Can Complex Collective Behaviour Be Generated Through Randomness, Memory and a Pinch of Luck?

Introduction to Research

MEFT - 2017

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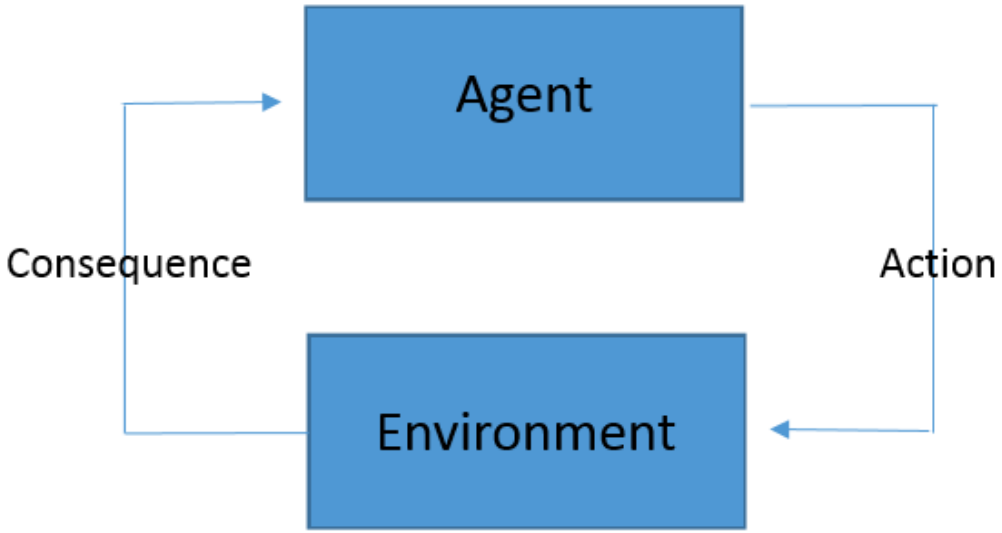
Structure of Presentation

- Motivation
- Setup
- Model
- Results
- Conclusions

Motivation



Reinforcement Learning

NATURE | ARTICLE

日本語要約

Mastering the game of Go with deep neural networks and tree search

David Silver, Aja Huang, Chris J. Maddison, Arthur Guez, Laurent Sifre, George van den Driessche, Julian Schrittwieser, Ioannis Antonoglou, Veda Panneershelvam, Marc Lanctot, Sander Dieleman, Dominik Grewe, John Nham, Nal Kalchbrenner, Ilya Sutskever, Timothy Lillicrap, Madeleine Leach, Koray Kavukcuoglu, Thore Graepel & Demis Hassabis

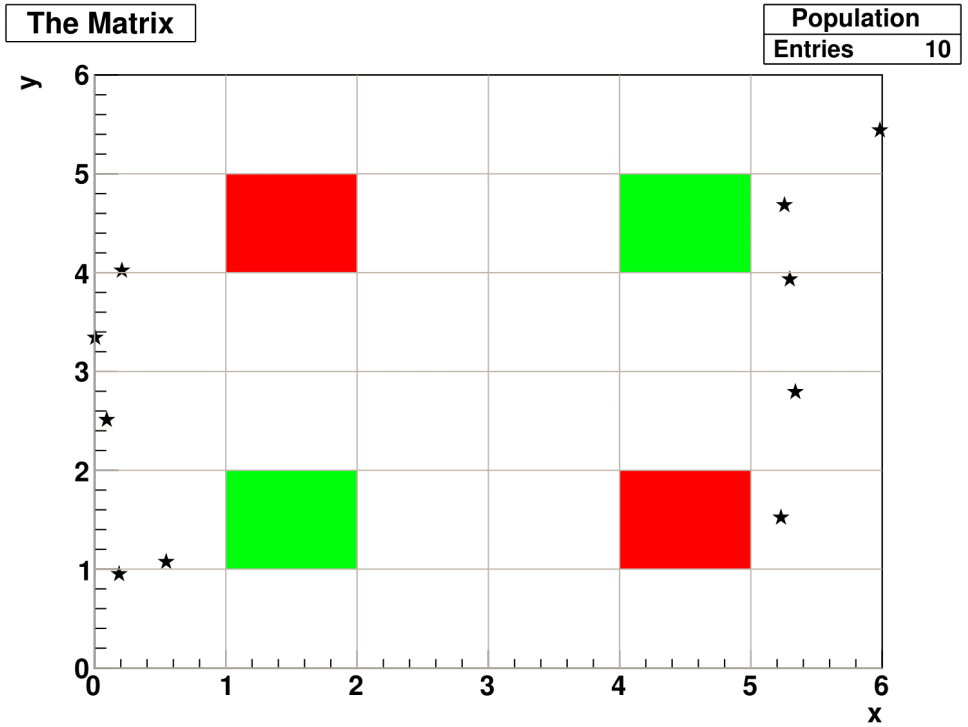
Playing Atari with Deep Reinforcement Learning

Volodymyr Mnih Koray Kavukcuoglu David Silver Alex Graves Ioannis Antonoglou
Daan Wierstra Martin Riedmiller
DeepMind Technologies

"Evolution forged the entirety of sentient life on this planet using only one tool: the mistake." - Dr. Robert Ford, HBO's Westworld

SETUP

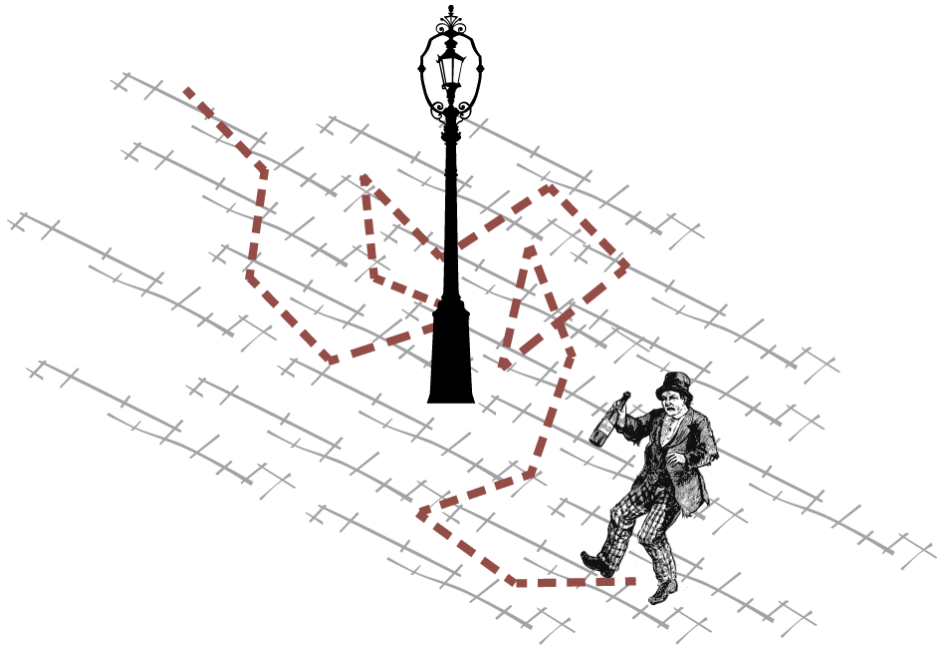
Name	Label	Meaning
Maximum Age	*maxage*	Number of days a cell can live before dying of "old age"
Maximum Days Without Food	*maxswof*	Number of days a cell can live without reaching a food site.
Minimun Age for Reproduction	*minagerep*	Minimum age for a cell to start reproducing.
Daily Food Limit	*dailyflimit*	Maximum number of cells who can feed on a food site daily.



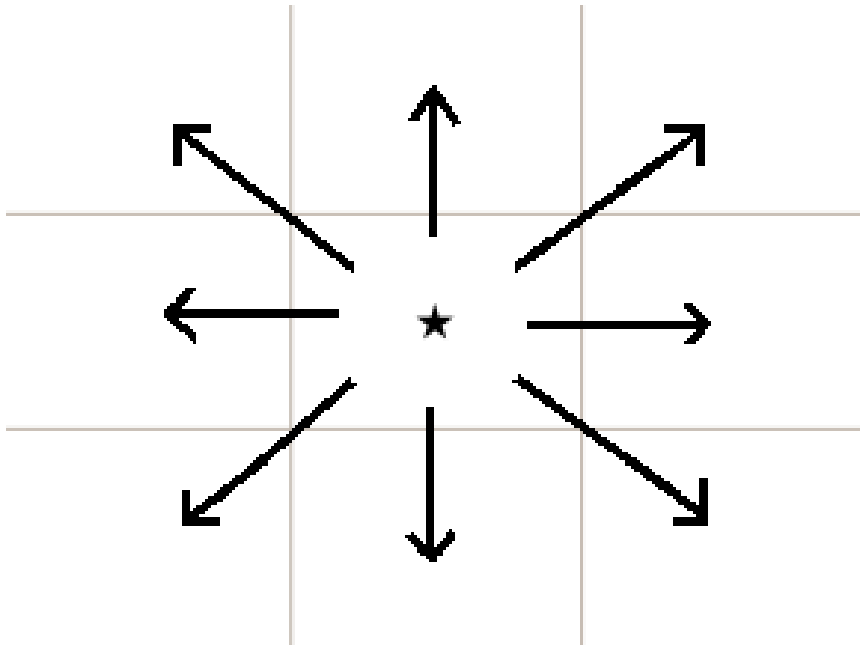
- L=6
- N=10
- Symmetric population distribution
- symmetric death and food sites distribution

Model

At t=0 :



Random Walker



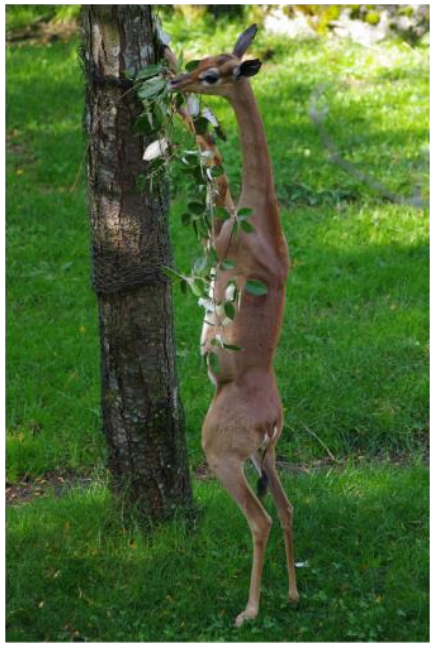
Possible Moves

Source: Theoretical Systems Biology, Imperial College London

Model

If one cell has many options for reproduction
it will choose at random one of the highest generation possible.

If many cells are in the same food site, the ones from higher generations and with lower age have pri-
ority to eat.



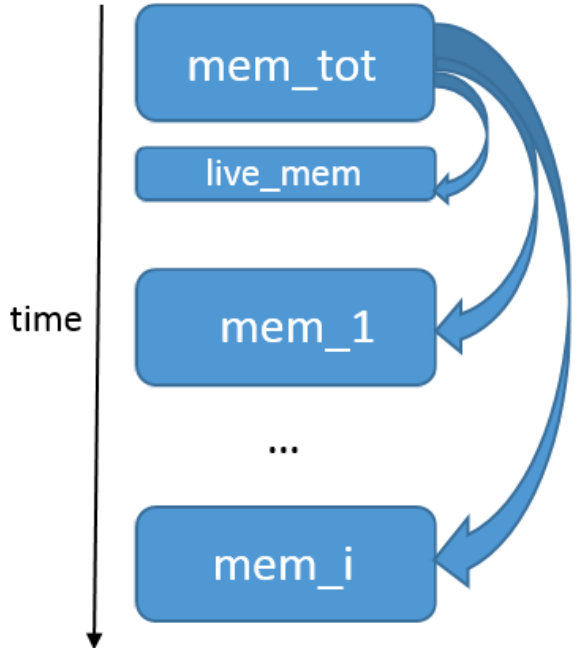
Cells Reproduce

$$gen_C = \max(gen_A, gen_B) + 1$$

Replication of what happens in nature.

Source: National Geographic Magazine

Model



Time Evolution of Memory Creation

Weights

Death Event in P
- 6 x P

Feeding Event in P
- 0 x P
- 1 x P-1
- 2 x NOT(P AND P-1)

mem_4.txt

```
4,0
4,0
4,1
4,1
4,2
4,2
4,3
4,5
```

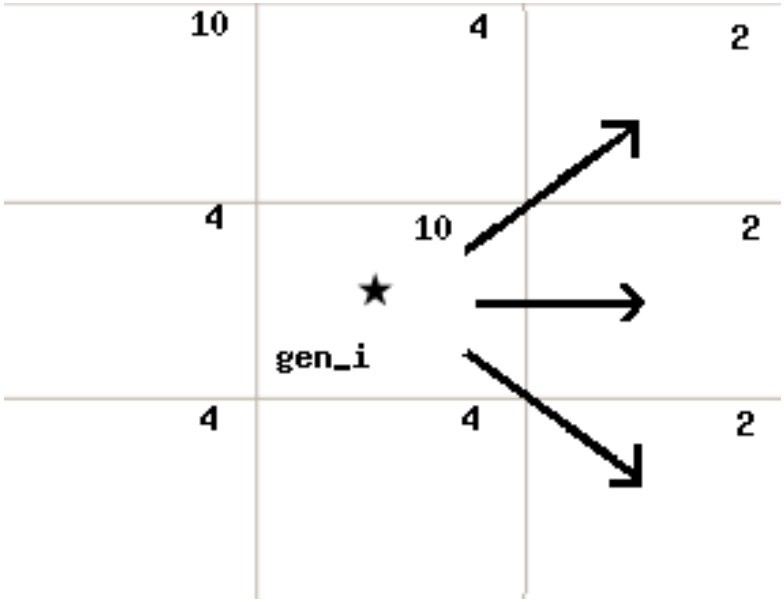
Part of the memory from a generation 4

live_mem
Effect of Communication is not negligible for generation 0

Model

$$P_{moving}(s) = \begin{cases} P_i & , \ w_{tot} = 0 \\ P_i \cdot e^{(P_i - \frac{w(s)}{w_{tot}})} & , \ w_{tot} > 0 \end{cases}$$

- Depends on the ratio of the weight of s with the total sum of weights in the available sites!
- Can be bigger than Pi !



Available moves with Memory

Model

Can Somebody die of hunger in a food Site?

No... Unless the food site becomes saturated!
(because of dailyflimit)

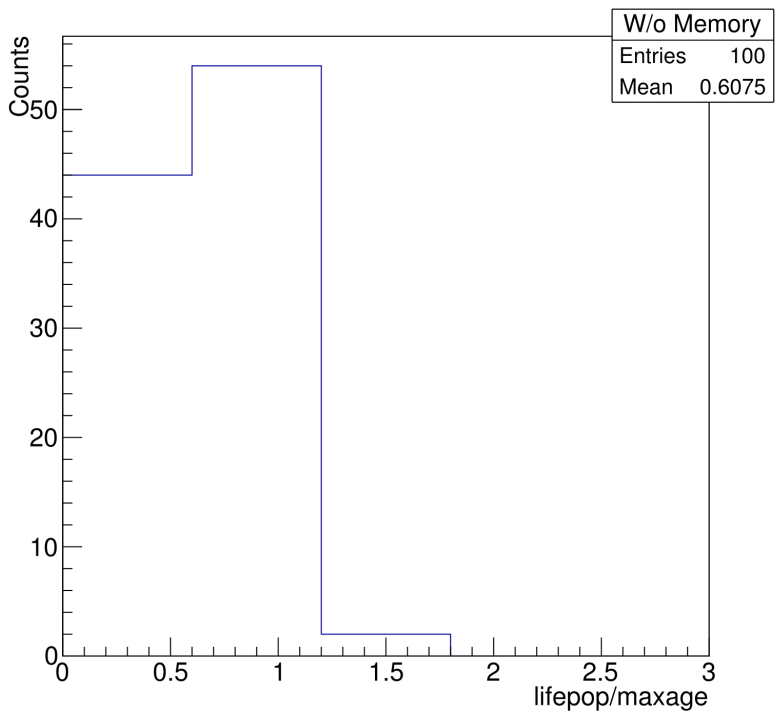
After this happens, different information is stored for a certain food site P' :

Death Event in P'
- 6 x P'

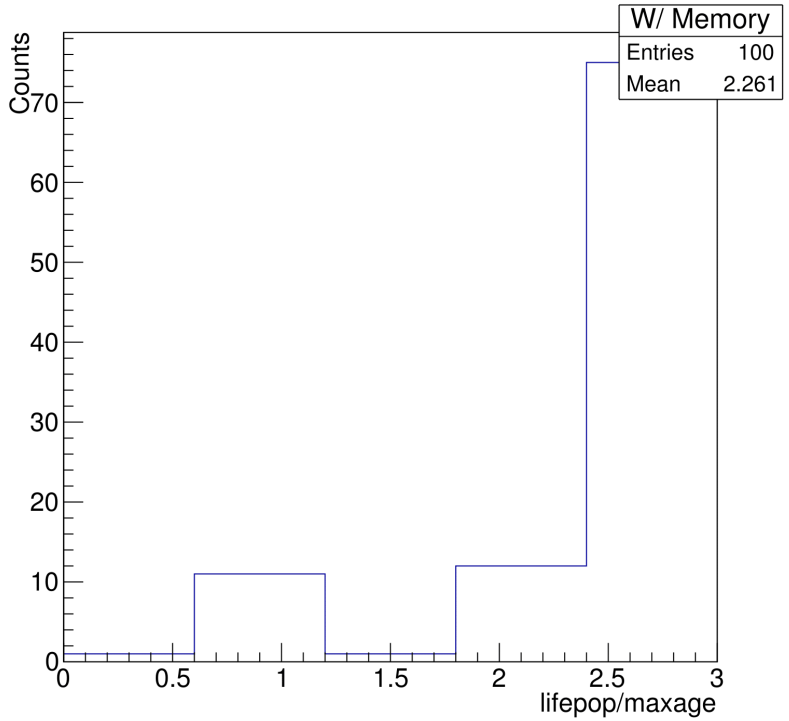
Feeding Event in P'
- 0 x P'
- 2 x P'-1
- 1 x NOT(P' AND P'-1)

- This 'Inversion' occurs when weight of P' equals the weight of the nearby sites - Population reaches Neq (Equilibrium Population Number).
- Reverts to the old weights if Population Number gets below the Neq.

Results

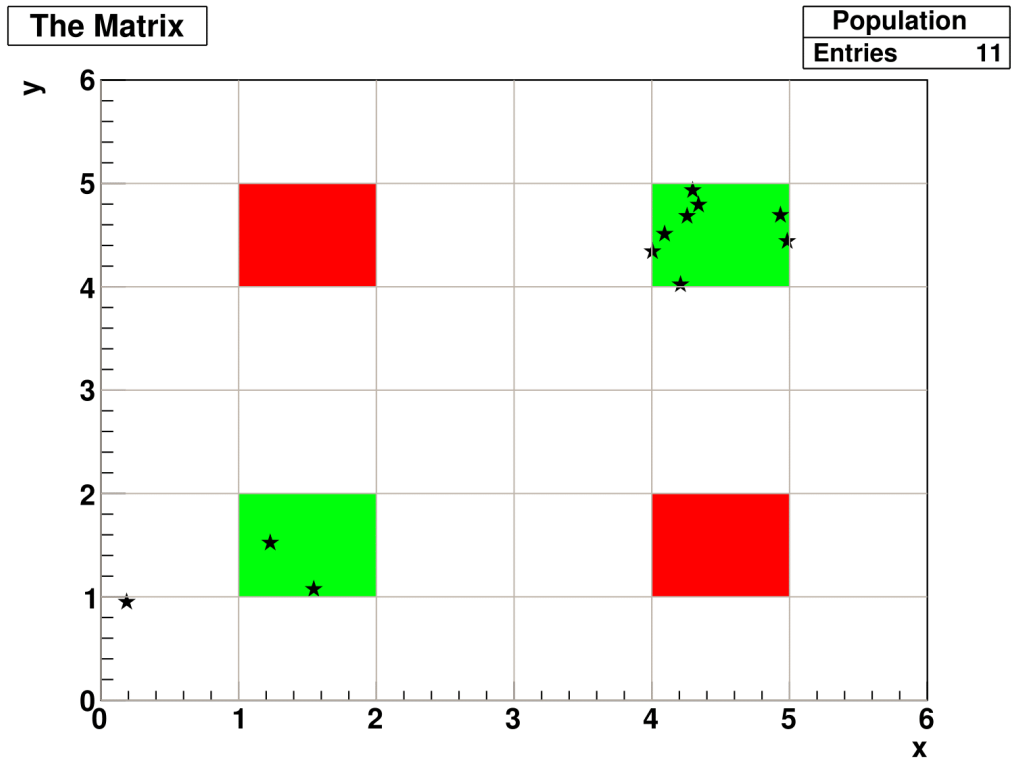


Pure Random Walker

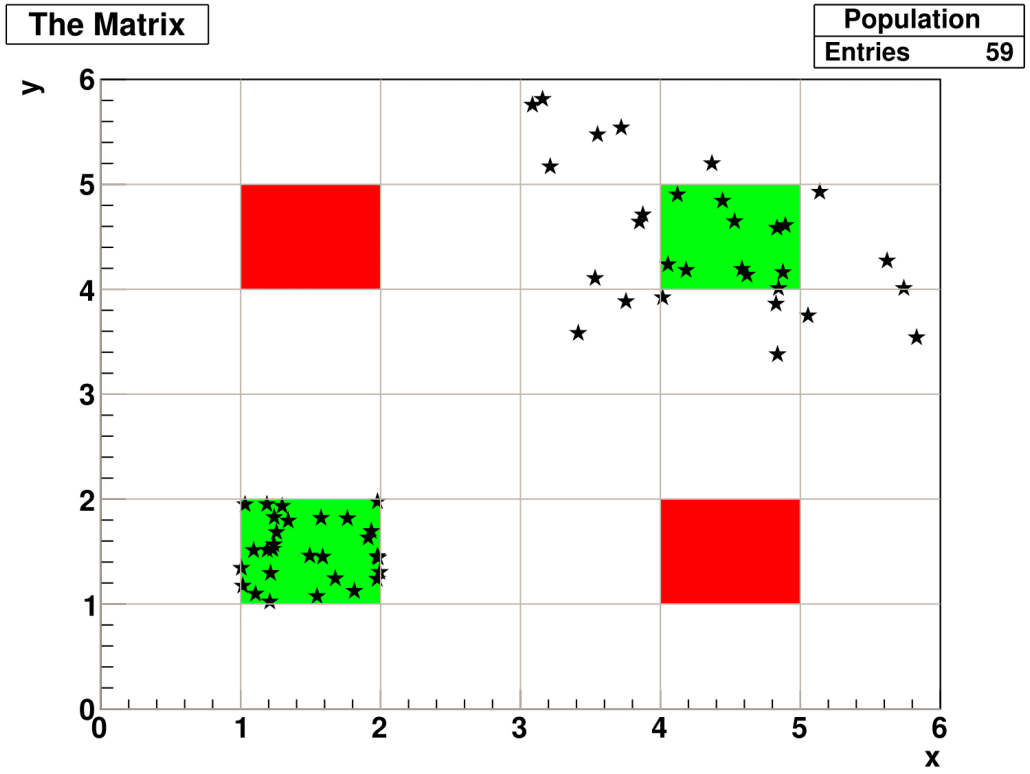


Model With Memory

Results – 'Lucky' evolution

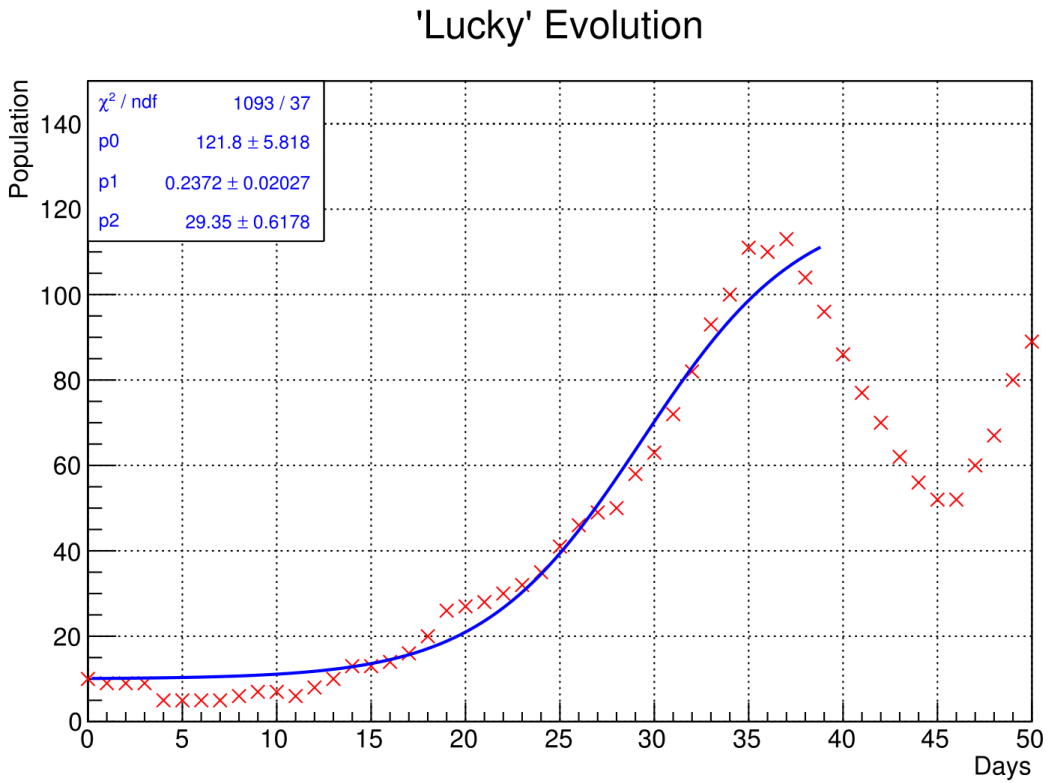


Day 5



Day 99

Results – 'Lucky' fit to logistic function



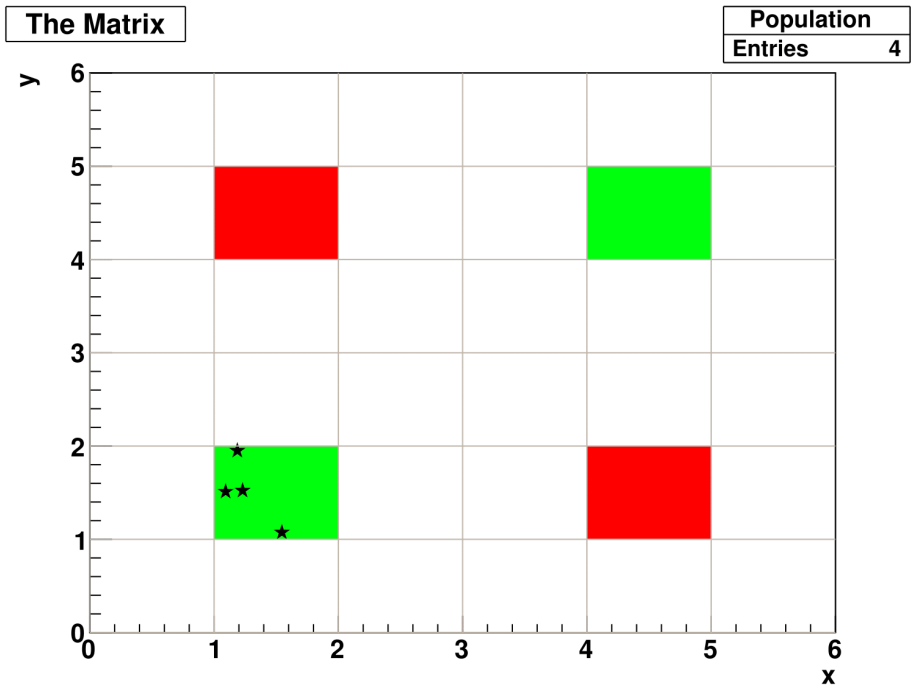
$$N(d) = N_i + \frac{N_{eq} - N_i}{1 + e^{-k(d-d_0)}}$$

p0=Neq

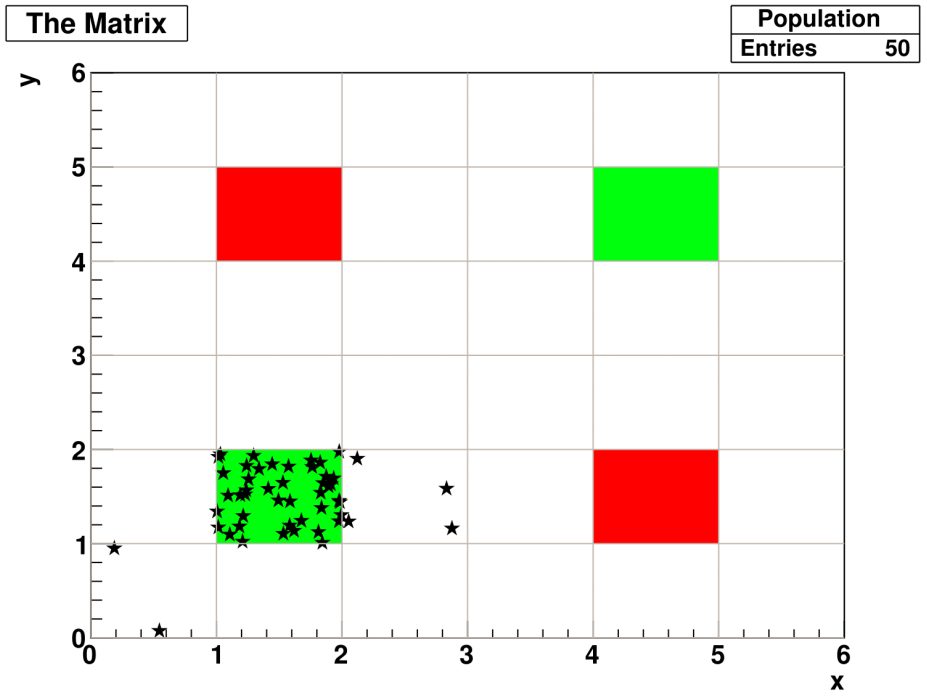
p1=k

p2=d

Results – 'Adventurous' evolution I

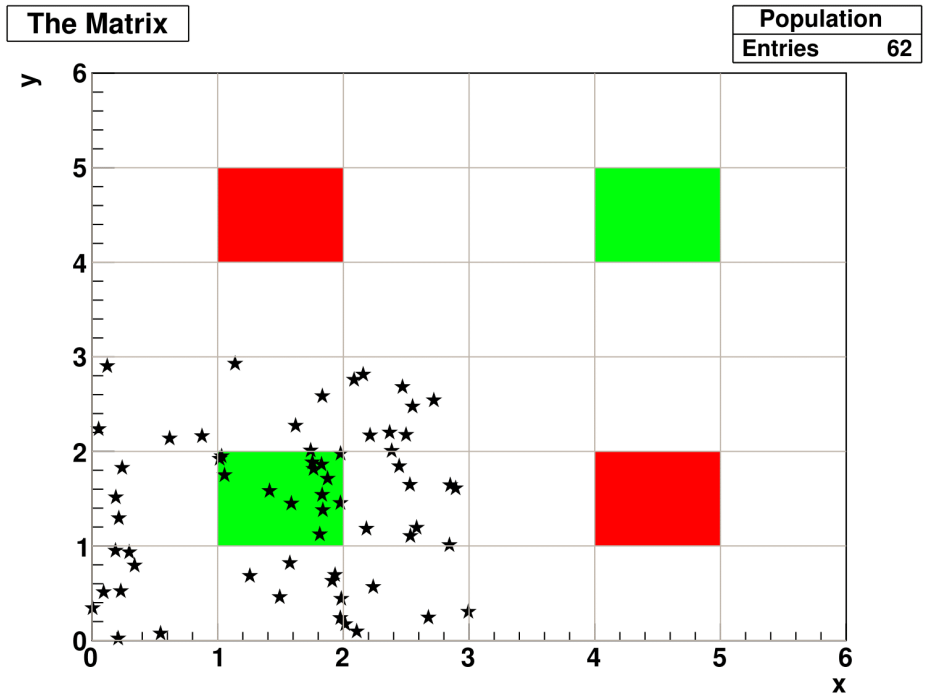


Day 4

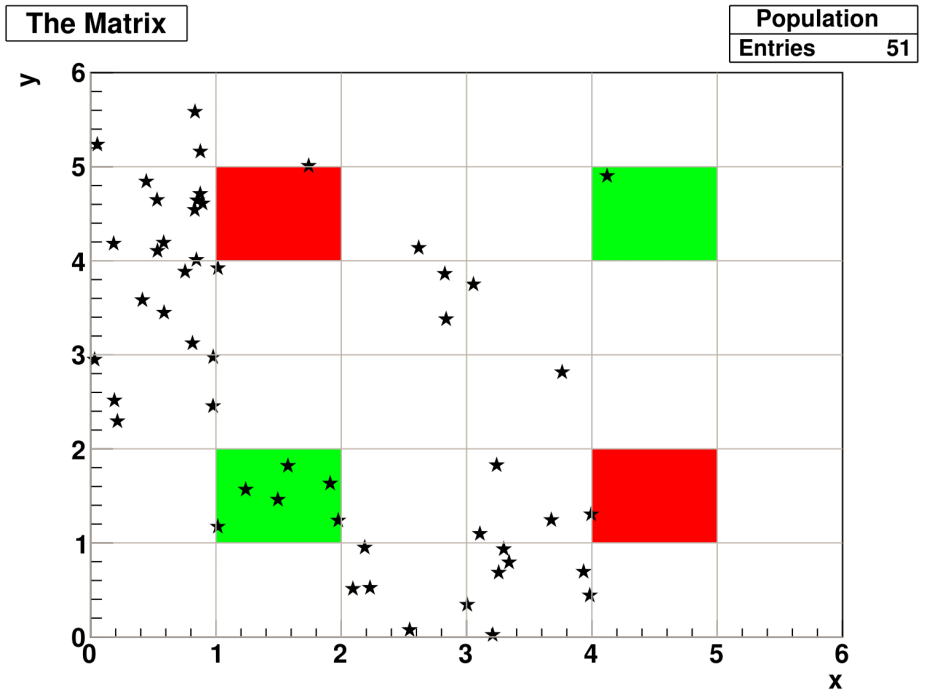


Day 18

RESULTS – 'ADVENTUROUS' EVOLUTION II

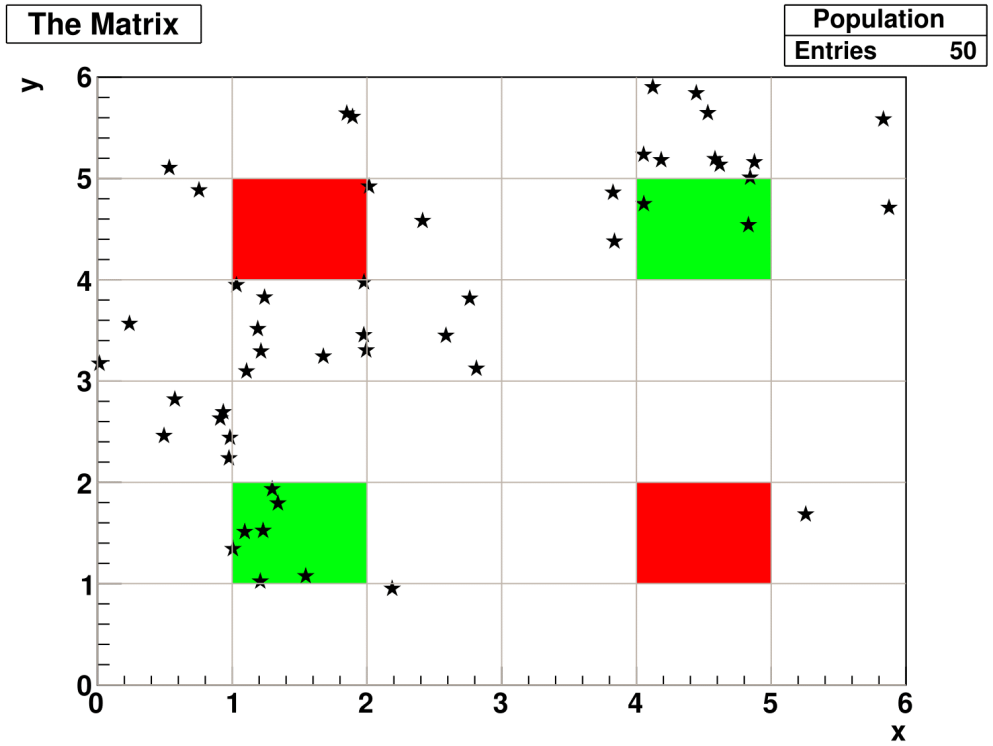


Day 23

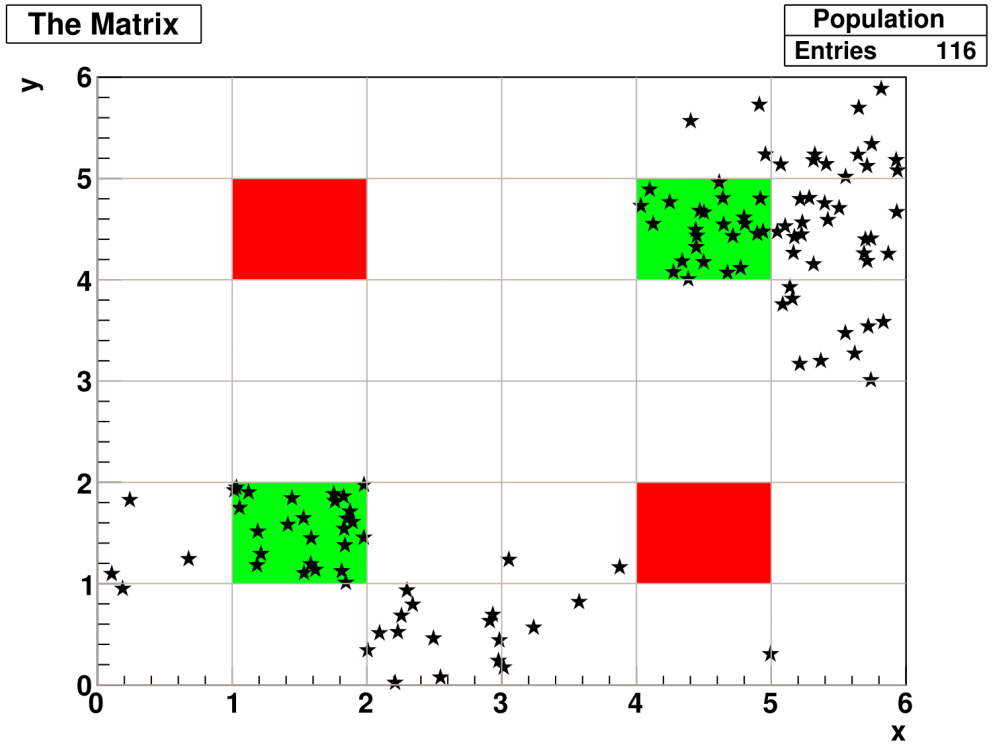


Day 45

RESULTS – 'ADVENTUROUS' EVOLUTION III

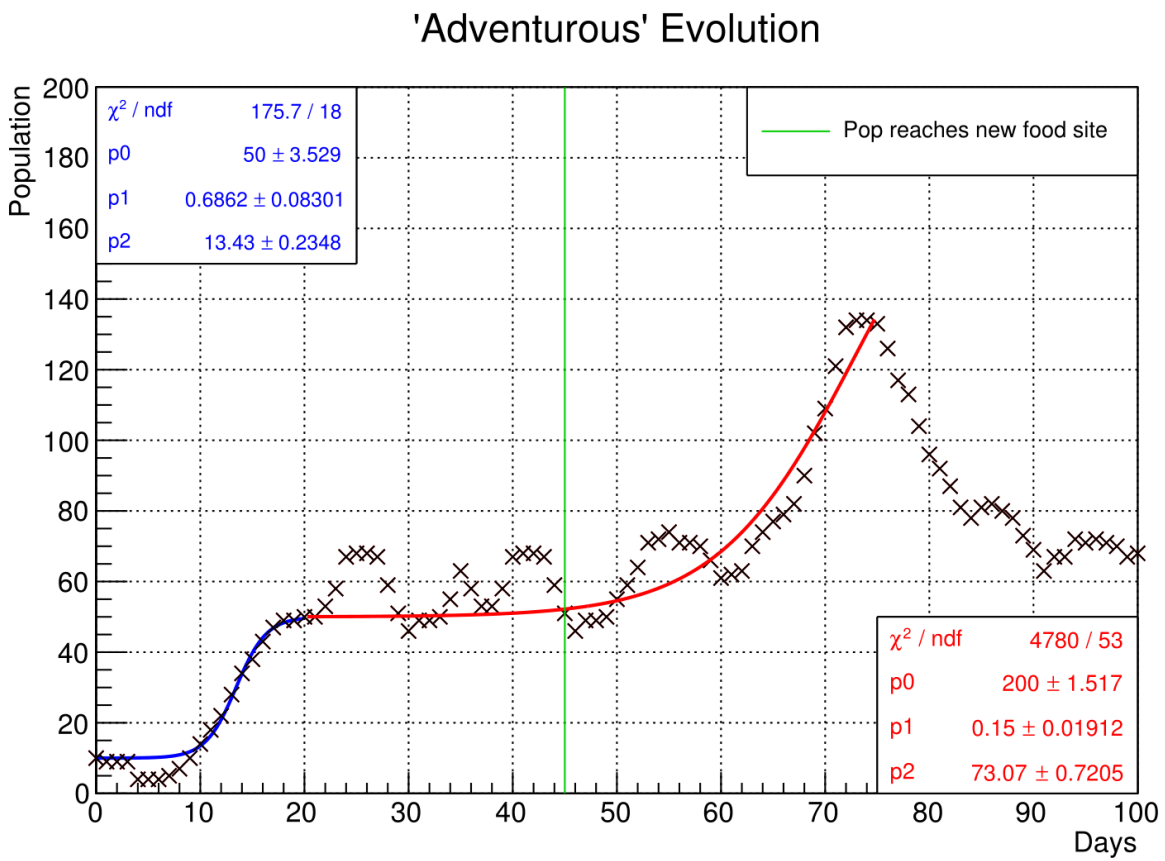


Day 51



Day 70

Results – 'Adventurous' fit to logistic function



$$N(d) = N_i + \frac{N_{eq} - N_i}{1 + e^{-k(d-d_0)}}$$

p0=Neq
p1=k
p2=d0
Ni=10 for Blue
Ni=50 for Red

Conclusions

- The model fulfilled its purpose of generating interesting collective behaviour having only three available tools: initial randomness, memory of deaths and good zones and a tuning of the initial conditions.

Conclusions

The breakthroughs that distinguished the memoryless case from the 'intelligent' one were:

- The correct definition of the probability distribution;
- Gifting generation 0 with a live memory that emulates their only way of sharing information – communication.
- Redefinition of the weights given in an eating event when food source saturates.

Conclusions

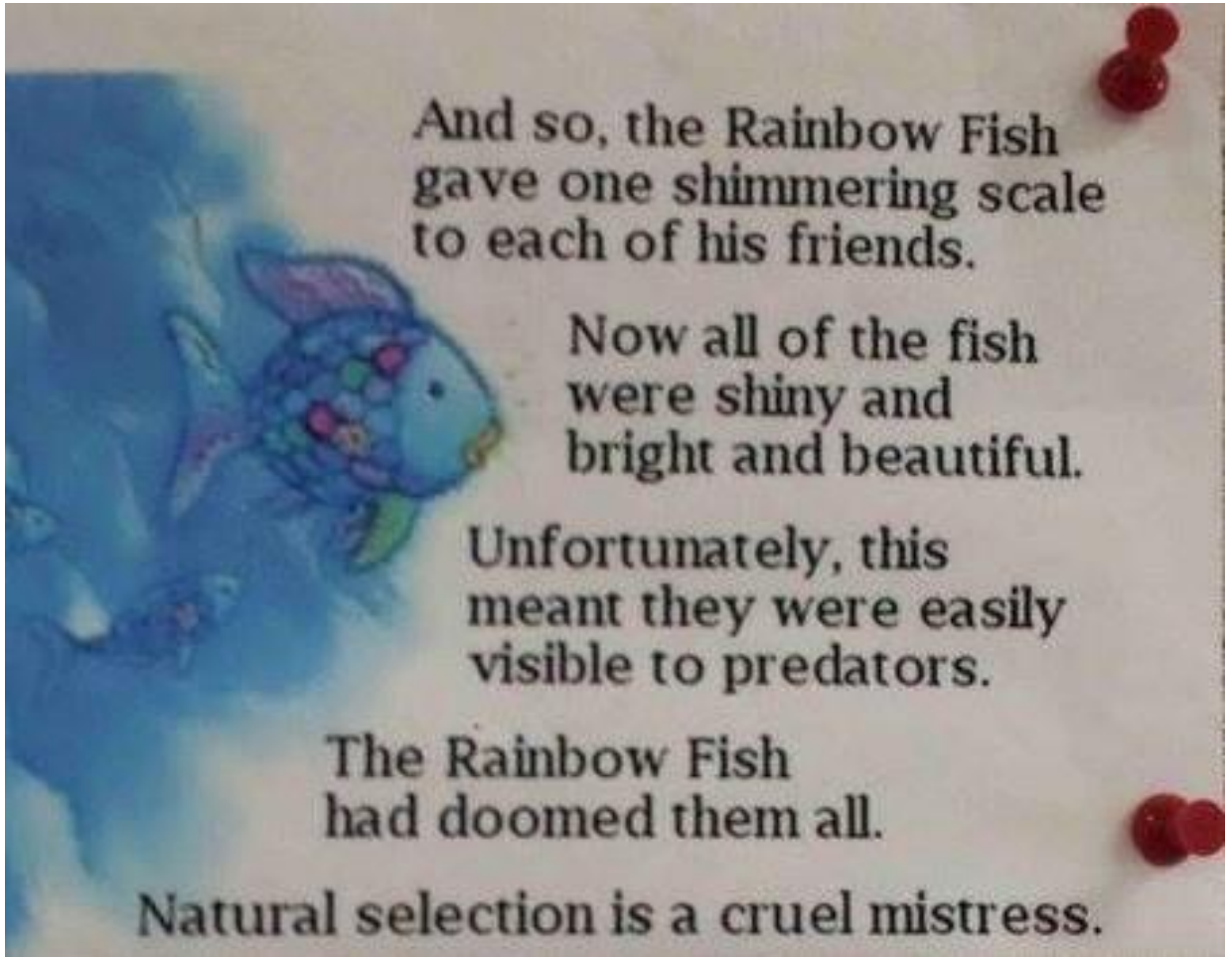
- Obvious improvement: Introducing mutations - randomly generated information added to the memory of some generations that can contribute in a good or bad way to the development.
- Interesting test: Introducing a concurrent population with a different mem_tot and observe if both populations tend to merge and add their memories.

Conclusions

- This model can be compared to the behaviour of unicellular organisms but also of humans around major cities, correctly predicting their migration when deaths start to increase abruptly (war zones and/or zones with a food shortage).

Source: Quartz (qz.com)

The end


And so, the Rainbow Fish
gave one shimmering scale
to each of his friends.
Now all of the fish
were shiny and
bright and beautiful.
Unfortunately, this
meant they were easily
visible to predators.
The Rainbow Fish
had doomed them all.
Natural selection is a cruel mistress.