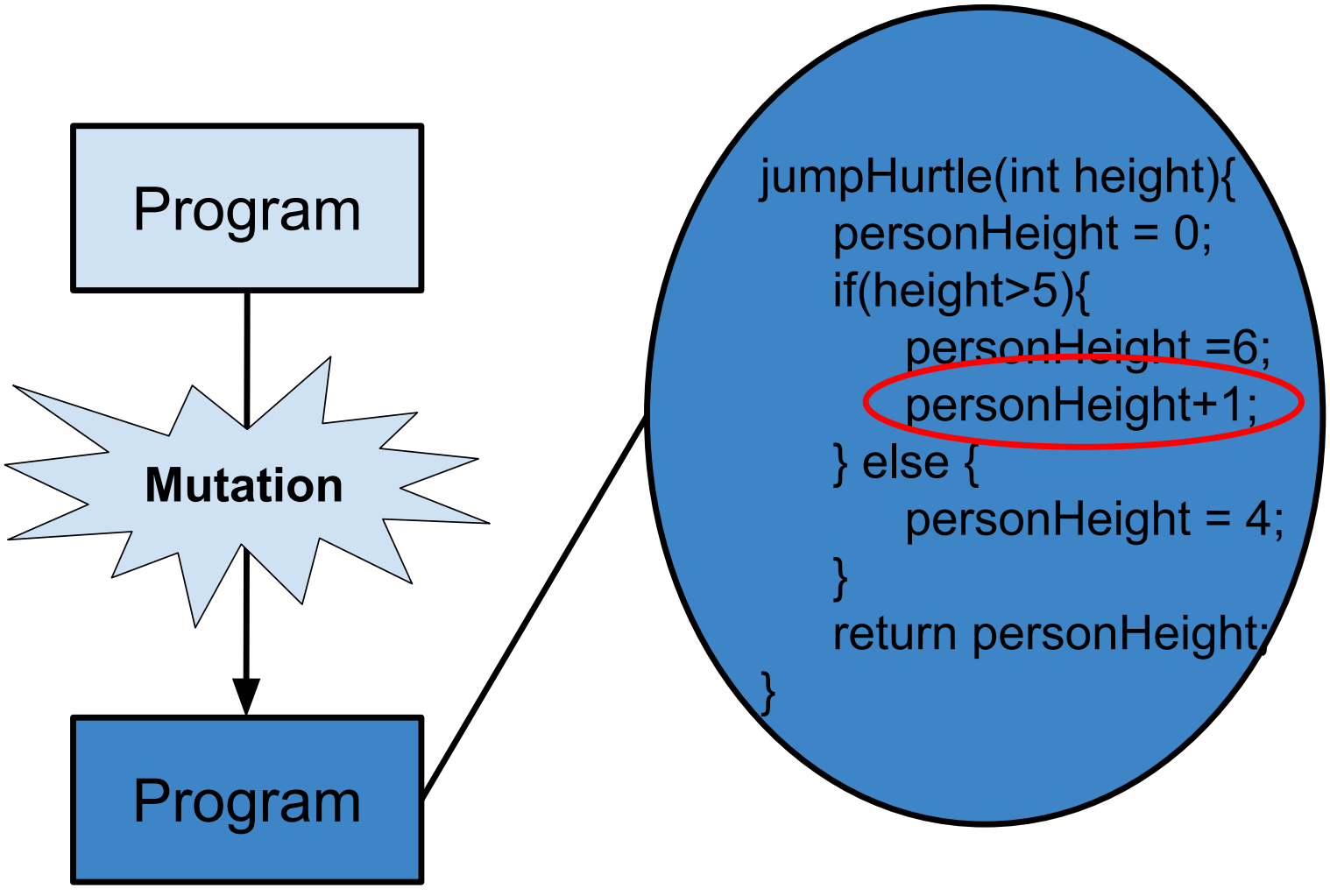

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Heuristics

Heuristics – a function that ranks alternatives in a search algorithm at each branching step and uses that information to choose which branch to follow.

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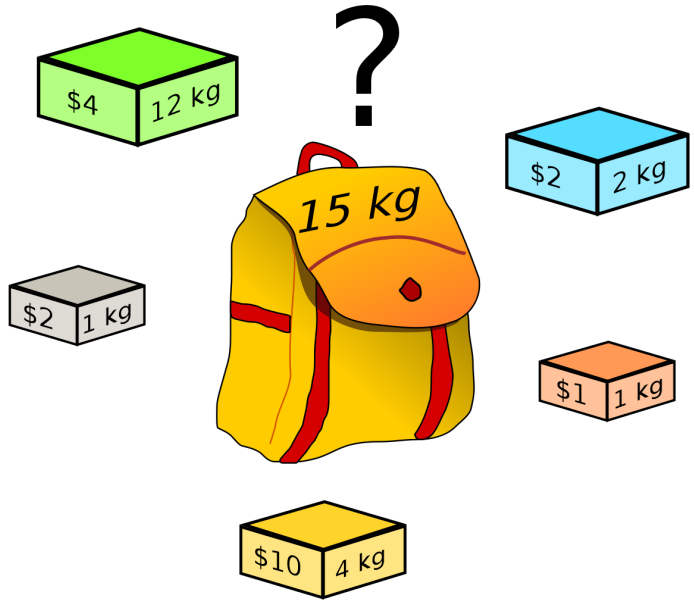
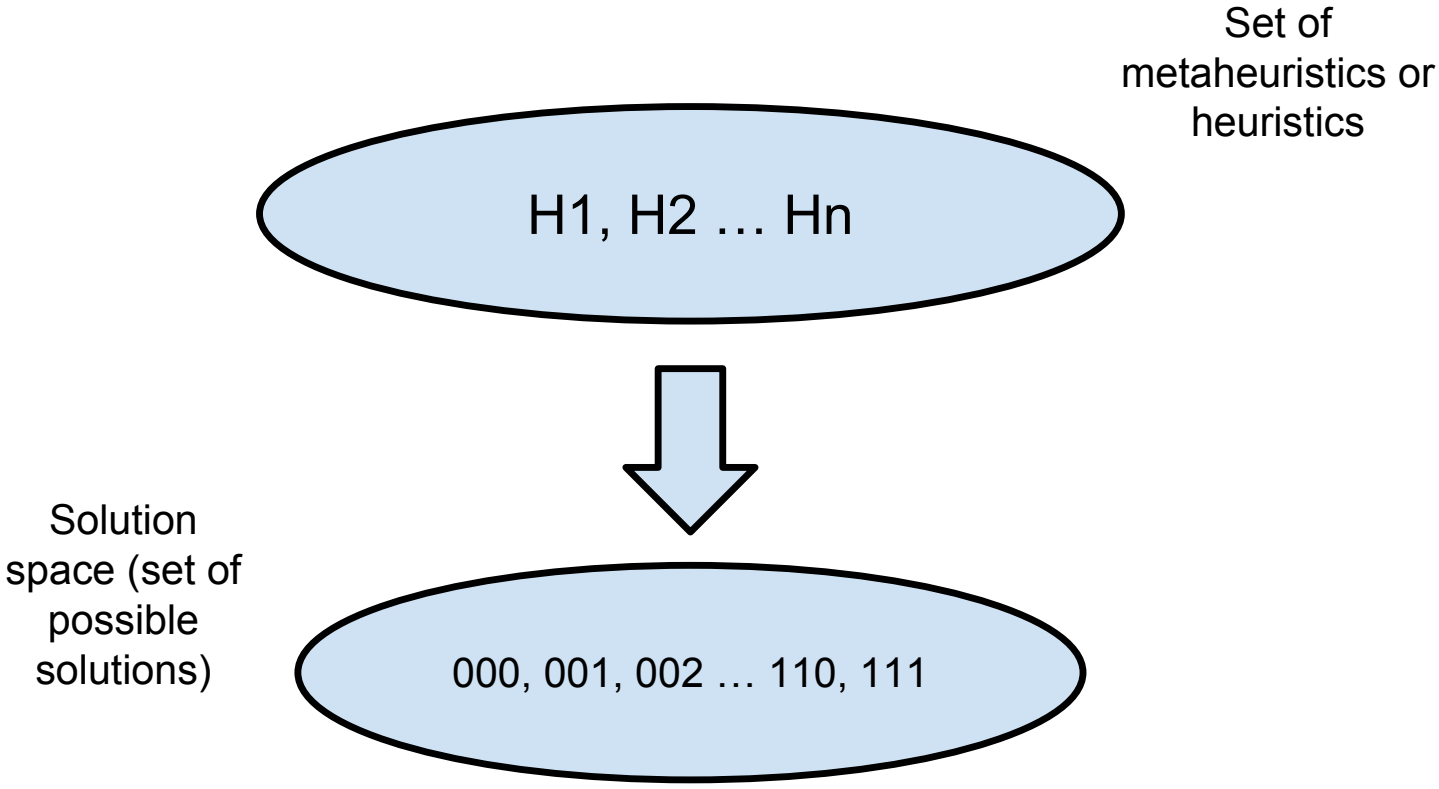


https://upload.wikimedia.org/wikipedia/commons/thumb/f/fd/Knapsack.svg/1200px-Knapsack.svg.png

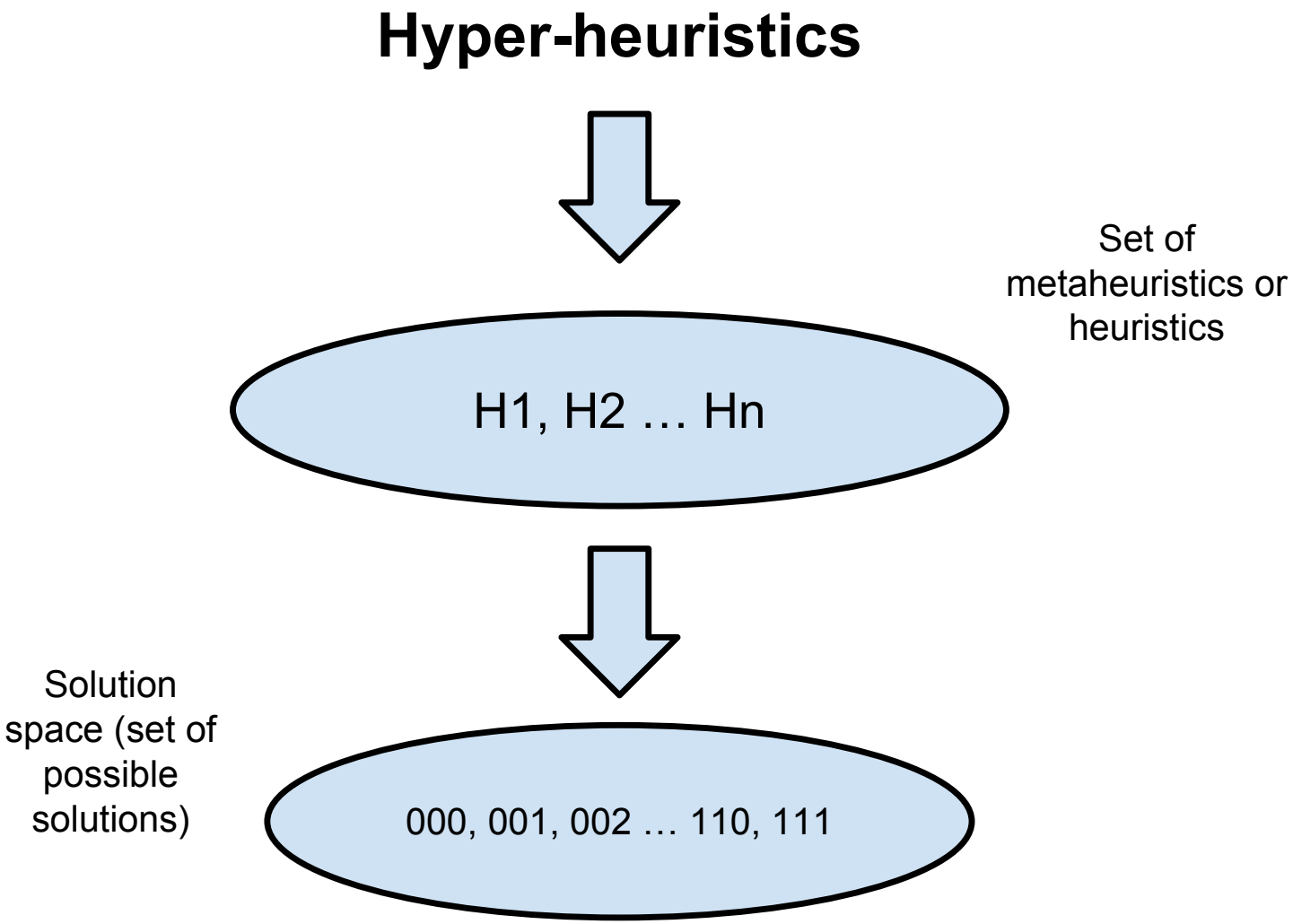
Metaheuristic

Metaheuristic – a heuristic that does not require knowledge about the problem and is not problem specific

Heuristics and Metaheuristics



Hyper-heuristics



Hyper-heuristics

Hyper-heuristics – heuristic search methods which seek to automate the process of selecting, generating, or adapting several simpler heuristics in order to solve computational search problems.

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Genetic programming hyper-heuristics – hyper-heuristics that use genetic programming for the process of selecting, generating, or adapting several simpler heuristics.

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Genetic programming variants

GP variants – variations on the structure and setup of a genetic programming system.

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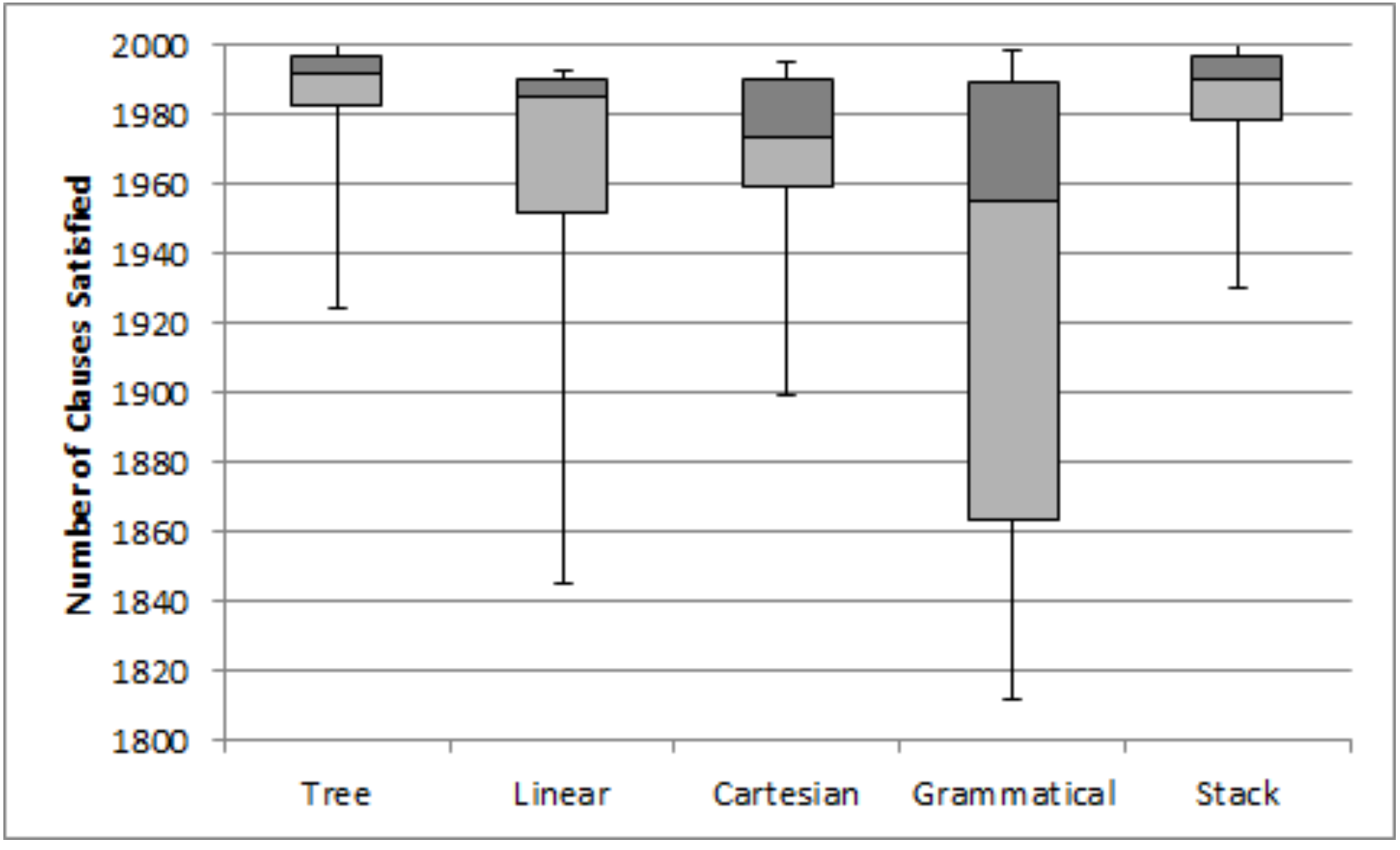
GP variants tested:

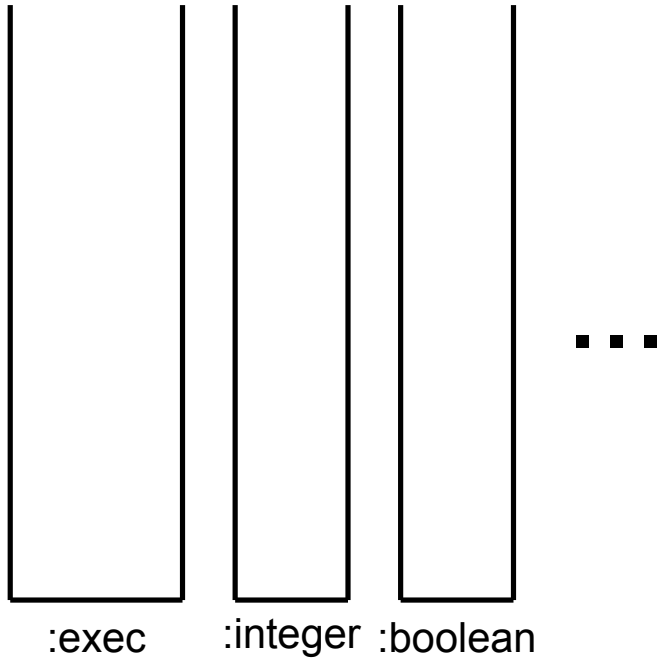
- Cartesian GP
- Linear GP
- Stack-based GP
- Tree-based GP
- Grammatical Evolution

Why should we care?



Stack-based genetic programming

Data-stacks are used for managing input and output of operations.



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Programs are represented as linear sequences of literals and instructions. Below is an example of a simple Push program:

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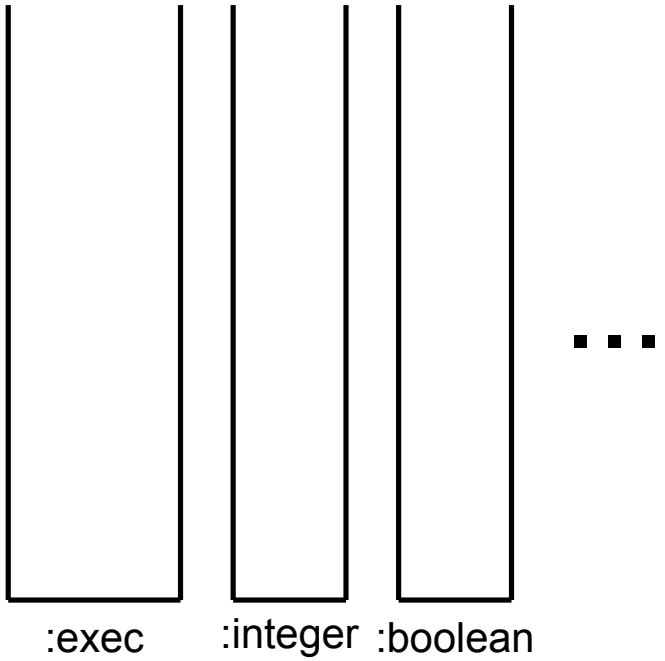

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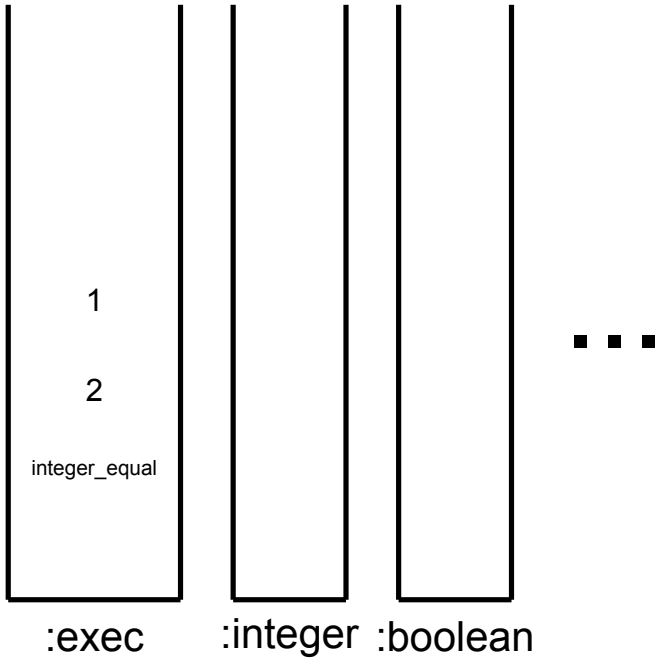

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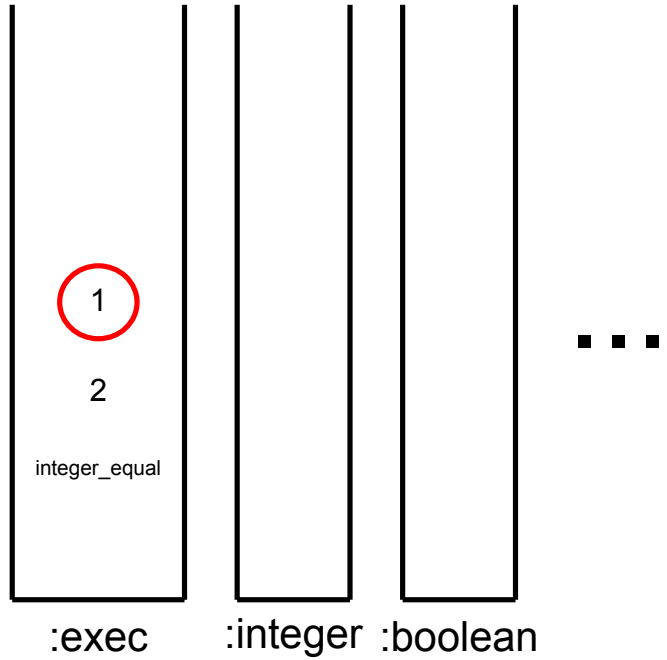

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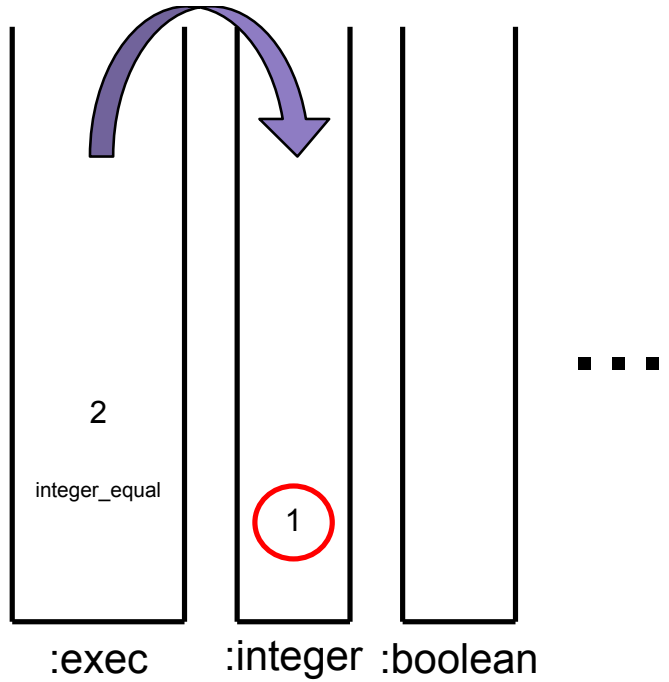

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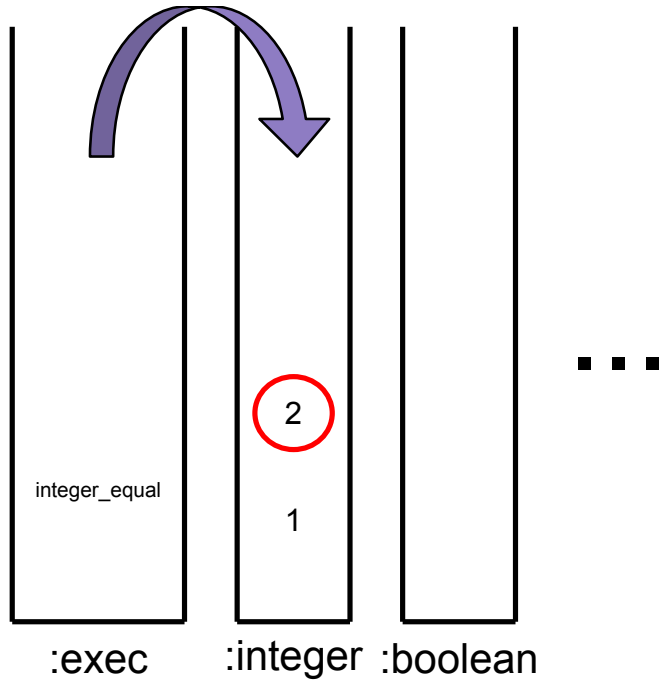

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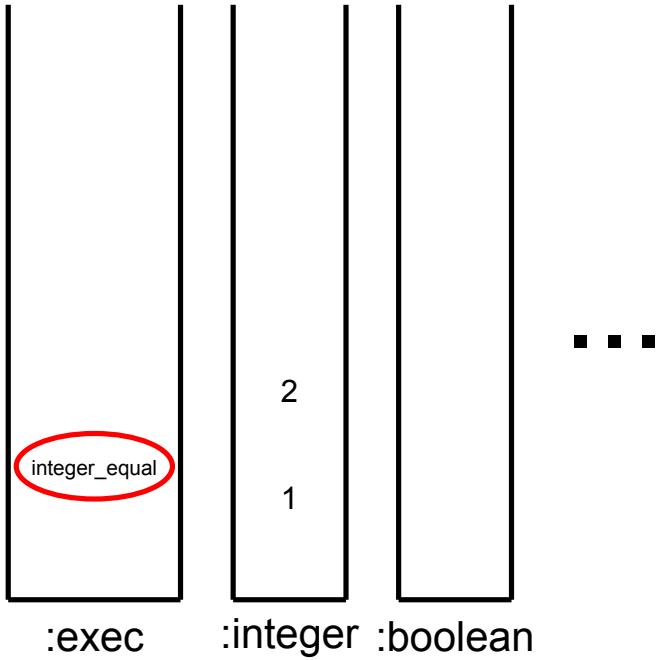

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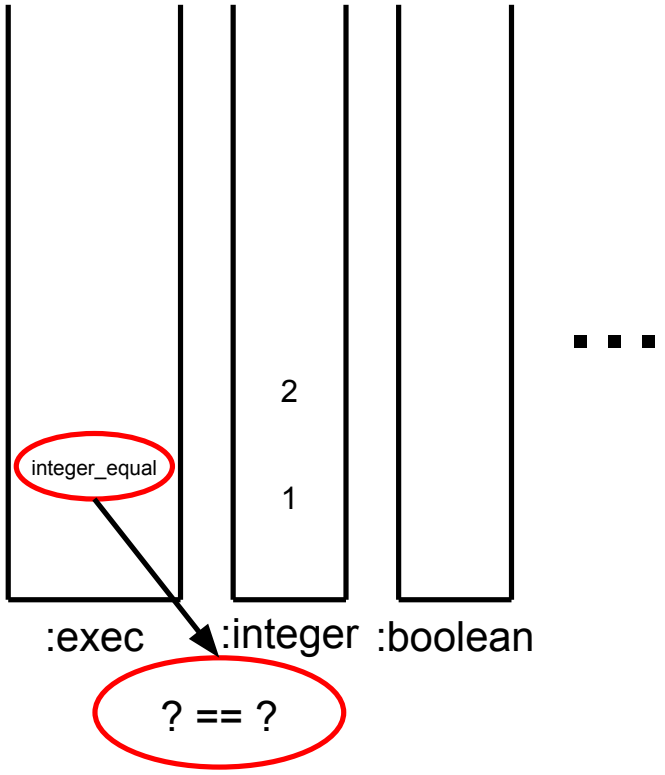

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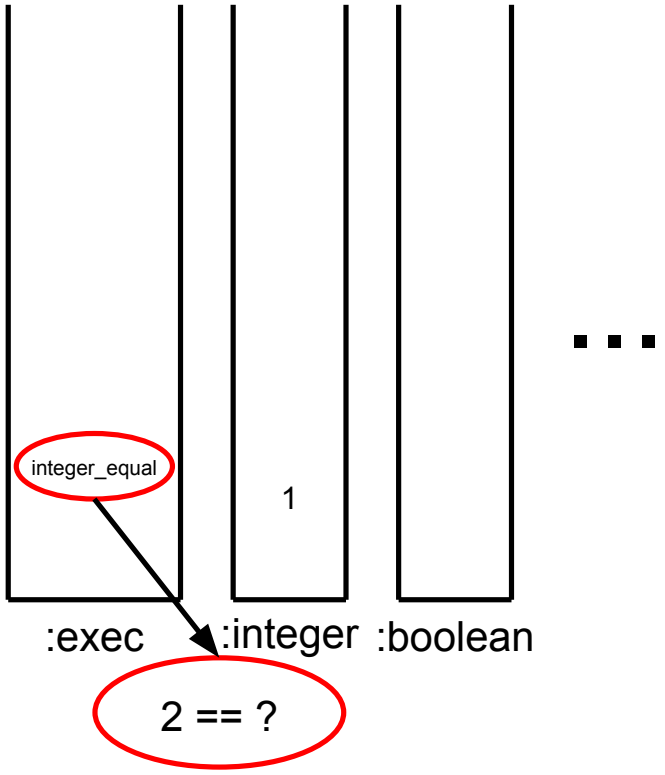

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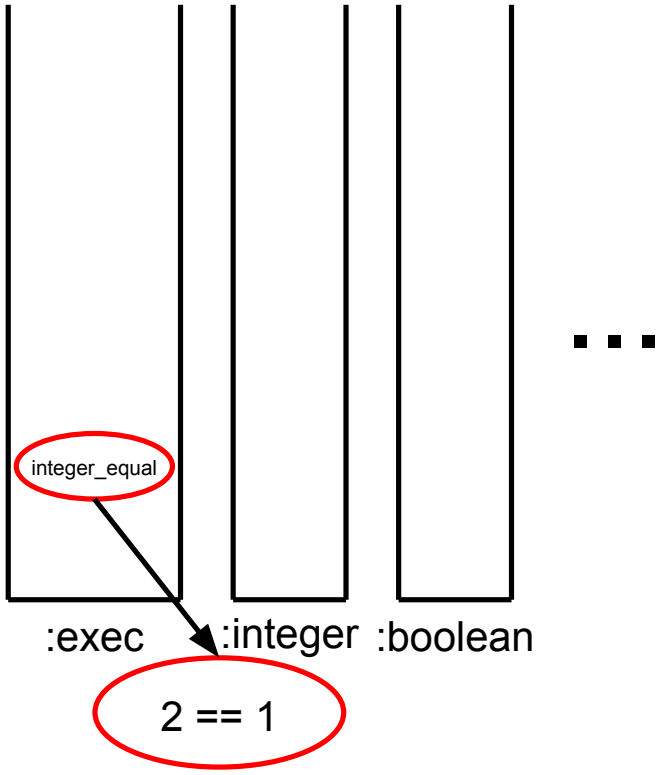

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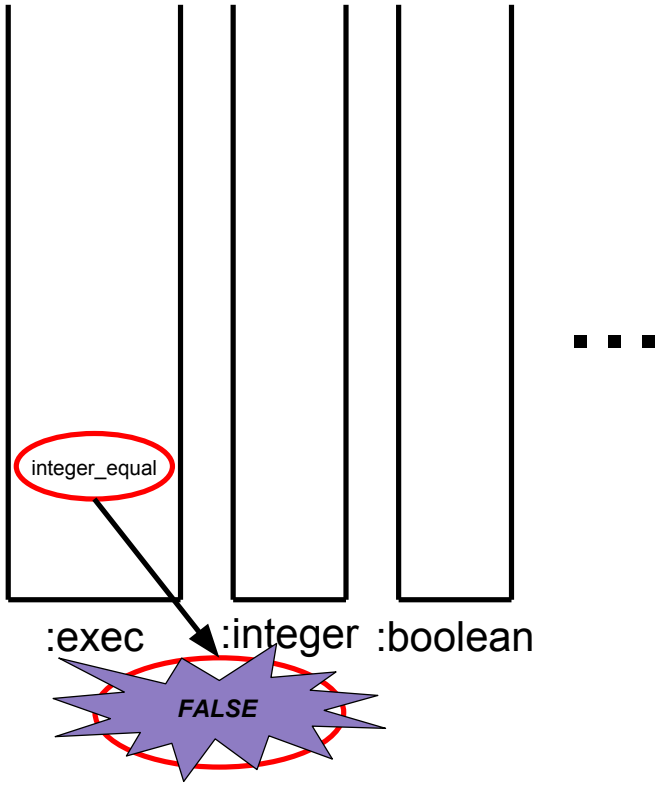

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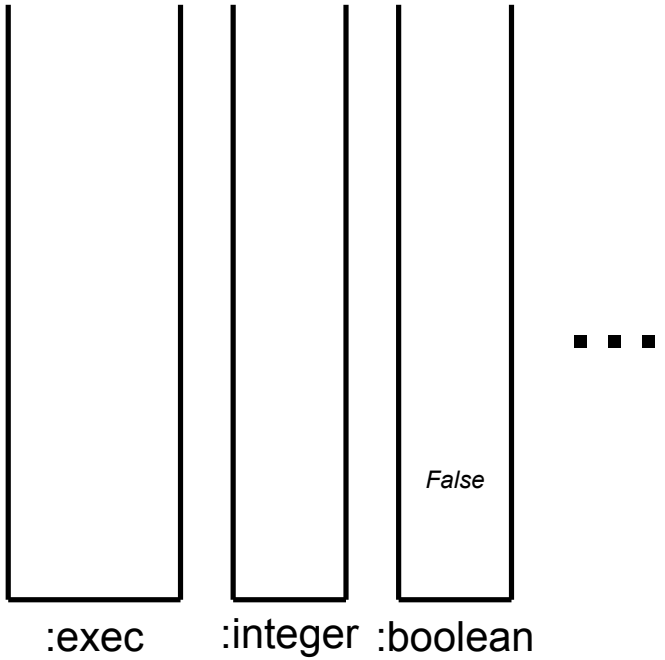

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- In most GPHH, the individual programs are evolving, but everything else is specified by the engineer; in autoconstruction, evolution is evolving as well.
- Programs are responsible for evolving solutions *and* responsible for evolving their offspring.

AutoDoG

A system that uses autoconstruction to evolve programs designed by Spector et al. [2].

Outline

References


S. Harris, T. Bueter, and D. R. Tauritz.
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In Sara Silva, editors, *GECCO '15*, pages 1043–1050, Madrid, Spain 2015.


L. Spector, N. F. McPhee, T. Helmuth, M. M. Casale, and J. Oks.
Evolution Evolves with Autoconstruction.
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See my paper for additional references.