~ Genetic Algoritms ~

In Search of the Missing Solution

Davide Carneiro

Press Start!

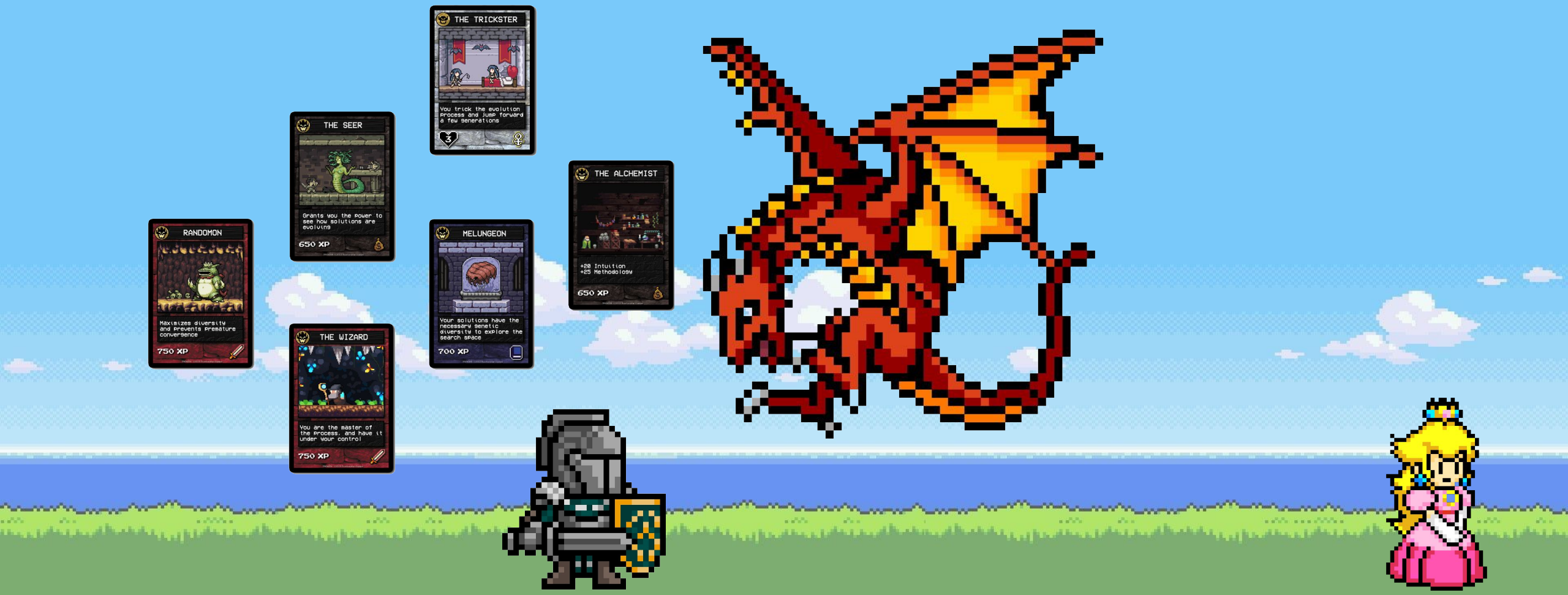
P.PORTO
ESCOLA SUPERIOR DE TECNOLOGIA E GESTÃO

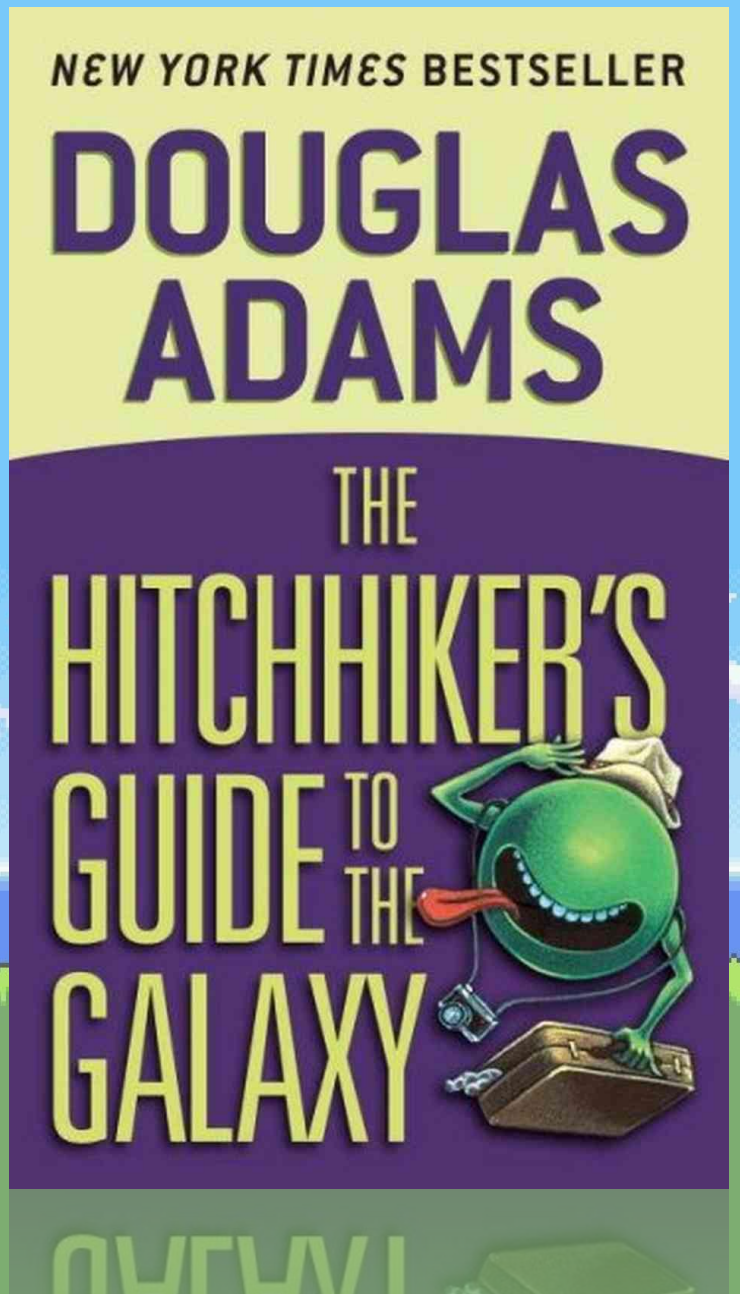
DSPT
DATA SCIENCE PORTUGAL

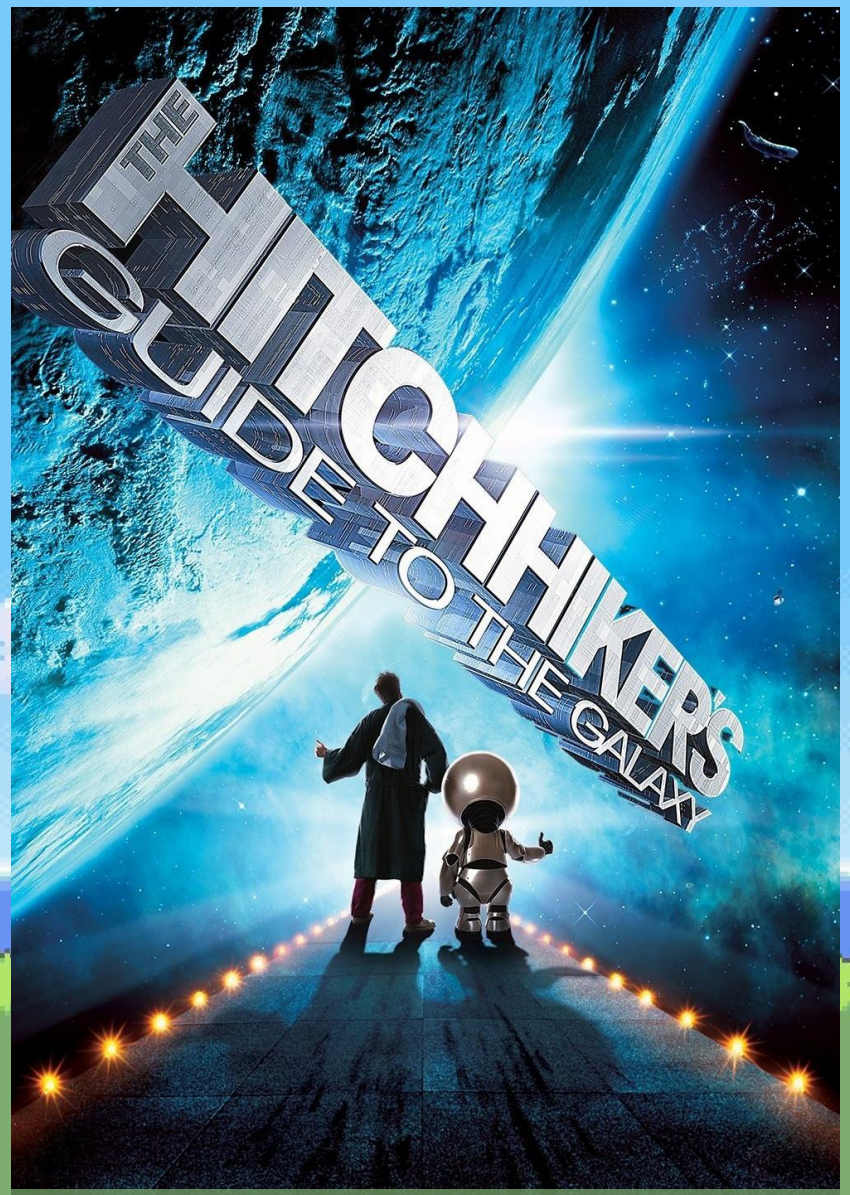
$ About 

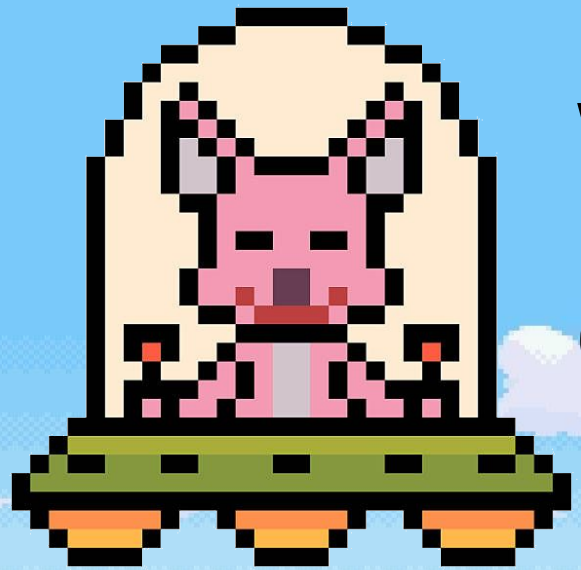
* PhD from the Universities of Minho, Aveiro and Porto (MAP-i)
* Interests/Teaching:
    - Artificial Intelligence
    - Data Science/Engineering
    - Decision Support Systems
    - ...
* Participation in Scientific Projects with real-life applications

$ About this


THE TRICKSTER
You trick the evolution process and jump forward a few generations
THE SEER
Grants you the power to see how solutions are evolving
650 XP
RANDOMON
Maximizes diversity and prevents premature convergence
750 XP
MELUNGEON
Your solutions have the necessary genetic diversity to explore the search space
700 XP
THE ALCHEMIST
+20 Intuition
+25 Methodology
650 XP
THE WIZARD
You are the master of the process, and have it under your control
750 XP

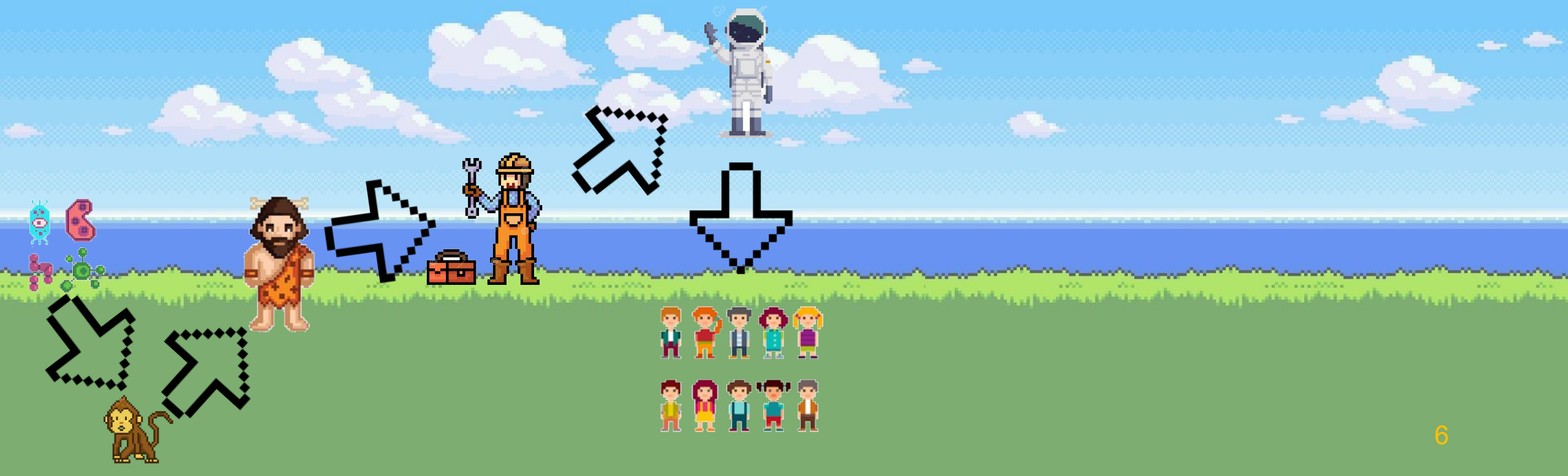

NEW YORK TIMES BESTSELLER
DOUGLAS ADAMS
THE HITCHHIKER'S GUIDE TO THE GALAXY


THE HITCHHIKER'S GUIDE TO THE GALAXY



What is the meaning of life?

How does this computer work?
How does it find a solution?
What does the solution even look like?



$ What are GAs?

* Search algorithms inspired by the natural mechanics of biological evolution

* Are good at taking potentially large multi-dimensional search spaces and navigating them, looking for optimal solutions

* Ideal when the path towards a good solution is not known and/or when brute-force approaches are not feasible

$ Algorithm

Define solution and
Initialize population

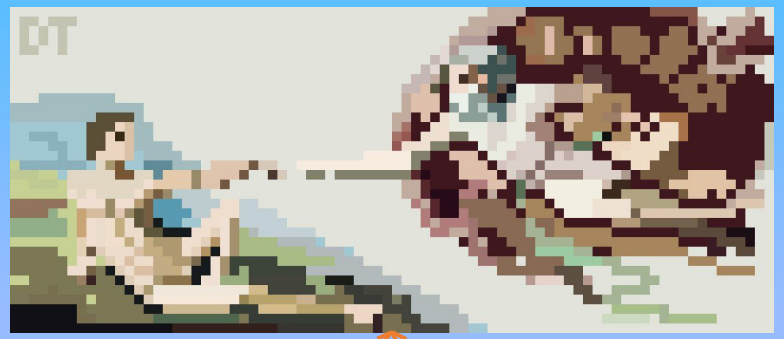
Evaluation population
(fitness function)

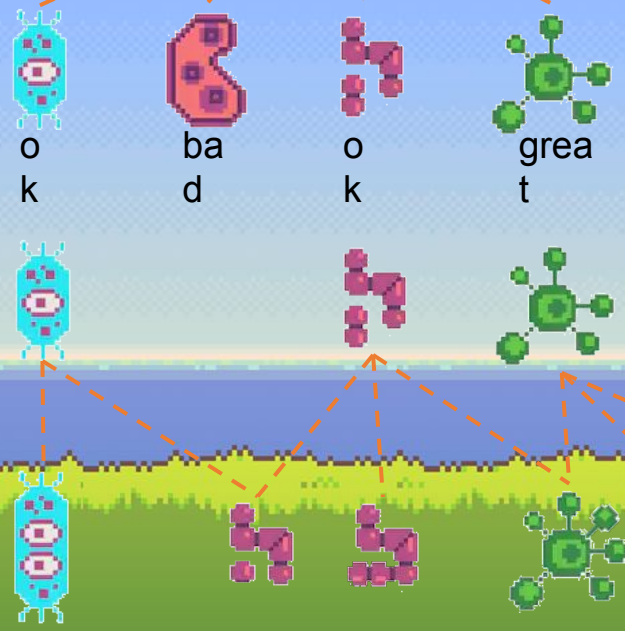
End

Select parents for
reproduction

Reproduce

while (!stopCriteria)

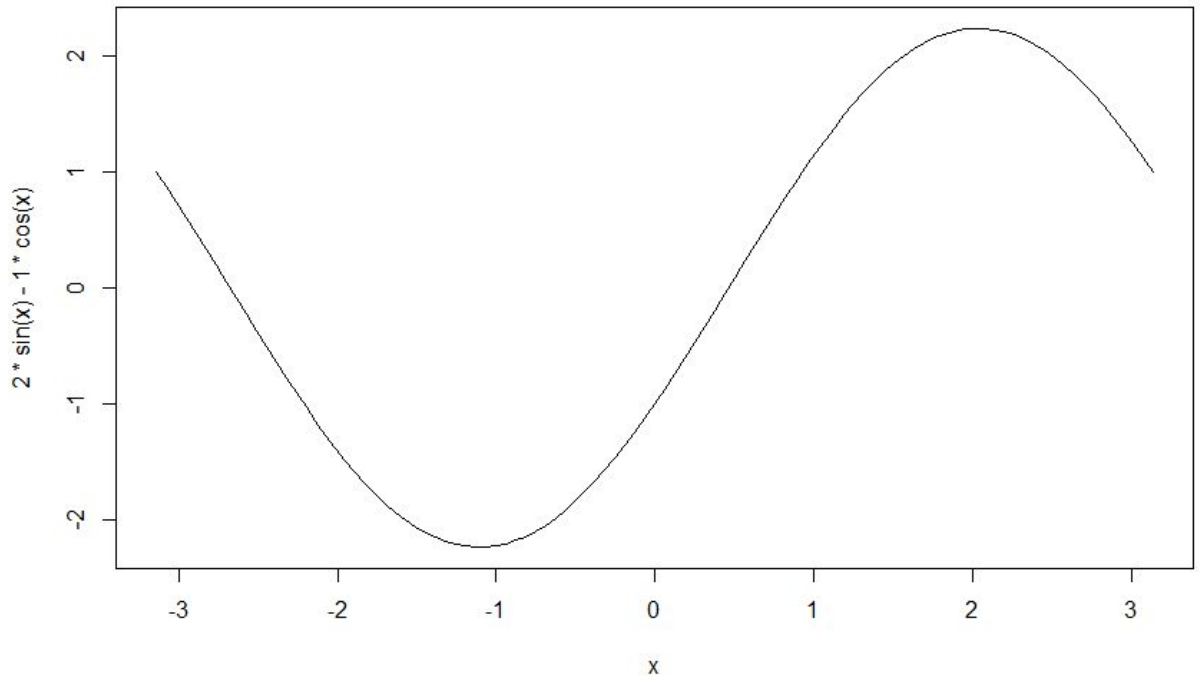




$ Quest #1

* Find the minimum of between –pi and pi

$$f(x) = 2 * \sin(x) - 1 * \cos(x)$$

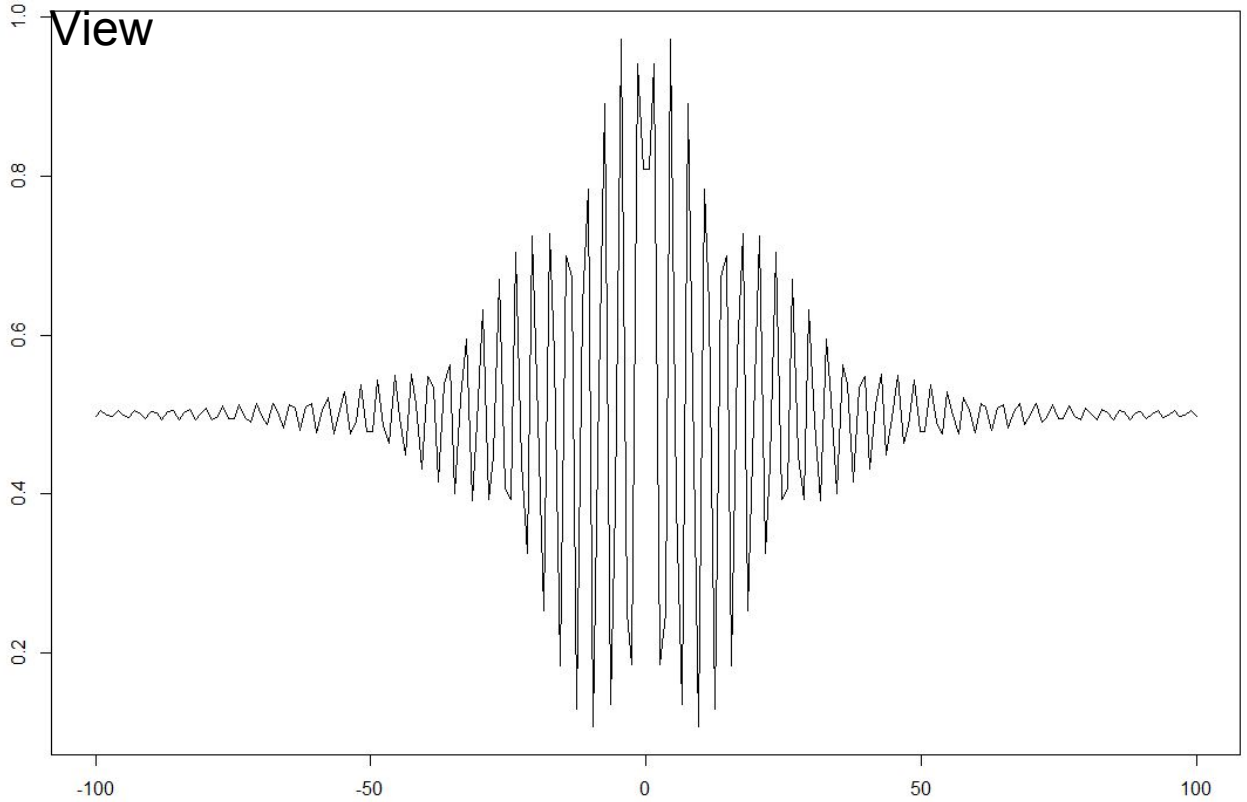


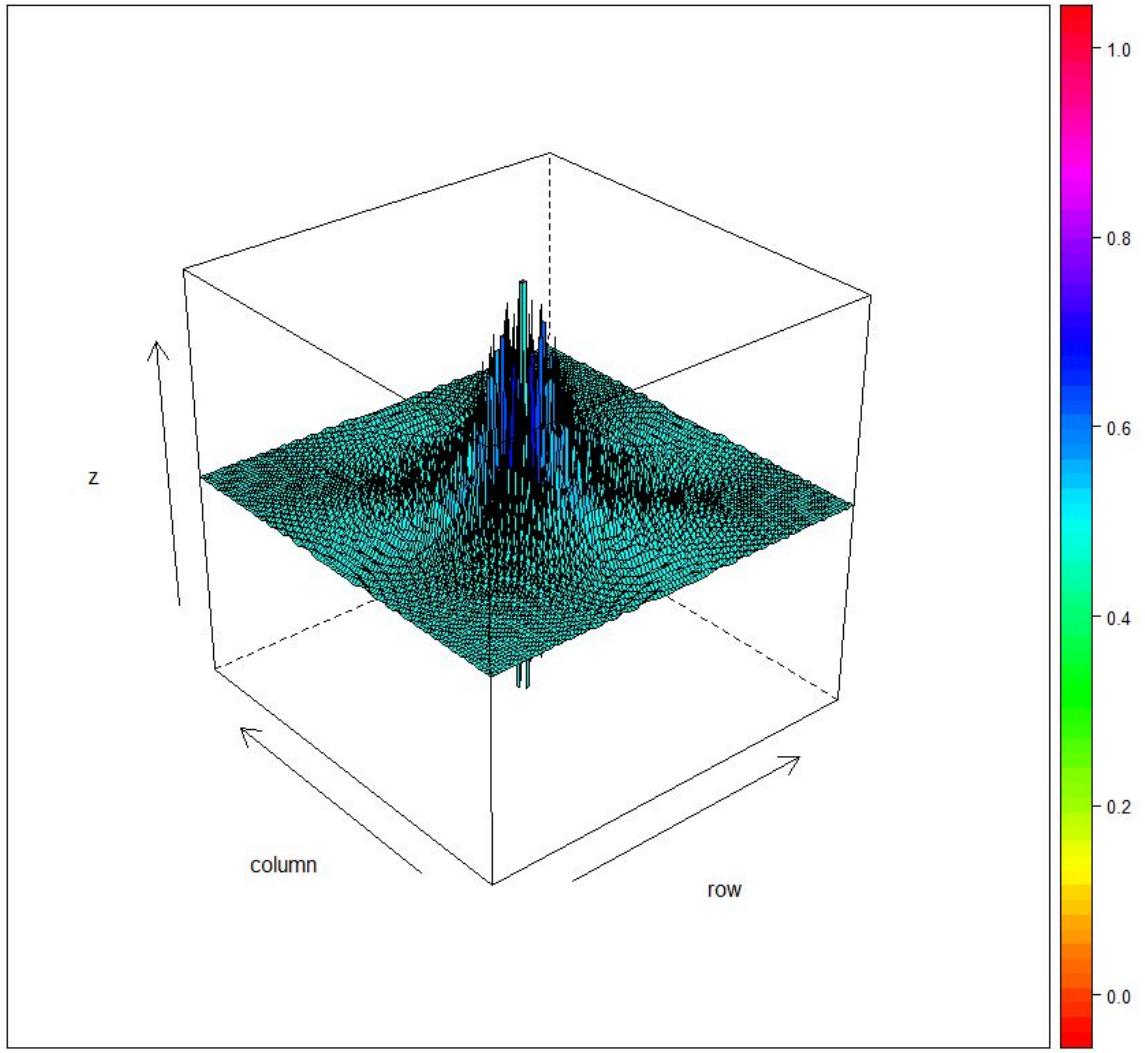
$ Quest #2

* Find the maximum of

$$f(x,y) = 0.5 + \frac{\sin(\sqrt{x^2+y^2})^2 - 0.5}{1+0.001 * (x^2+y^2)^2}$$

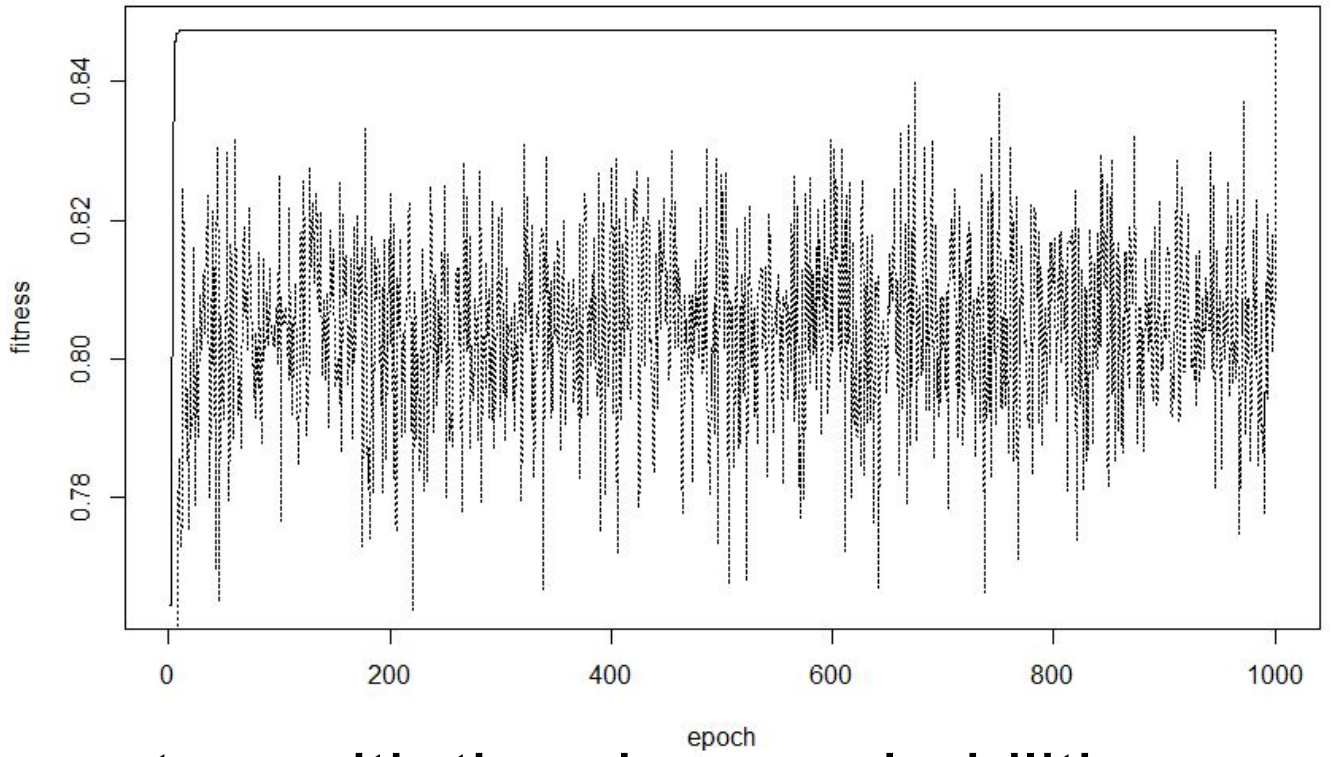
2D View





$ Configuration #1

* Population size: 20
* hereditRate: 0
* crossoverRate: 0
* mutationRate: 0.75
* maxIterations: 1000
* DeltaMin: 0,0000001
* MutationFactor: 0.2



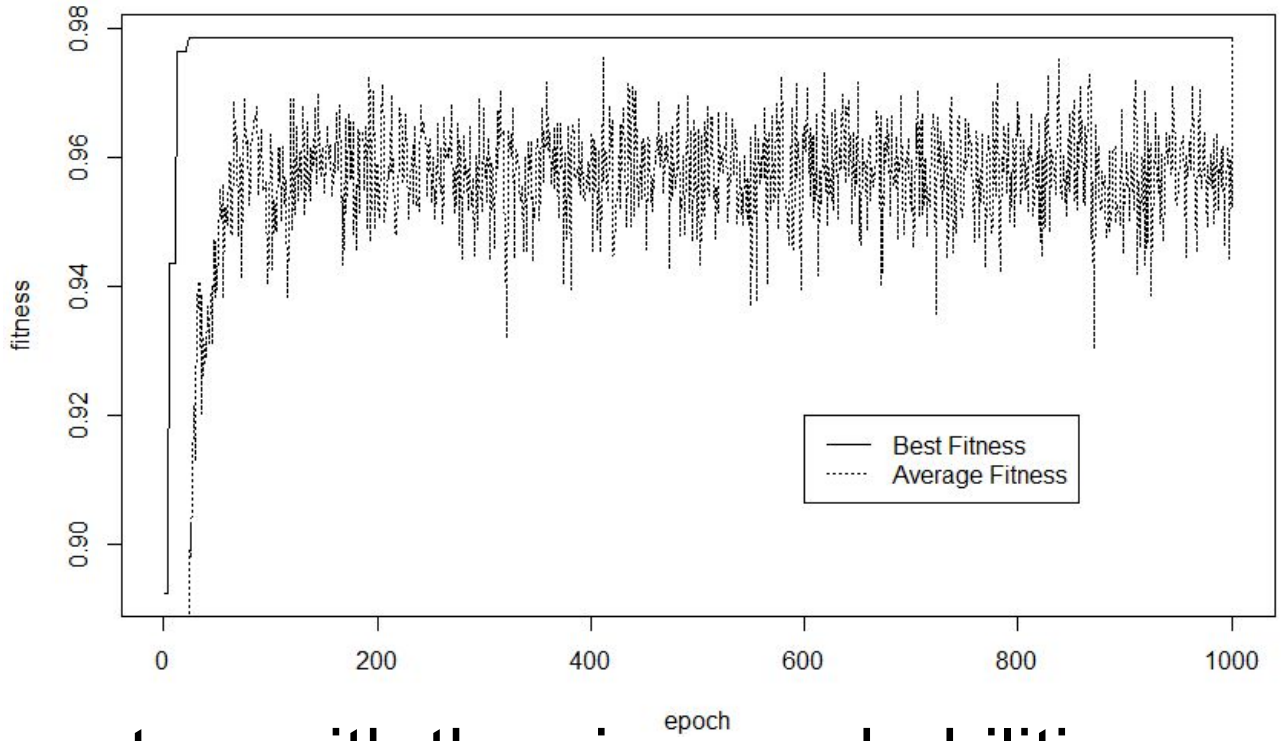
* Strategy: apply the genetic operators with the given probabilities to all solutions, select best afterwards

$ Configuration #1

* Populatio
* heredityF
* crossove
* mutationI
* maxIterat
* DeltaMin
* MutationI
* Strategy: apply the genetic operators with the given probabilities to all solutions, select best afterwards

$ Configuration #2

* Population size: 20
* hereditityRate: 0.1
* crossoverRate: 0.25
* mutationRate: 0.25
* maxIterations: 1000
* DeltaMin: 0.0000001
* MutationFactor: 0.2



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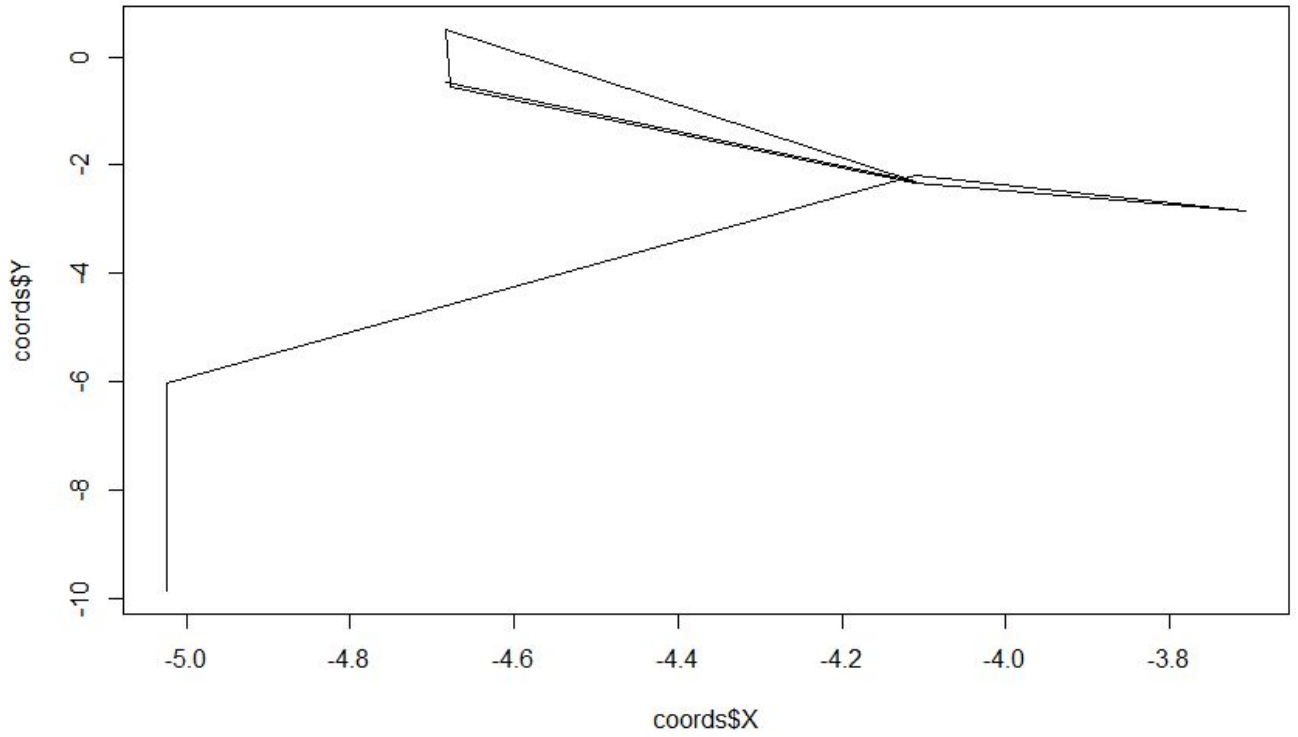

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$ Configuration #3 – start at (-100, -100)

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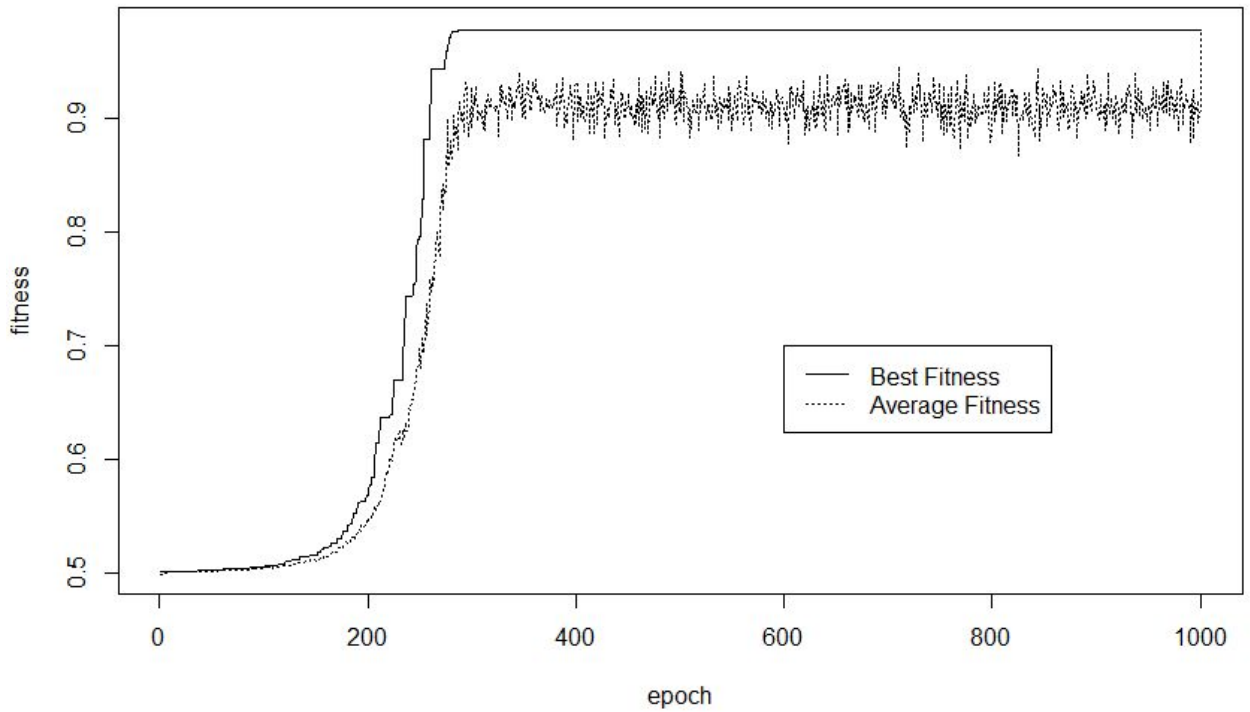

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$ Configuration #3 – start at (-100, -100)

* Popula
* heredi
* crosso
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* DeltaM
* Mutati

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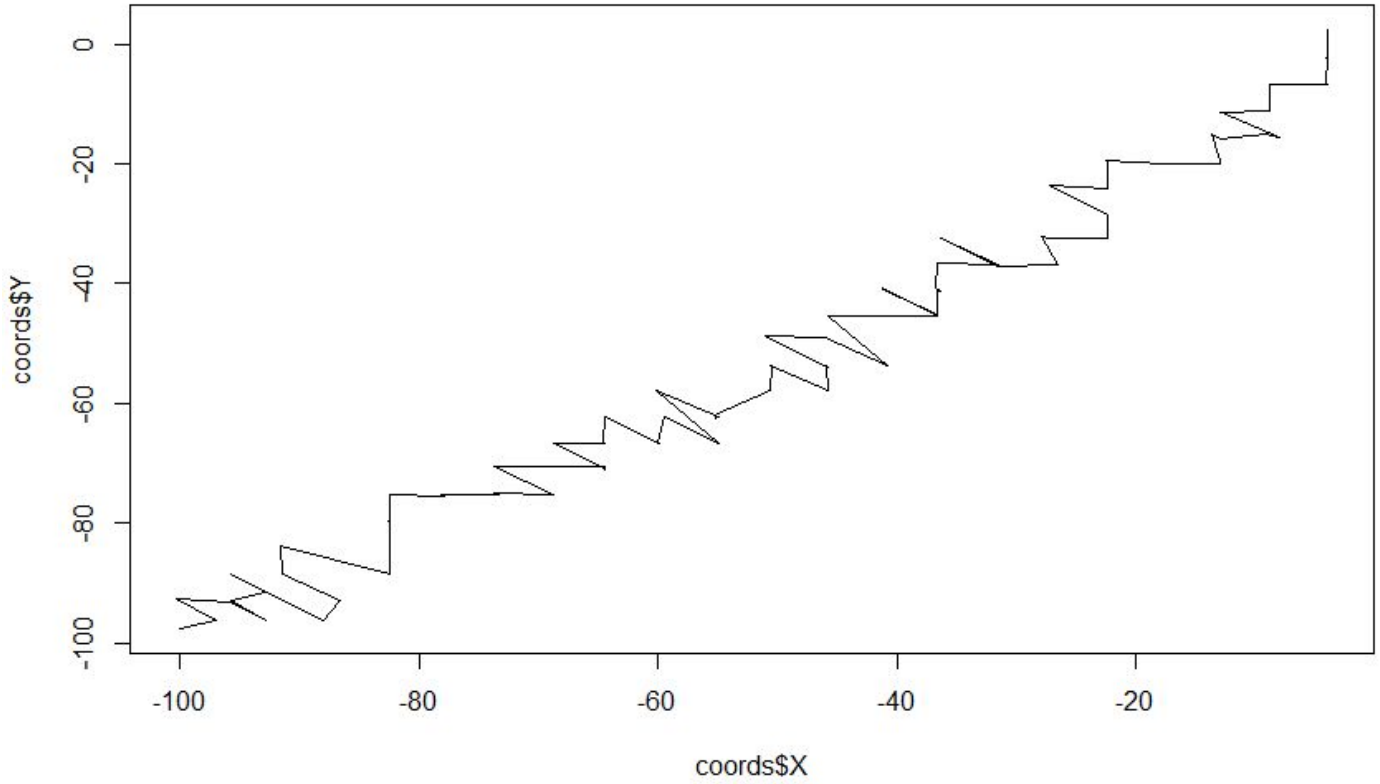

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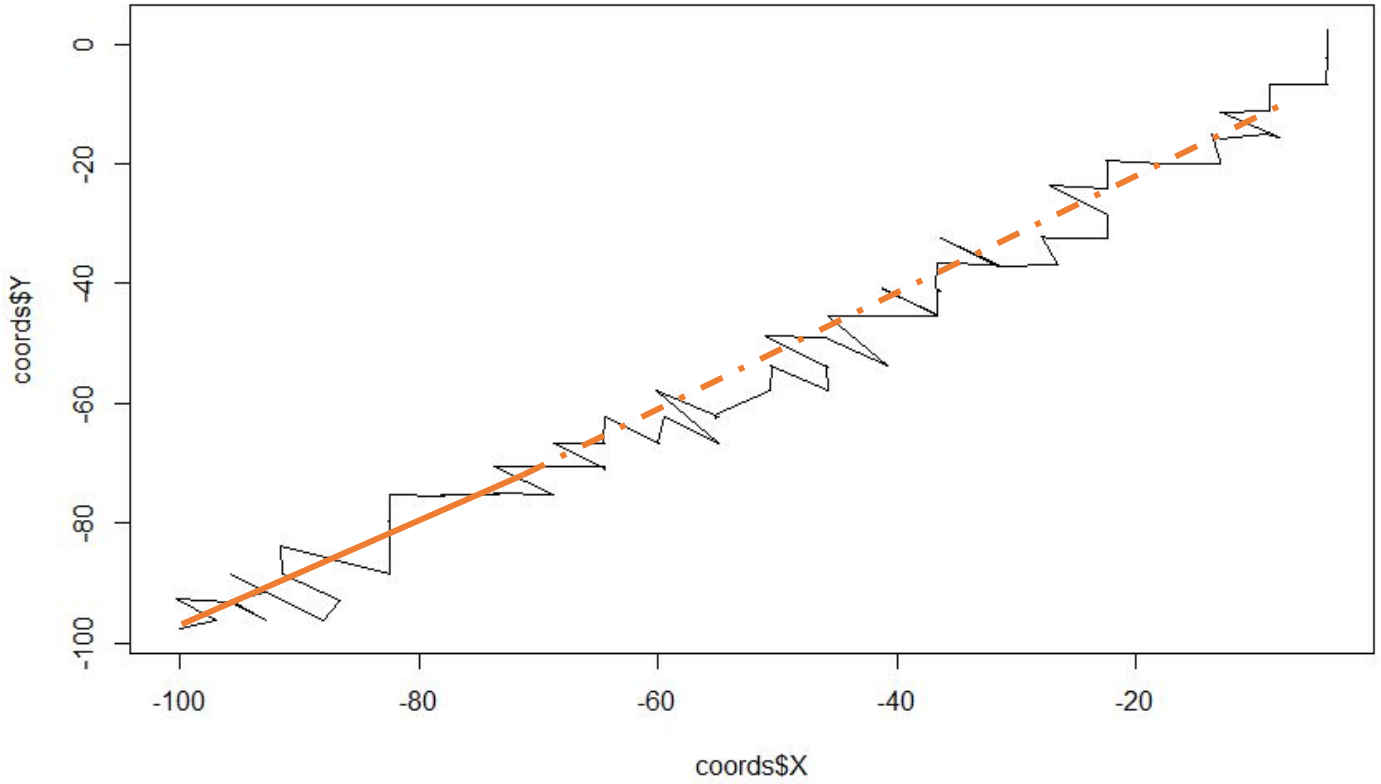

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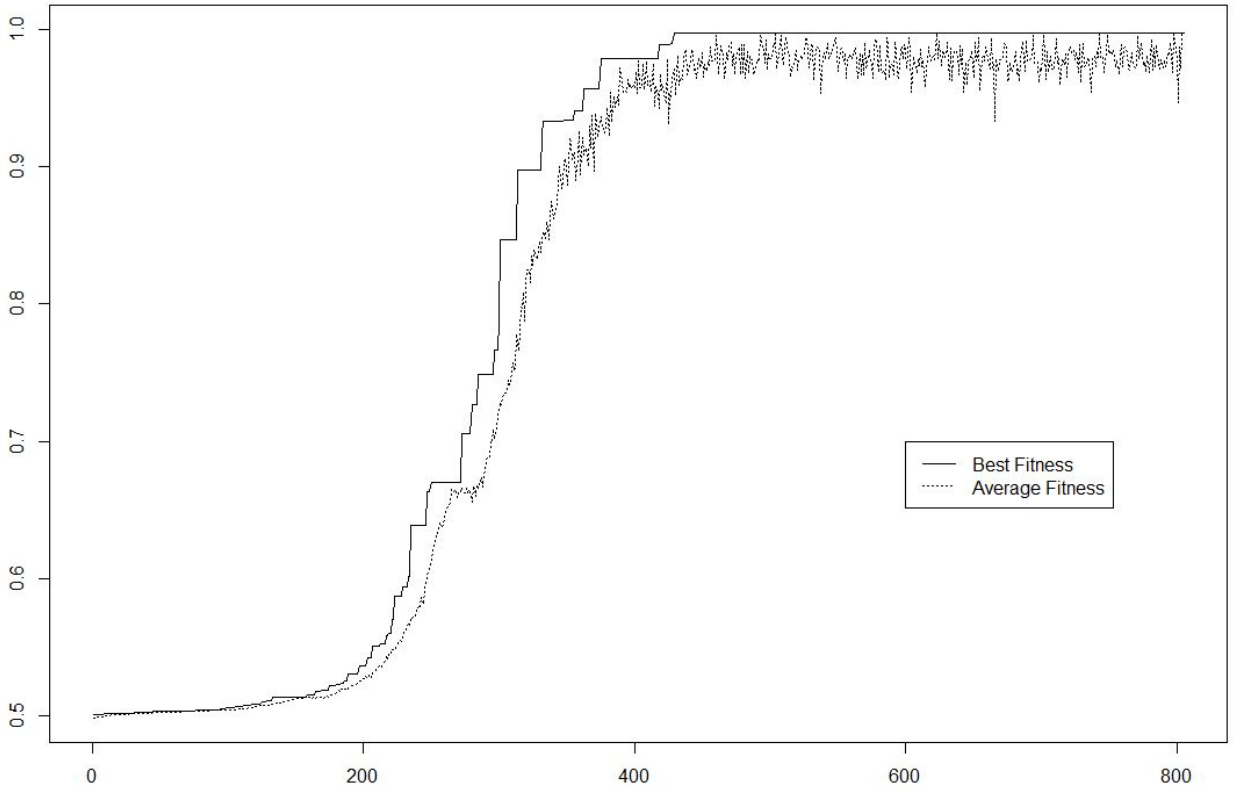
* Popula
* heredit
* crossov
* mutatic
* maxIte
* DeltaM
* MutationFactor: 0.2

* Strategy: apply the genetic operators with the given probabilities to all solutions, select best afterwards

$ Configuration #4 – start at (-100, -100)

* Population size: 20
* hereditRate: 0.1
* crossoverRate: 0.25
* mutationRate: 0.25
* maxIterations: 1000
* DeltaMin: 0.0000001
* MutationFactor: 0.2



* Strategy: apply the genetic operators with the given probabilities to the top 20% of solutions, select best

$ Configuration #4 – start at (-100, -100)

* Popul
* hered
* crosso
* mutati
* maxIte
* DeltaM
* MutationFactor: 0,2

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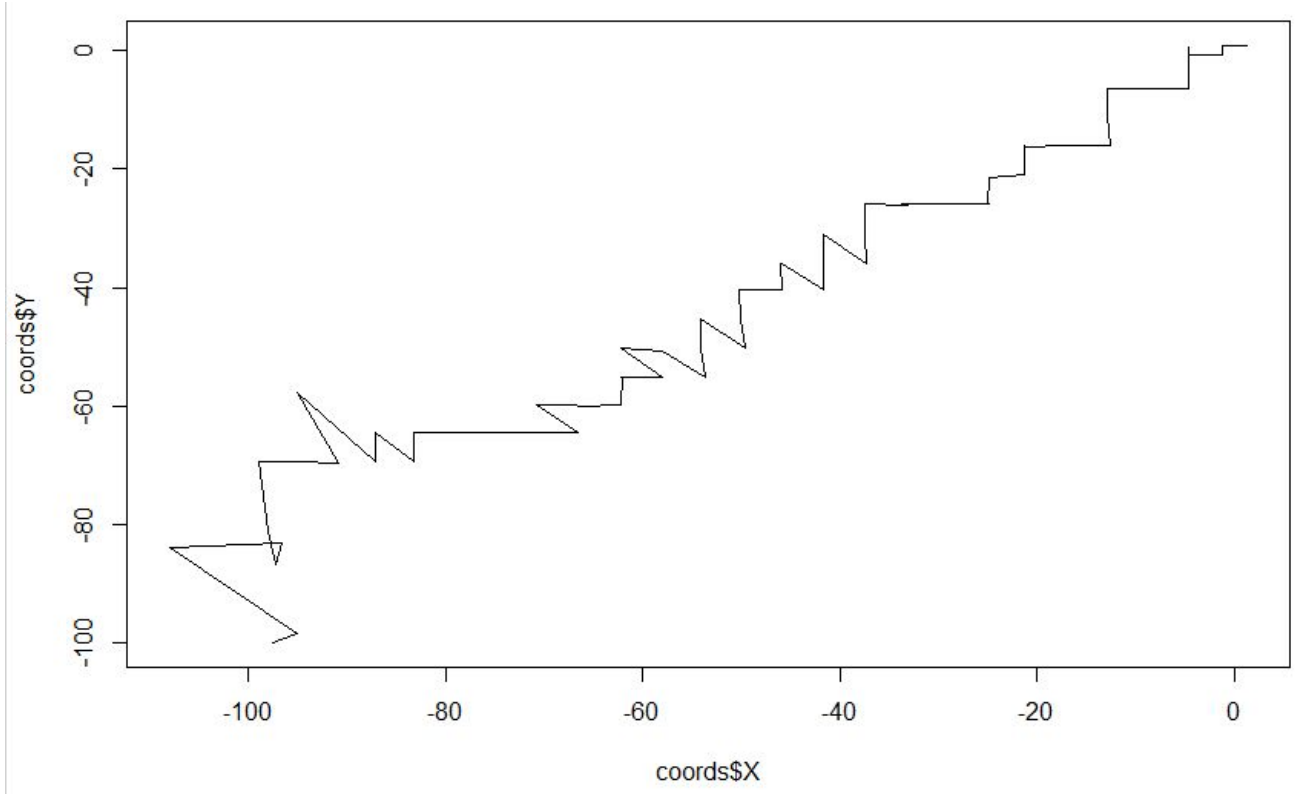
* mutationRate: 0,25
* maxIterations: 1000
* DeltaMin: 0,0000001
* MutationFactor: 0,2



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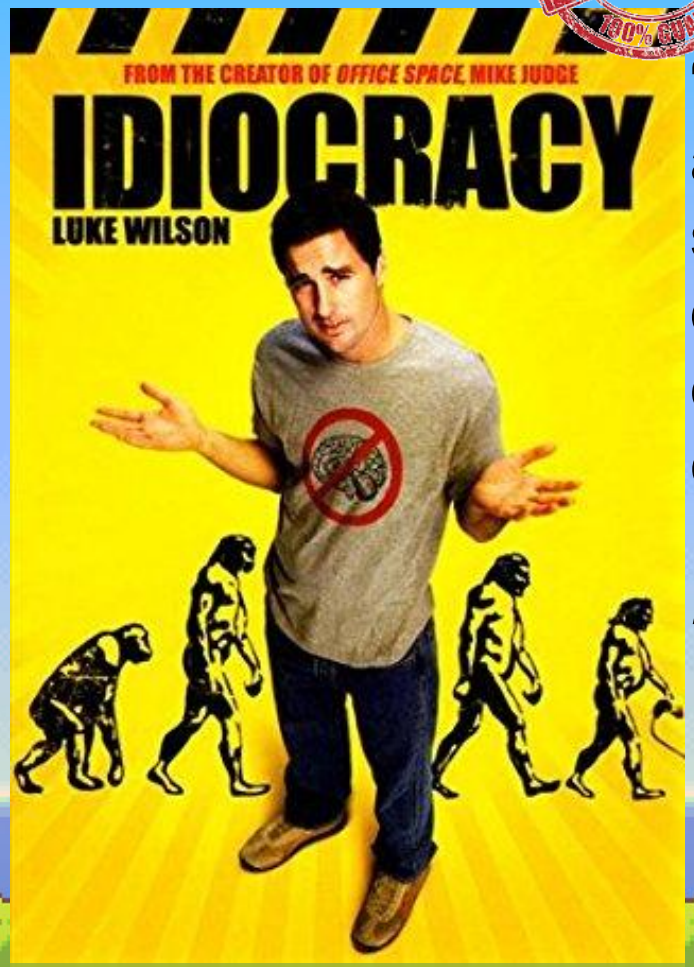

"A very educational movie, addressing the importance of proper selection strategies and genetic diversity towards the successful evolution of species. And a wake up call to our own evolution!"

- Davide Carneiro

$ Quest #3

$$Ch = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix}$$

P1 P2 P3

$$Ch = \begin{bmatrix} 0{,}2 & 0{,}3 & 0{,}5 \\ 1 & 0 & 0 \\ 0{,}1 & 0{,}8 & 0{,}1 \end{bmatrix}$$

$$P = \left| Ch_1 = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix} \right| \left| Ch_2 = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix} \right| \ldots \left| Ch_s = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix} \right|$$

$$V_{m,n} \in A, \quad A = \{x \in \mathbb{R} \mid 0 \leq x \leq 1\}$$

$$\sum_{i=1}^{n} V_{m,n} = 1, \forall\, m \in \{1, 2, \ldots, m\}$$

$$R_n = \sum_{i=1}^{m} V_{m,n}$$

$$V_{m,i} = 1 \Rightarrow V_{m,x} = 0, \forall\, x \in \{1, 2, \ldots, n\}, x \neq i$$

$ Quest #3

$$Ch = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix}$$

P1 P2 P3

$$Ch = \begin{bmatrix} 0{,}2 & 0{,}3 & 0{,}5 \\ 1 & 0 & 0 \\ 0{,}1 & 0{,}8 & 0{,}1 \end{bmatrix}$$

$$P = \left[Ch_1 = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix} \middle| Ch_2 = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix} \middle| \ldots \middle| Ch_s = \begin{bmatrix} V_{1,1} & \cdots & V_{1,n} \\ \vdots & \ddots & \vdots \\ V_{m,1} & \cdots & V_{m,n} \end{bmatrix} \right]$$

$$V_{m,n} \in A, \qquad A = \{x \in \mathbb{R} \mid 0 \leq x \leq 1\}$$

$$\sum_{i=1}^{n} V_{m,n} = 1, \forall\, m \in \{1, 2, \ldots, m\}$$

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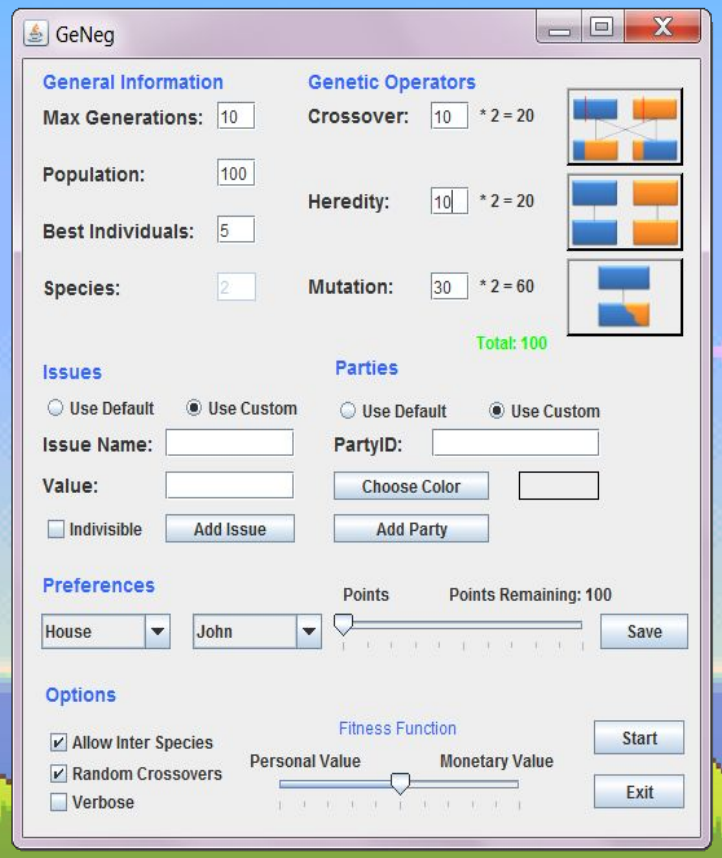
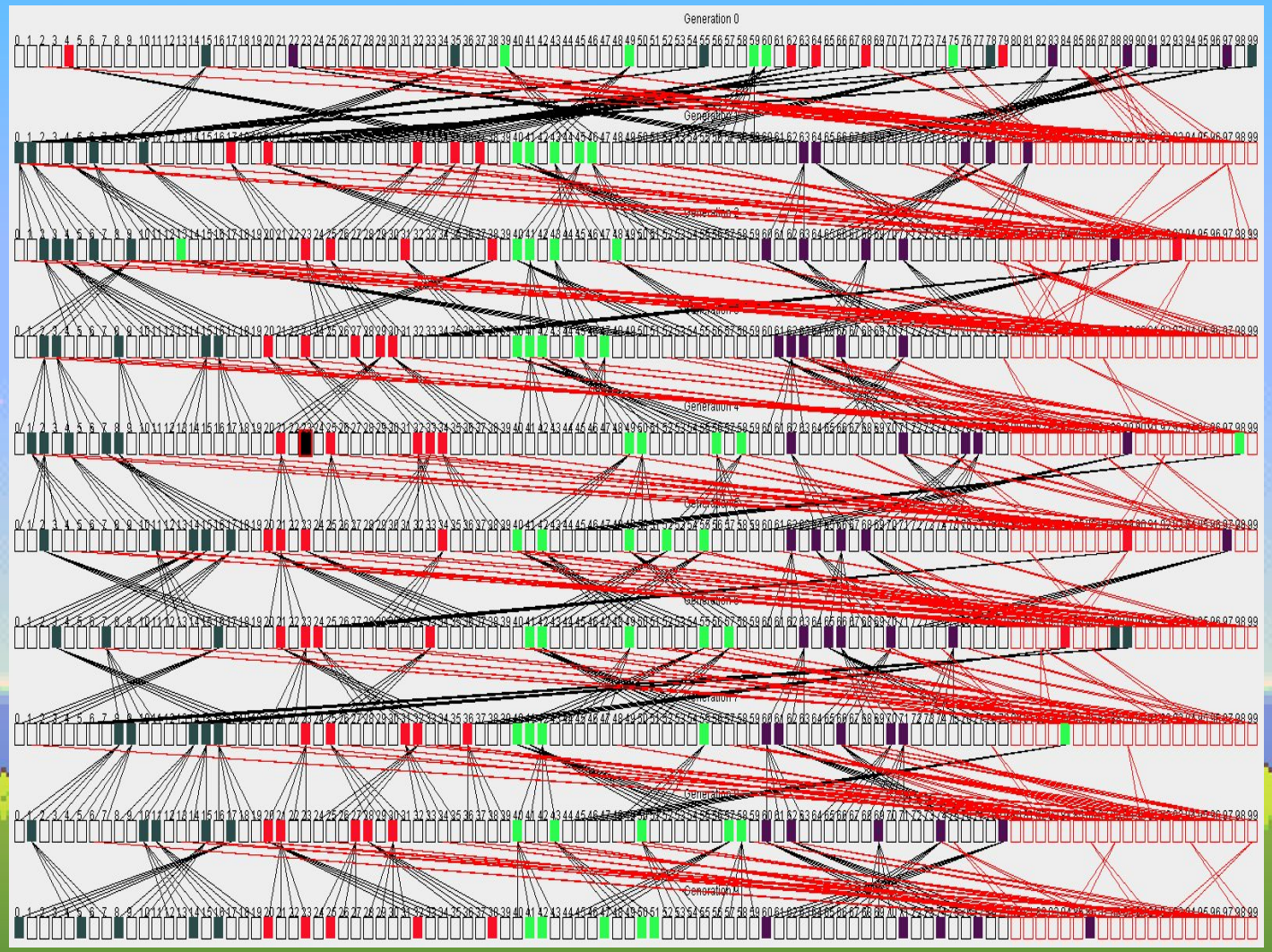
$ Quest #3


GeNeg
General Information
Max Generations: 10
Population: 100
Best Individuals: 5
Species: 2
Genetic Operators
Crossover: 10 * 2 = 20
Heredity: 10 * 2 = 20
Mutation: 30 * 2 = 60
Total: 100
Issues
Use Default
Use Custom
Issue Name:
Value:
Indivisible
Add Issue
Parties
Use Default
Use Custom
PartyID:
Choose Color
Add Party
Preferences
Points
Points Remaining: 100
House
John
Save
Options
Allow Inter Species
Random Crossovers
Verbose
Fitness Function
Personal Value
Monetary Value
Start
Exit

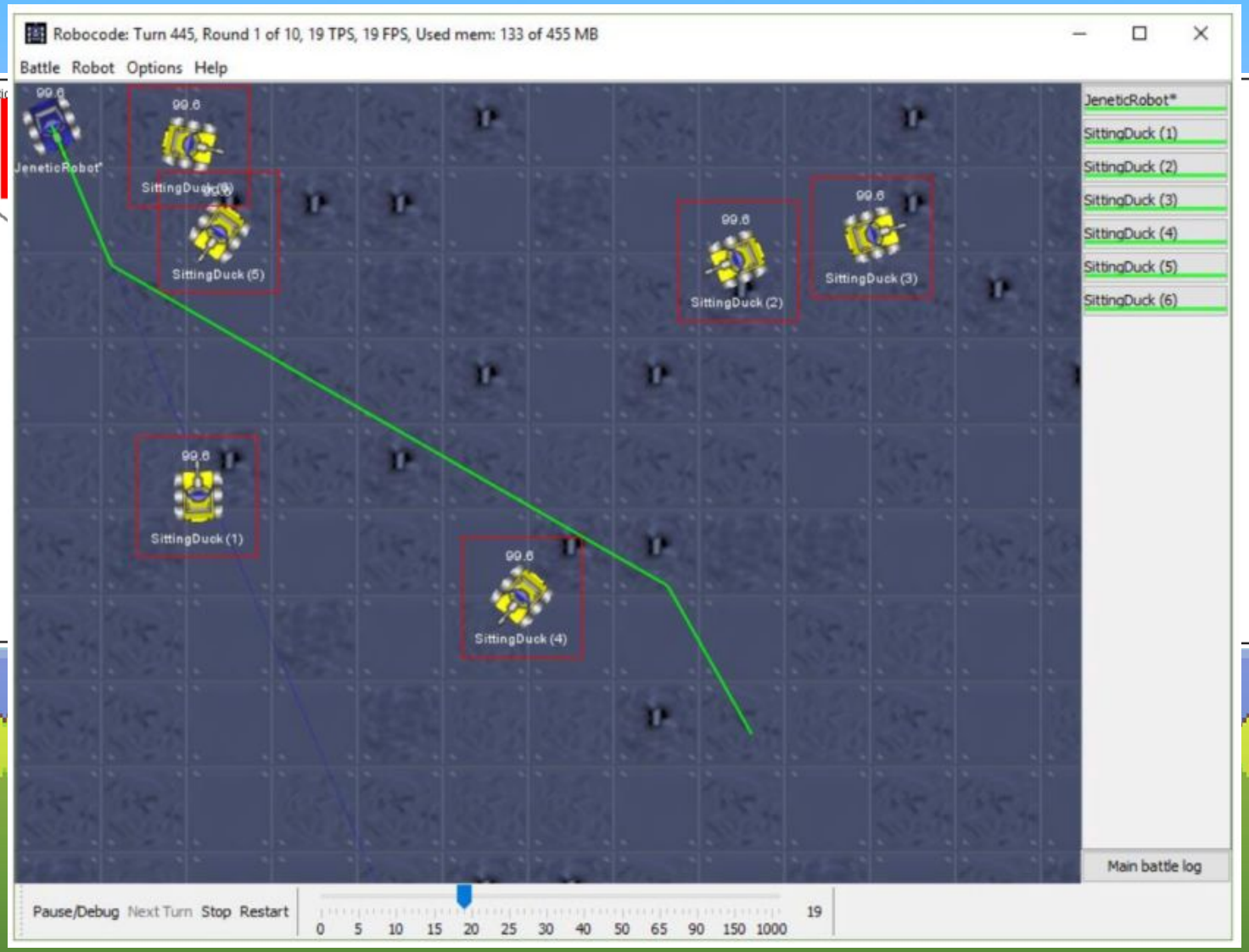

Generation 0

$ Quest #3

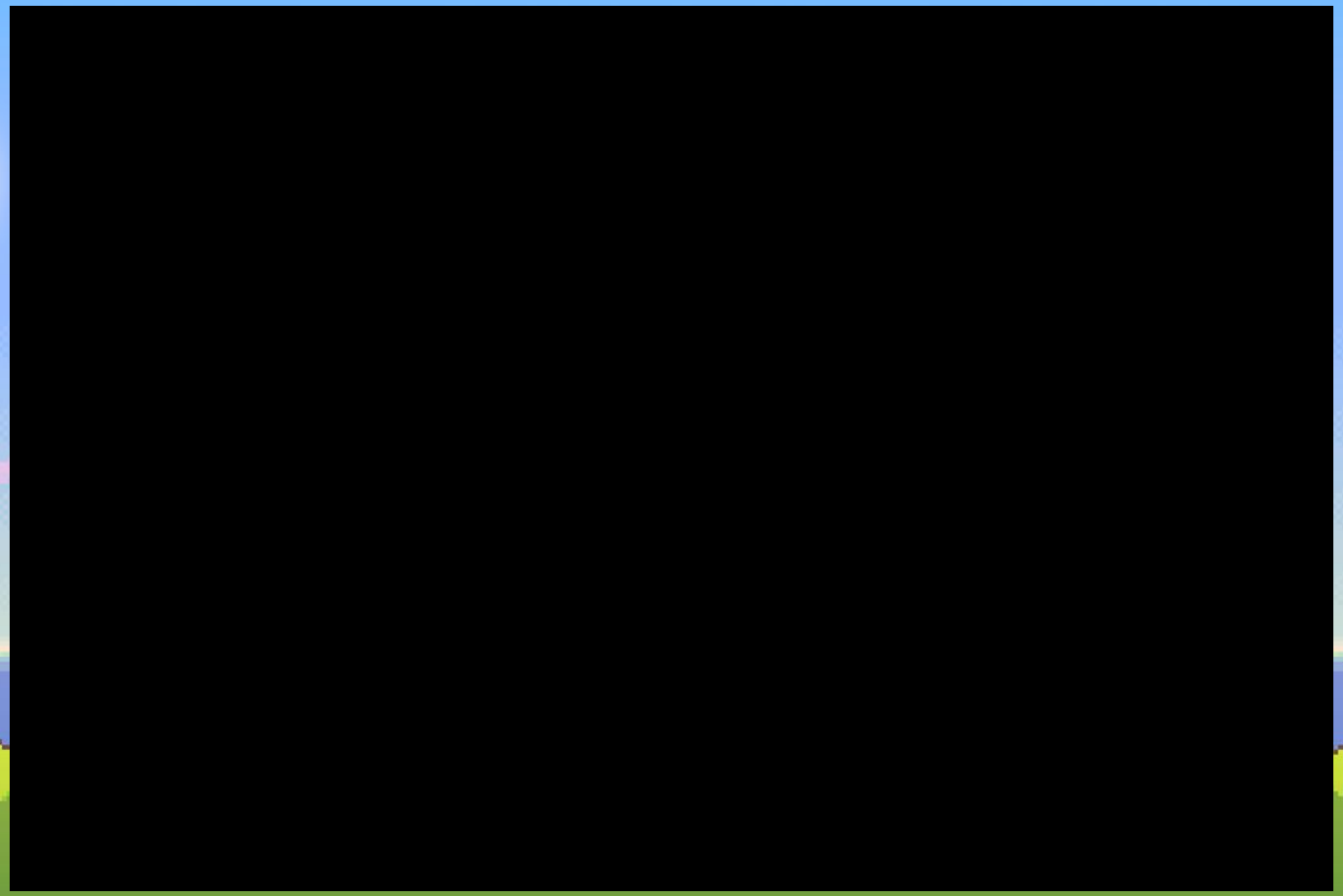
GeNeg
General Information
Max Generations: 10
Population: 100
Best Individuals: 5
Species: 2
Genetic Operators
Crossover: 10 * 2 = 20
Heredity: 10 * 2 = 20
Mutation: 30 * 2 = 60
Total: 100
Issues
Use Default
Use Custom
Issue Name:
Value:
Indivisible
Add Issue
Parties
Use Default
Use Custom
PartyID:
Choose Color
Add Party
Preferences
Points
Points Remaining: 100
House
John
Save
Options
Allow Inter Species
Random Crossovers
Verbose
Fitness Function
Personal Value
Monetary Value
Start
Exit


THE WIZARD
You are the master of the process, and have it under your control
750 XP

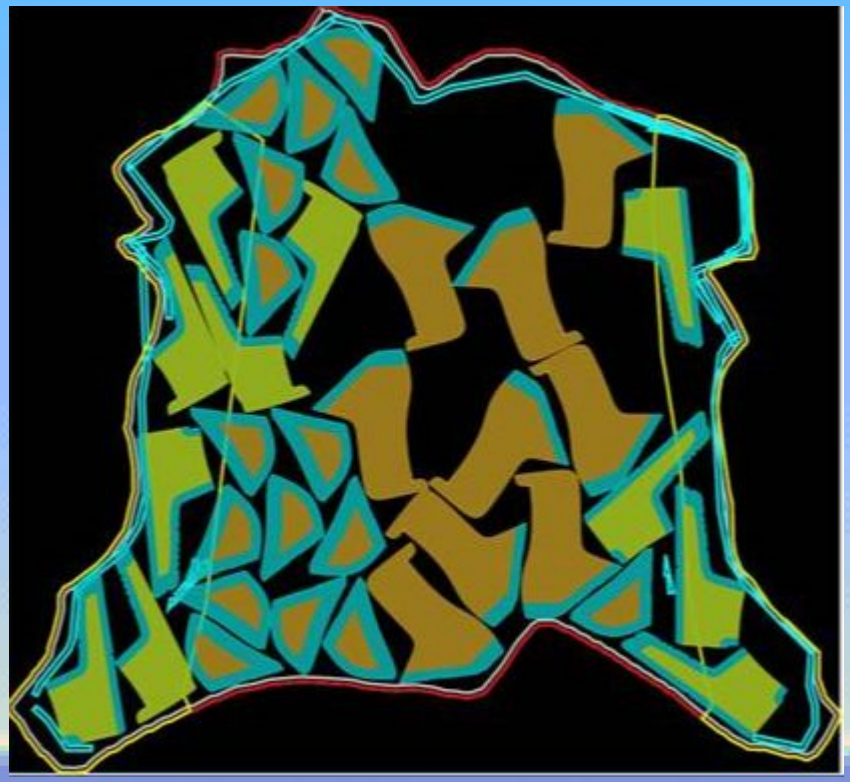
$ Quest #4


Generation 7 Best Soluti
START
Robocode: Turn 445, Round 1 of 10, 19 TPS, 19 FPS, Used mem: 133 of 455 MB
Battle Robot Options Help
JeneticRobot*
SittingDuck (1)
SittingDuck (2)
SittingDuck (3)
SittingDuck (4)
SittingDuck (5)
SittingDuck (6)
Main battle log
Pause/Debug Next Turn Stop Restart
0 5 10 15 20 25 30 40 50 65 90 150 1000
19

$ Quest #5



$ Quest #6



$ Quest #7





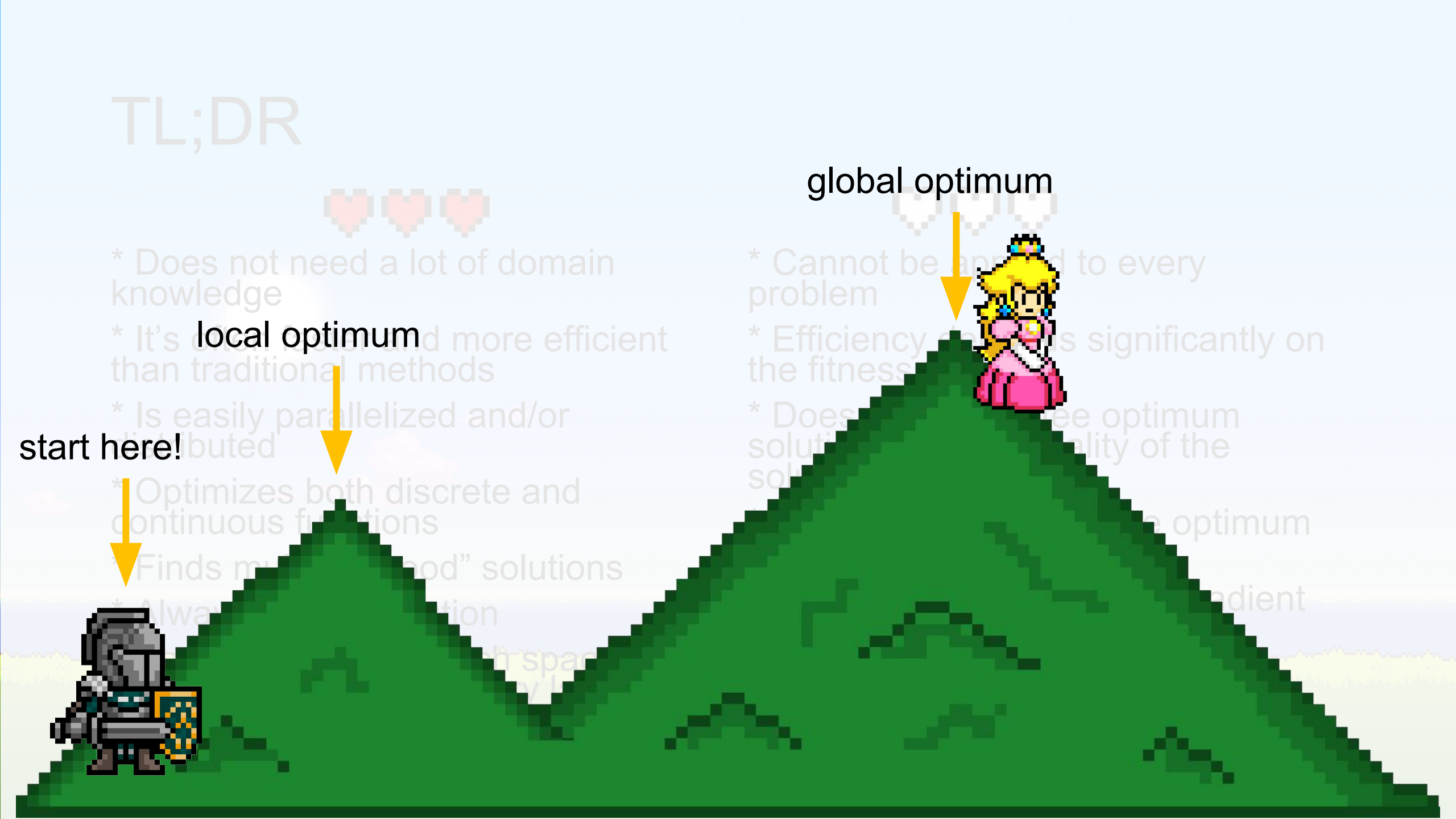




TL;DR

* Does not need a lot of domain knowledge
* It’s often faster and more efficient than traditional methods
* Is easily parallelized and/or distributed
* Optimizes both discrete and continuous functions
* Finds multiple “good” solutions
* Always finds a solution
* Useful when the search space is multi-dimensional and very large

* Cannot be applied to every problem
* Efficiency depends significantly on the fitness function
* Does not guarantee optimum solutions nor the quality of the solution found
* May not converge to the optimum solution
* Has the disadvantage of gradient search methods


global optimum
local optimum
start here!

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Game Over!

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