Simulierte Evolution: Hands-On-Starter Kit

Java User Group Frankfurt 2023

Heiko Spindler
Freelancer

Heiko Spindler

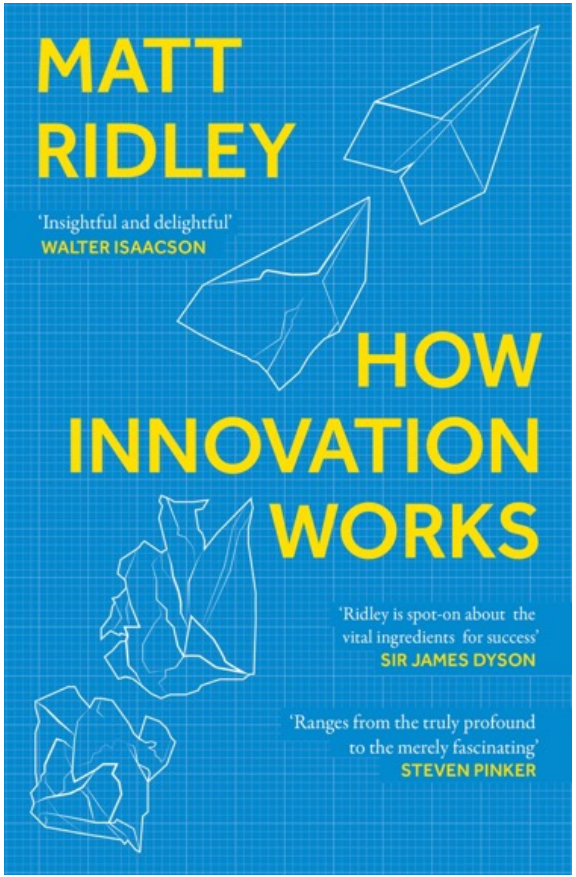
Freiberuflicher IT-Berater,
Software-Entwickler
und Coach

hs@heikospindler.de

Evolution
- not only in nature!

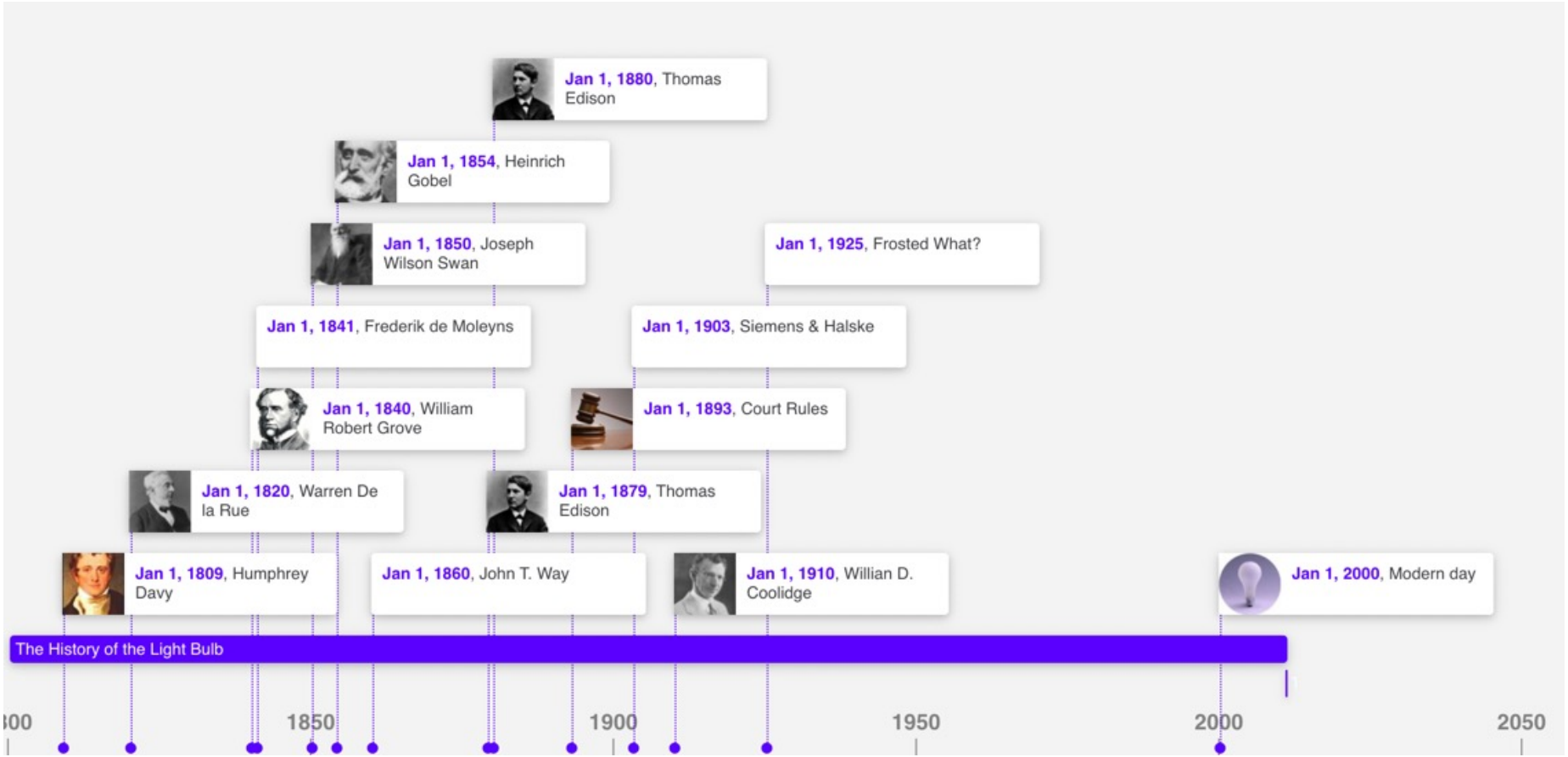
Do you know other areas where Evolution takes place?


NOKIA
Connecting People
Know our past. Create the future...
1982
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
UI



How Innovation Work - Matt Ridley

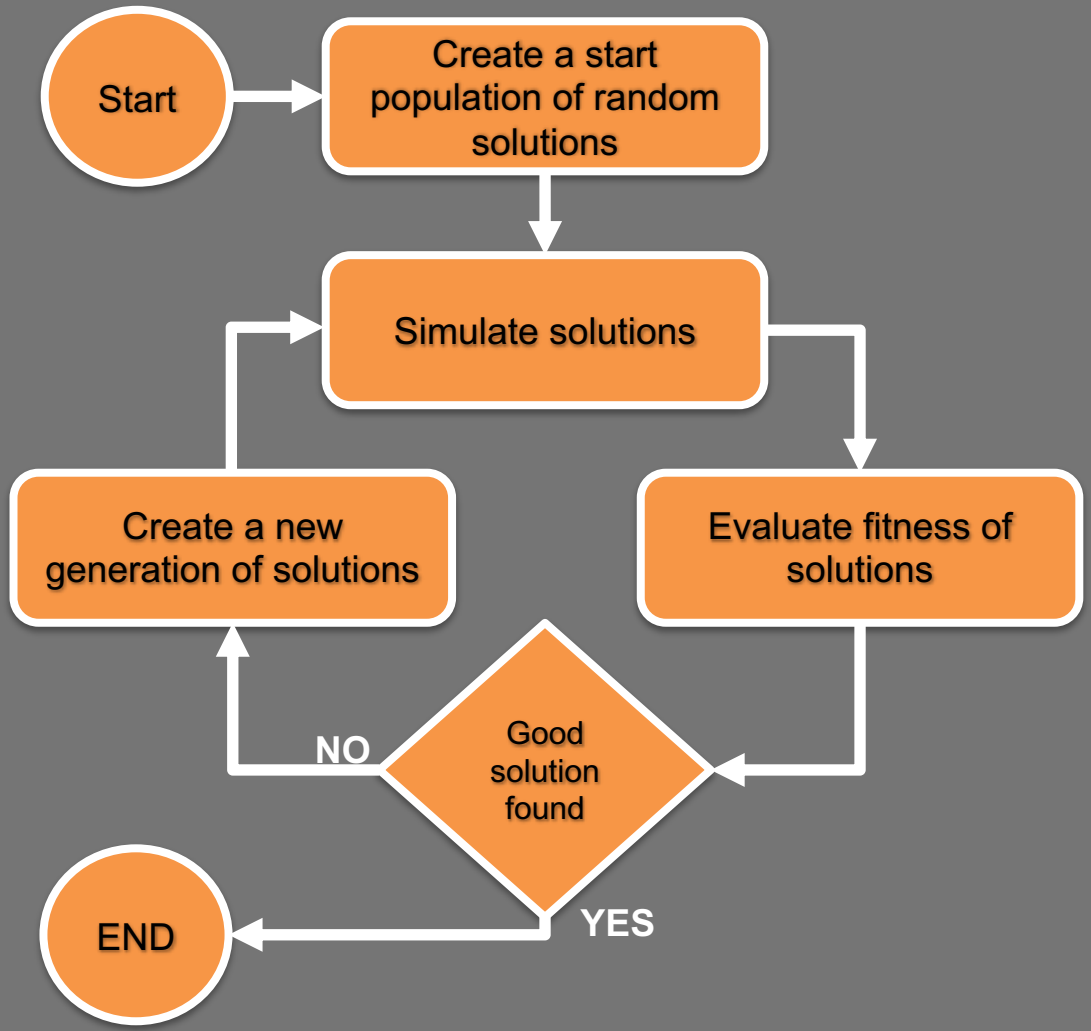
"Innovation: It is always a collective, collaborative phenomenon, not a matter of a lonely genius."

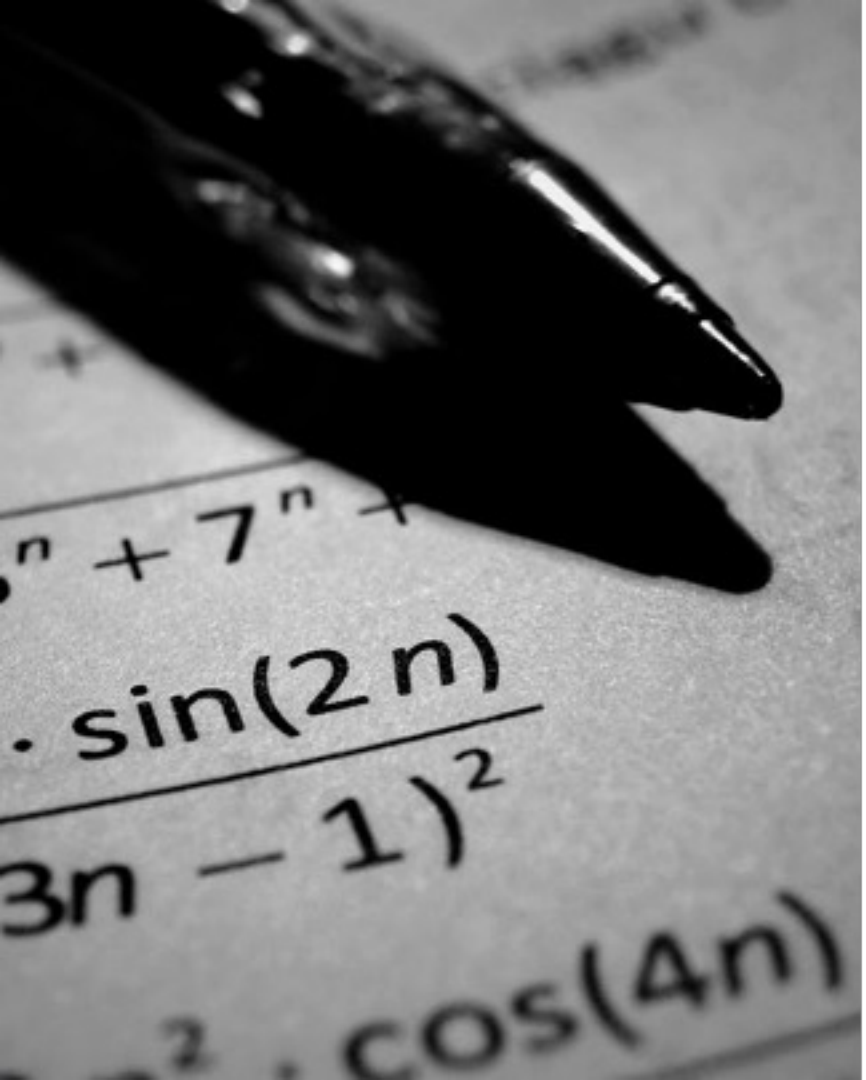

Jan 1, 1880, Thomas Edison
Jan 1, 1854, Heinrich Gobel
Jan 1, 1850, Joseph Wilson Swan
Jan 1, 1925, Frosted What?
Jan 1, 1841, Frederik de Moleyns
Jan 1, 1903, Siemens & Halske
Jan 1, 1840, William Robert Grove
Jan 1, 1893, Court Rules
Jan 1, 1820, Warren De la Rue
Jan 1, 1879, Thomas Edison
Jan 1, 1809, Humphrey Davy
Jan 1, 1860, John T. Way
Jan 1, 1910, Willian D. Coolidge
Jan 1, 2000, Modern day
The History of the Light Bulb
1850
1900
1950
2000
2050

What do we need to simulate Evolution?

- Data structure for genes
- Implementation of genetic operations
- Implement simulation of solutions
- Define fitness function
- Implementation of the process
- Find good parameters values

Process of Evolution

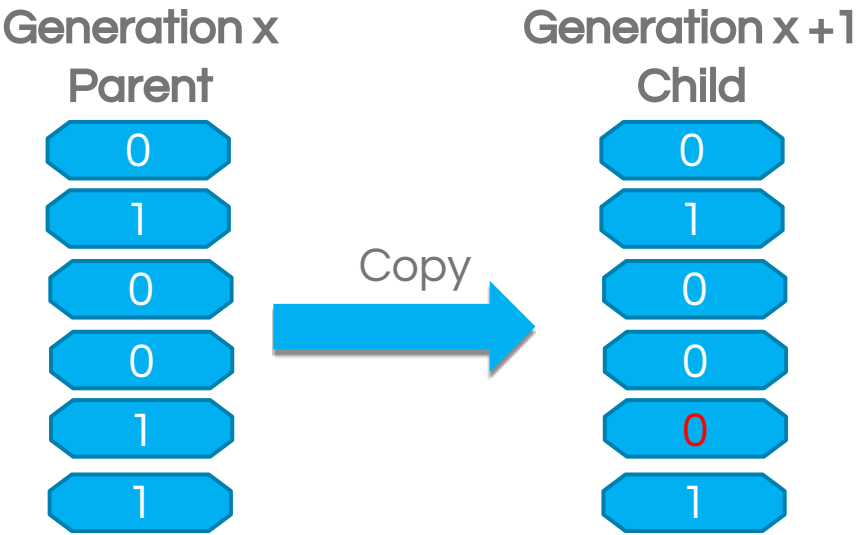




Define a Fitness Function

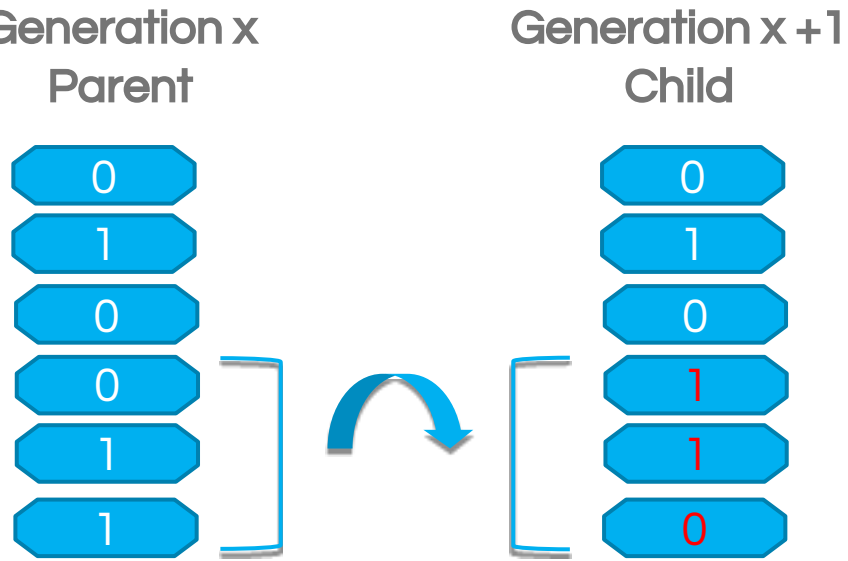
- **Simple to calculate**
- **Maps a solution to a number (Higher number = better solution)**

Mutation



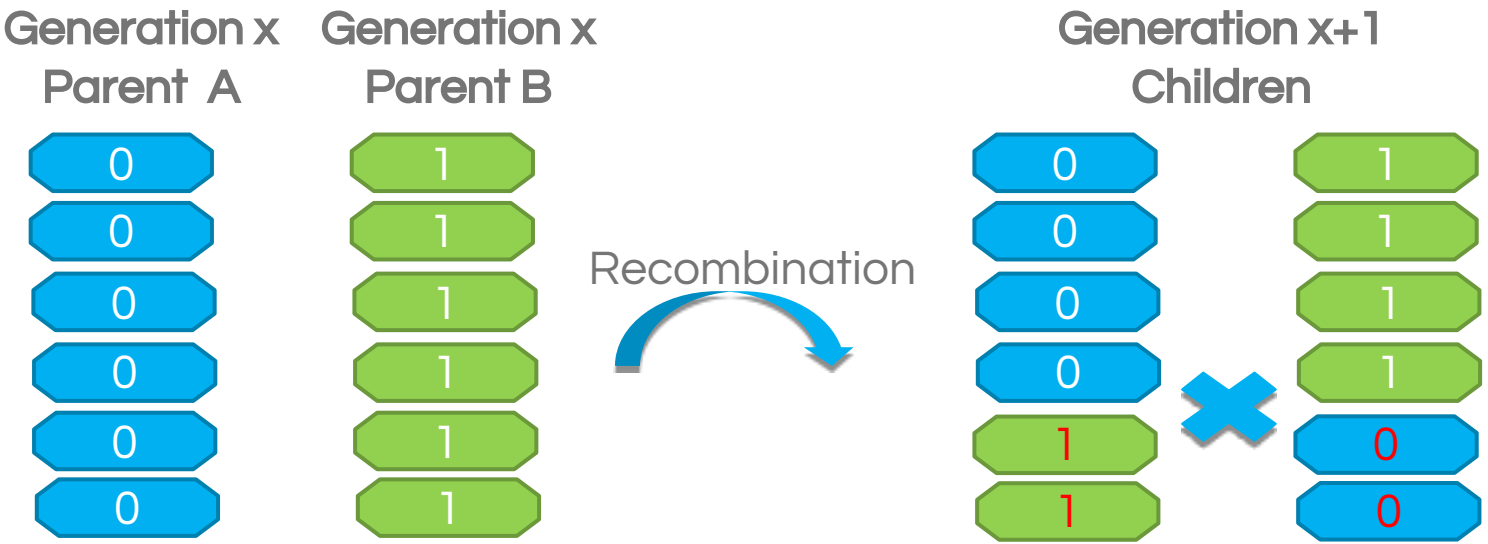
Changes a value at a random position.

Inversion



The sequence changes.

Recombination / Cross Over



What do we need to simulate Evolution?

- Data structure for genes
- Implementation of genetic operations
- Implement simulation of solutions
- Define fitness function
- Implementation of the process
- Find good parameters values

Sample 1

Evolve a sequence of letters to find target Sentence

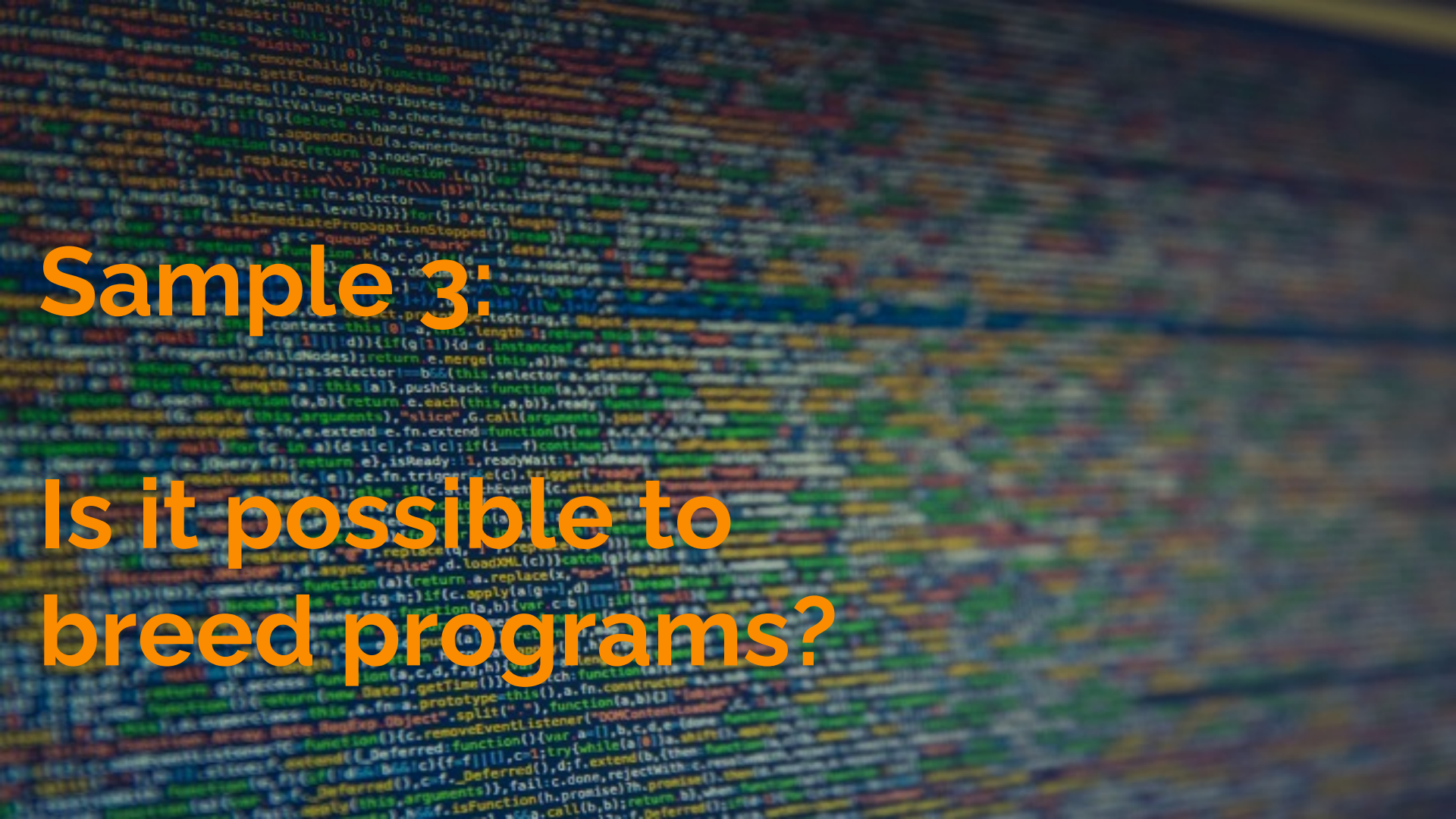
Sample 2

Evolve a Word Search Exercise

Description

- Select and put words from a list in a grid of letters.
- Words flow horizontal, vertical and diagonal.
- Words should fit in the grid.
- Overlapping words should share the same letters.

```
_R__S_D_
KATZE_O_
_DH_E_R_
GIU__RF_
EONHEMDG
N_D_R__E
O__KABEL
MBURG__D
```

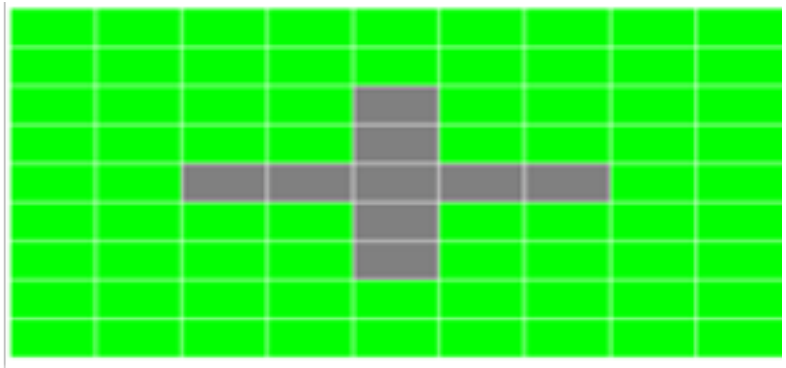

Sample 3:
Is it possible to
breed programs?

The Challenge

A robot should visit and mark all cells of a given board (9 x 9 cells).

Some cells are blocked (gray).

The memory holds up to 30 commands.



Robot Commands

Command	Description
`Move` <left, right, up, down>	Moves the robot
`Set`	Marks the cell where the robot is located
`Nop`	„No Operation“
`Goto` <Command No.>	Continues the execution of the program at another position
`If` <left, right, up, down> = <free, marked, border> `Goto` <Command No.>	Conditional jump depends on the state of the current cell

Fitness Function

Priority 1: „Get the job done“:

- Fitness is given by the percentage of marked cells (0.0 to 100.0).

...

Fitness Function

Priority 1: „Get the job done“:

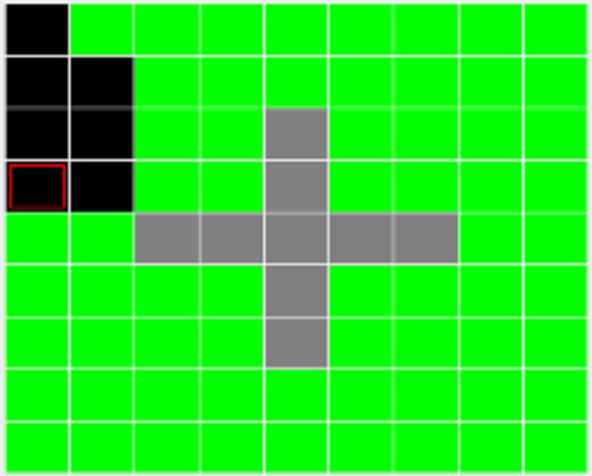
- Fitness is given by the percentage of marked cells (0.0 to 100.0).

Priority 2: „Be efficient“:

- **Every command execution consumes energy**
- **The robot gets energy for new marked cell**
- **The energy left after marking all cells defines the fitness.**

globalbest.indiv

0.MOVE left
1.IF (left==marked) GOTO 10
2.MOVE left
3.SET
4.MOVE right
5.MOVE down
6.SET
7.IF (left==marked) GOTO 9
8.GOTO 2
9.IF (down==free) GOTO 21
10.MOVE up
11.IF (right==marked) GOTO 20
12.SET
13.GOTO 15
14.IF (up==blocked) GOTO 2
15.IF (right==free) GOTO 4
16.MOVE left
17.NOP
18.MOVE up
19.GOTO 0
20.MOVE up
21.MOVE left
22.IF (up==free) GOTO 21
23.MOVE down
24.MOVE down
25.MOVE down
26.MOVE down
27.MOVE right
28.GOTO 4
29.GOTO 0



Energy : 154

Steps : 25

Frameworks

JGAP: http://jgap.sourceforge.net

~~Apache Commons Math: http://commons.apache.org~~

Jenetics: http://jenetics.io

Features

- Java, Open Source
- Data structures
- Genetic operations
- Interfaces for fitness functions
- Process of simulated evolution

Frameworks for Python

Geneticalgorithm

- Implements the basic features
- https://github.com/rmsolgi/geneticalgorithm

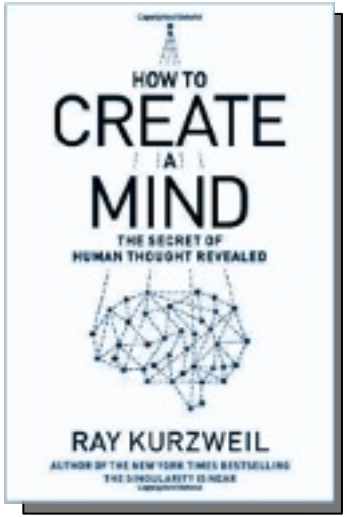
PyGAD

- https://pygad.readthedocs.io/
- Integration with Keras and PyTorch

Simulated Evolution in Action

Ray Kurzweil, 2016

“How to Create a Mind: The Secret of Human Thought Revealed”



Conclusion

- Frameworks exist and provide good support
- Implementation activities
  - Mapping business domain to genome
  - Simulate solutions
  - Calculate fitness
- Find good parameters for the evolution process

Links

- Artikel:
  https://www.informatik-aktuell.de/entwicklung/programmiersprachen/einstieg-in-die-simulierte-evolution-mit-java.html

- Source Code:
  https://github.com/brainbrix/evolution

Q & A

Heiko Spindler

Freelacer
hs@heikospindler.de