# Ant Colony Systems and the Calibration of Multi-Agent Simulations: a New Approach

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Multi-Agents for modelling Complex Systems (MA4CS'07)




# Plan

# Introduction

- Discrete and spatial modelling
- Bottom-up approach
  - Entities-oriented modelling
  - Interaction-oriented modelling
- Agent behaviour is the composition of :
  - Perception of the environment
  - Decision based on :
    - internal state
    - state of the environment
  - Action upon the environment
- Artificial world made up of agents in interaction in a simulated environment.
  The dynamics of the system is the result of local actions of the agents and interactions between them.

# Problem

But

# Problem

But

- Huge parameter space in the design of a model
- Imperfect knowledge of some parameters
- Sensitivity of some models to the parameters

# Objectives and Proposition

## Objectives

- Find a parameter set that is compatible with the corresponding observations on the real system
- Determine the different classes of system's dynamics
- Compare different models

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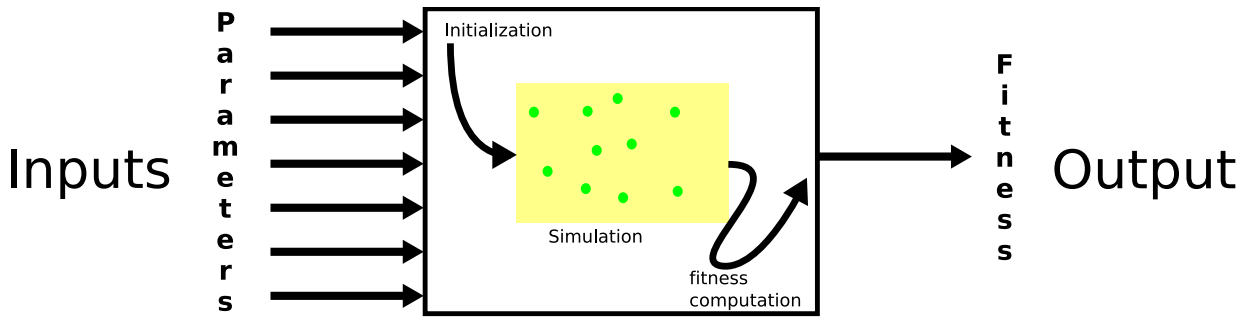
## Our approach

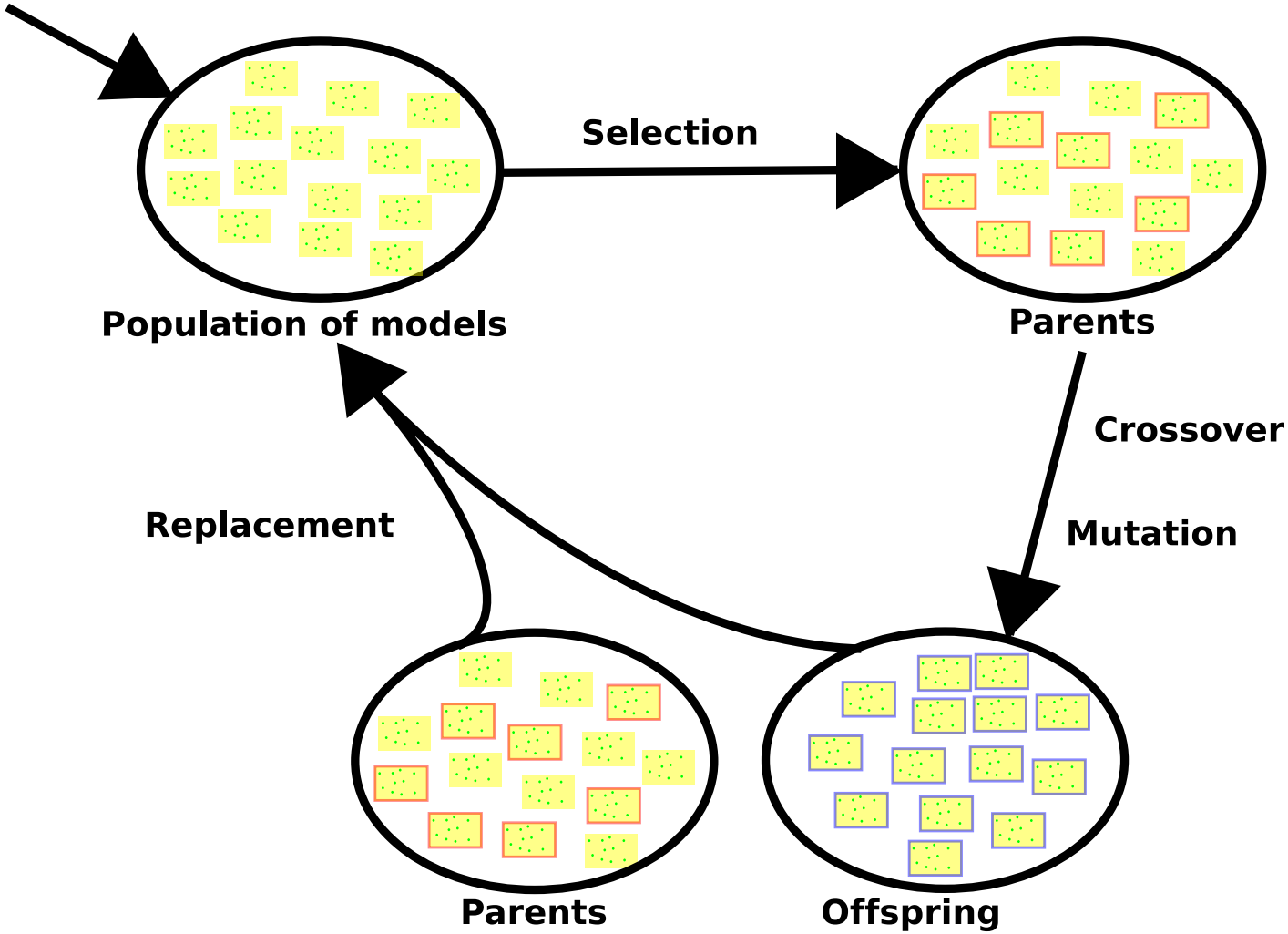
- Automatic exploration of the parameter space
- Optimization problem

# Naïve approach

- Black box
- Optimization algorithms like genetic algorithms



# Naïve approach



# Naïve approach

But

- Introduction of many parameters :
  - choice of the optimization algorithm : for instance, genetic algorithms, simulated annealing...
  - choice of the parameters of the optimization algorithm : for instance, mutation rate, number of chromosomes...
  - ...
- Black box approach
  $\Longrightarrow$ doesn't take into account the particularities of the model
  $\Longrightarrow$ only one parameter setting evaluated at each simulation

# Plan

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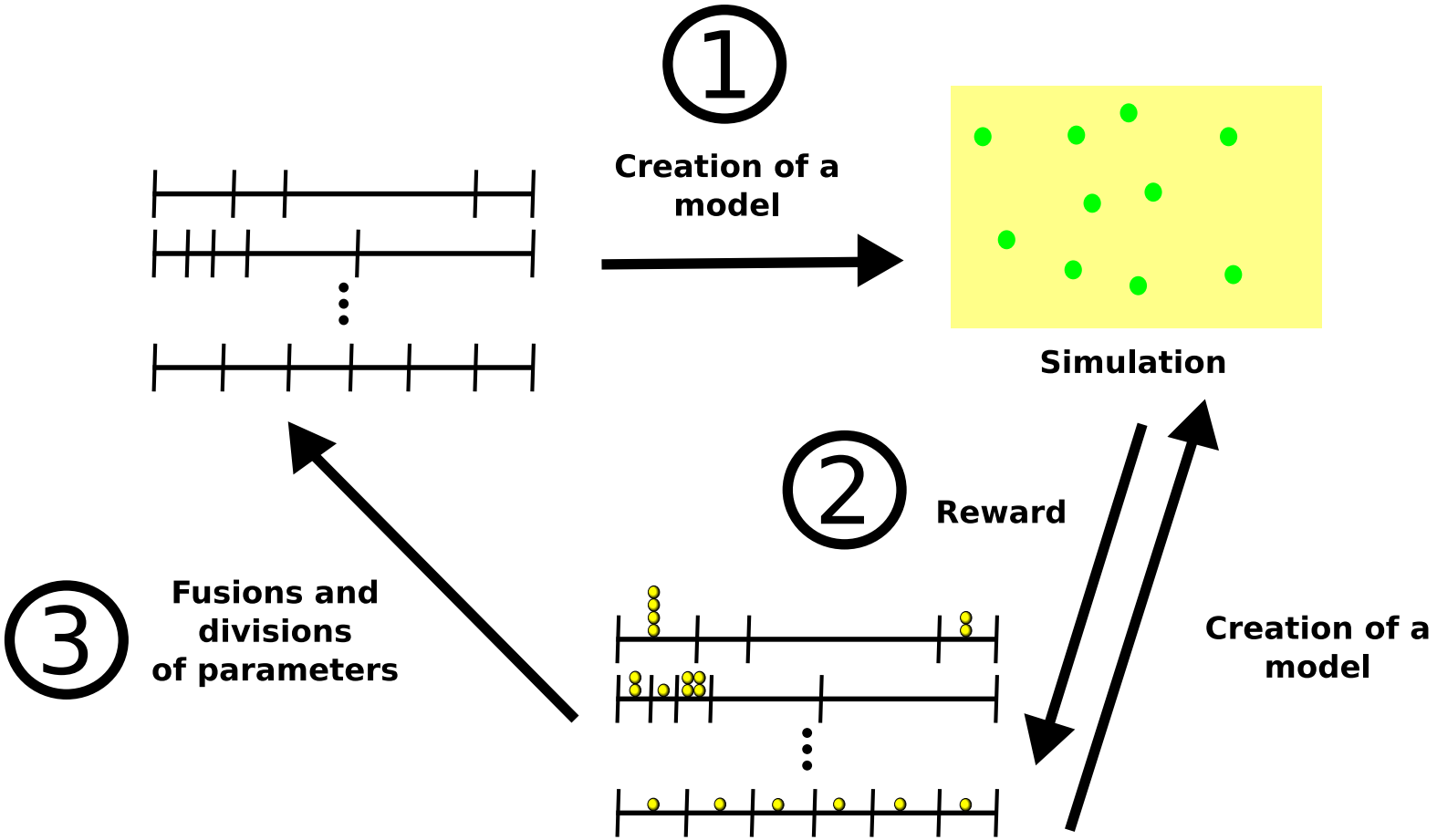
# Principle

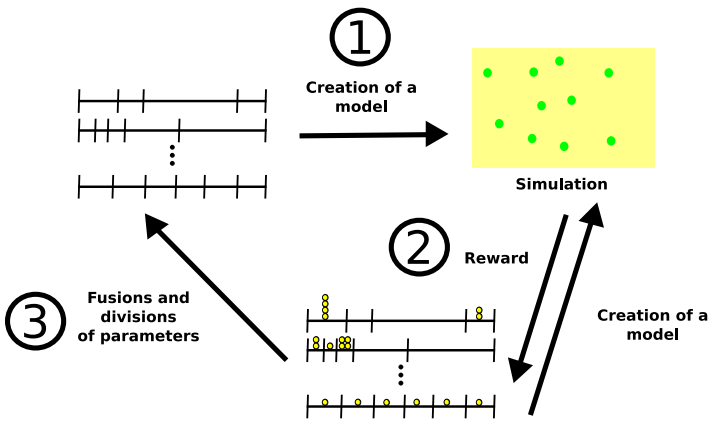
- To have a systematic approach
- Agent-based simulations are generally composed of several agents with the same behaviour
  - Use this particularity to explore the parameter space cleverly
  - Different settings for the different agents
- All regions of the parameter space aren't interesting
  - Division of parameters into intervals
  - Adaptive exploration

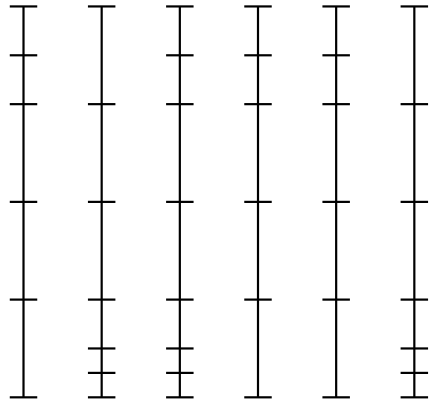
# Principle


1
Creation of a model
Simulation
2
Reward
3
Fusions and divisions of parameters
Creation of a model

# ① Creation of a model

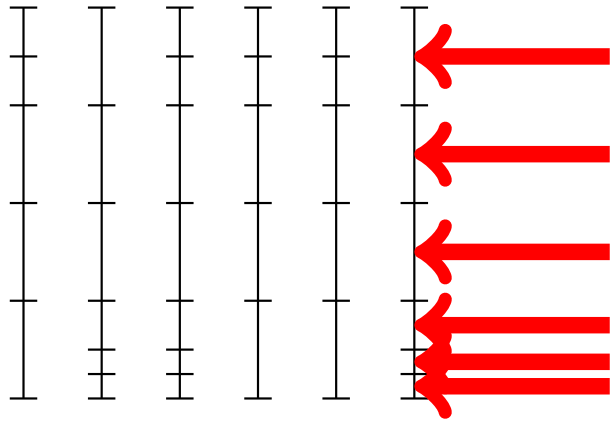
## Agent initialization



**For each parameter**

- Choice of an interval
- Choice of a value in this interval



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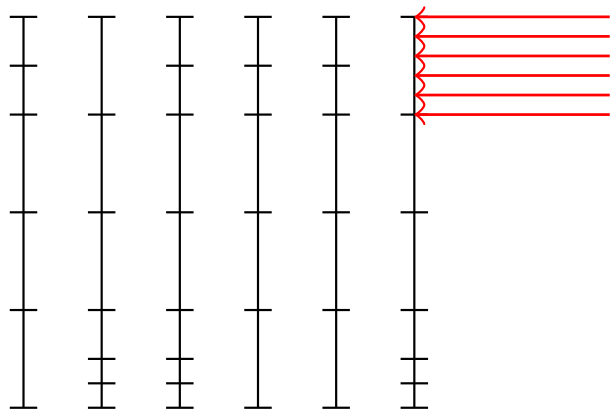
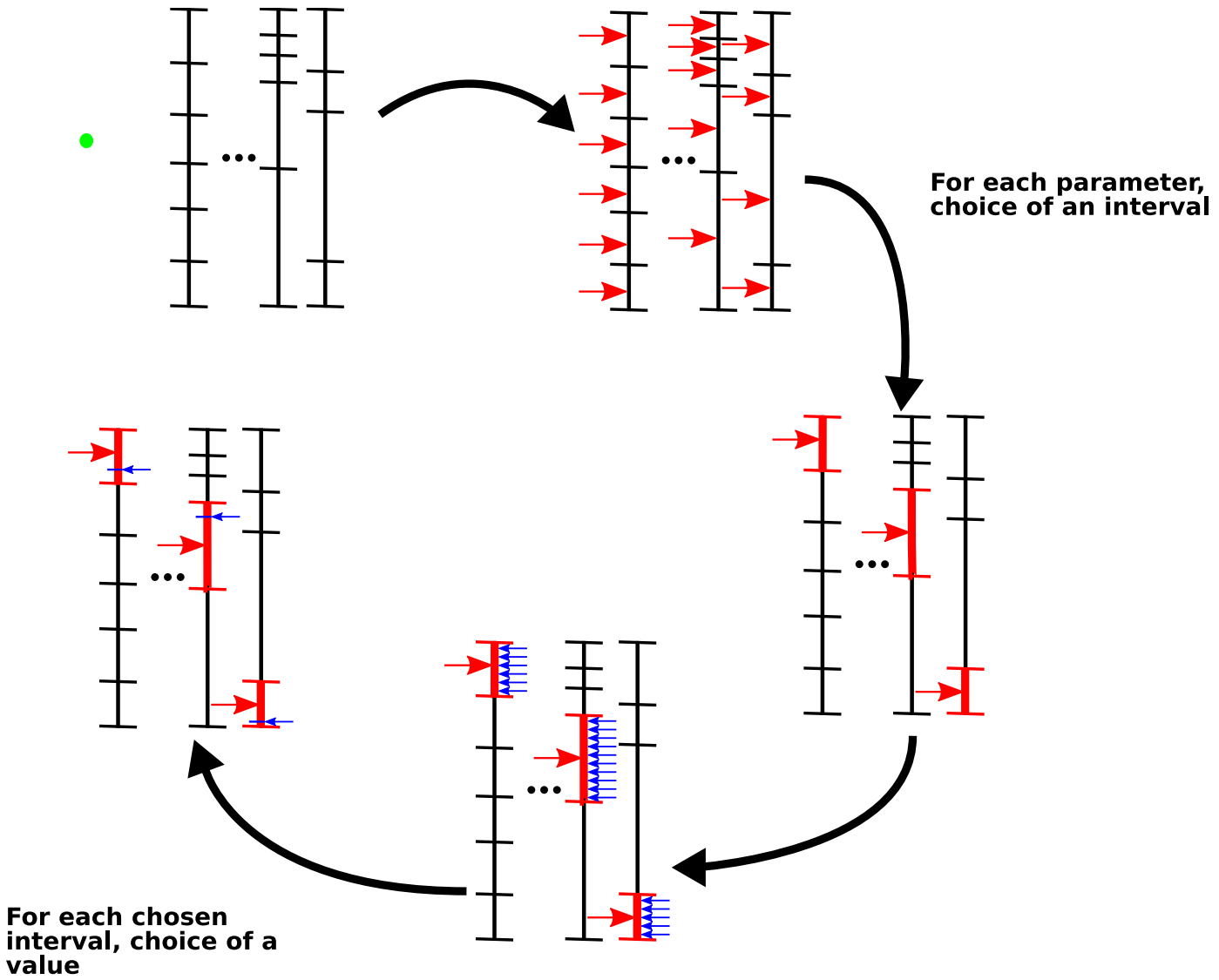
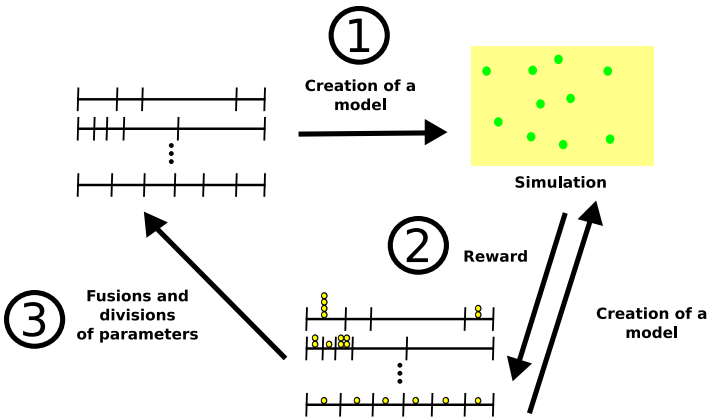


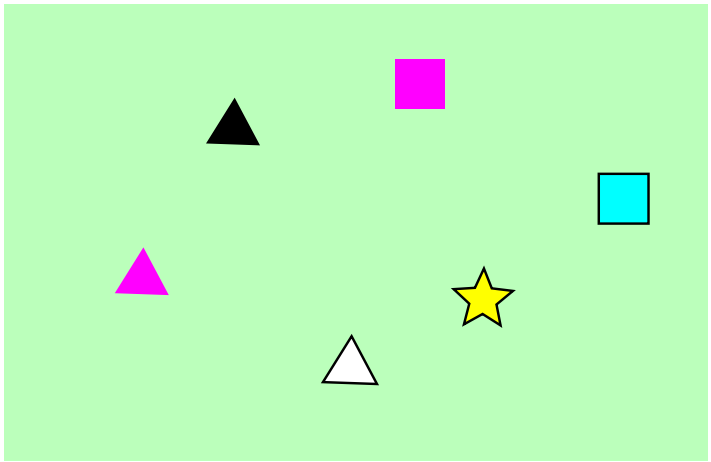
# ① Creation of a model

## Agent initialization



# ② Interval Rewards



**Simulation**

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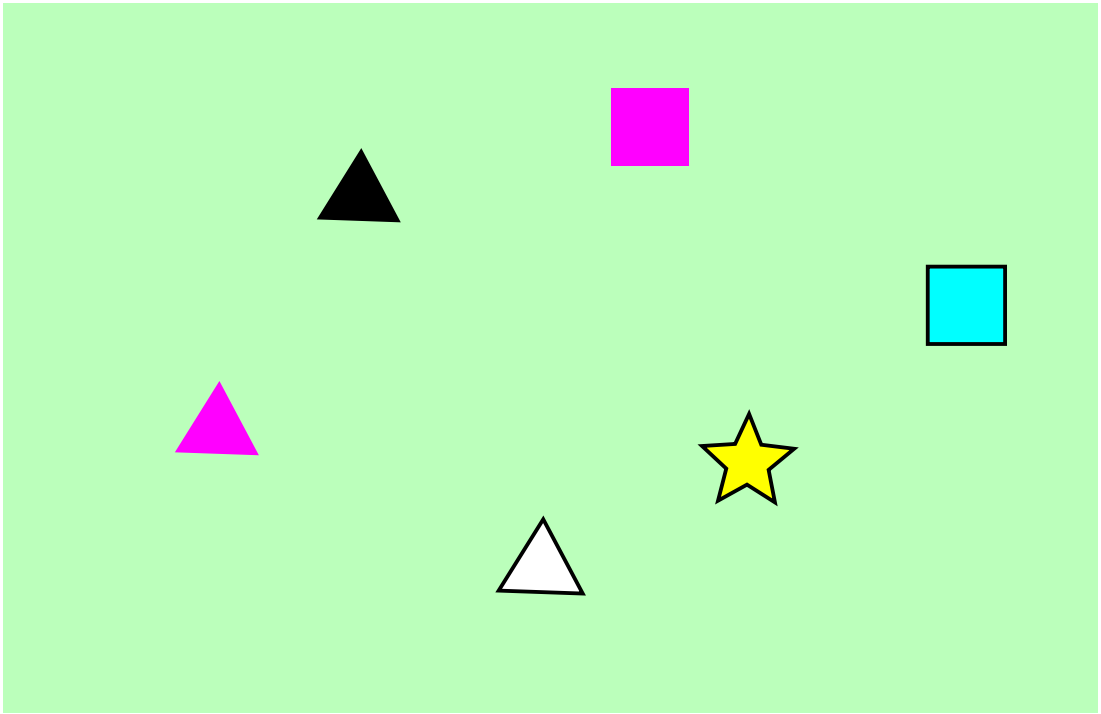

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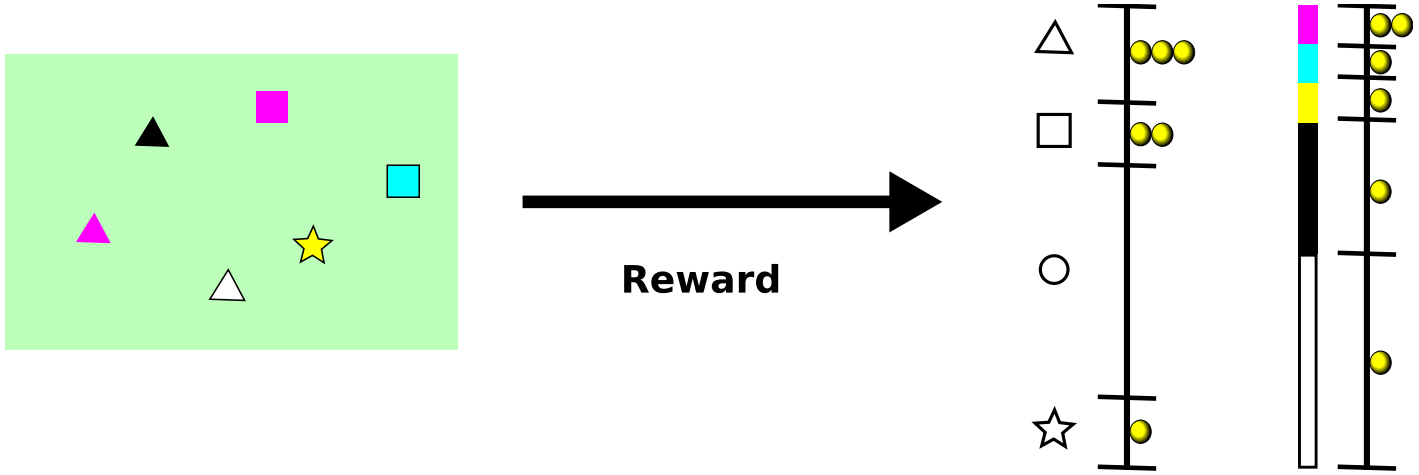

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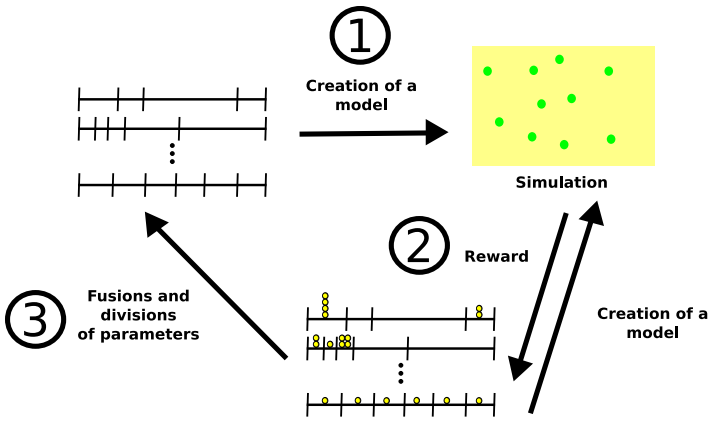
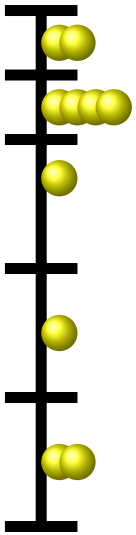
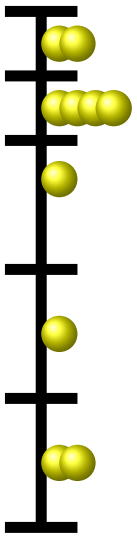


# ③ Fusions and divisions of parameters

## An example of an interval division

- When the number of rewards received by each interval is sufficient
- Choice of the interval that has the highest average of rewards
- Division into two intervals



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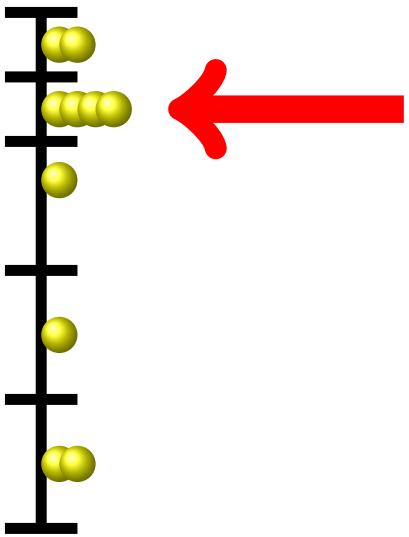

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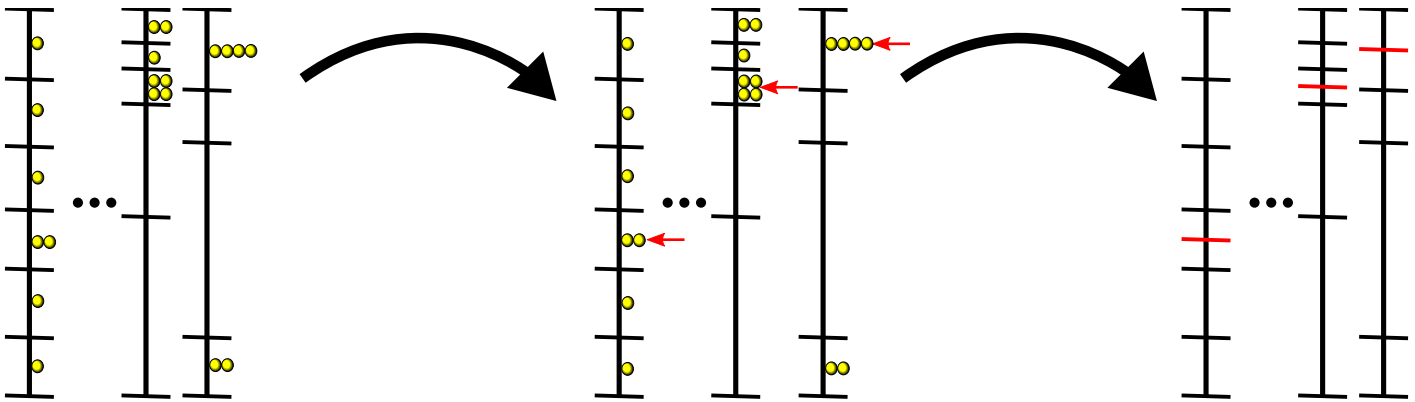


# Plan

# Principle

## General principle

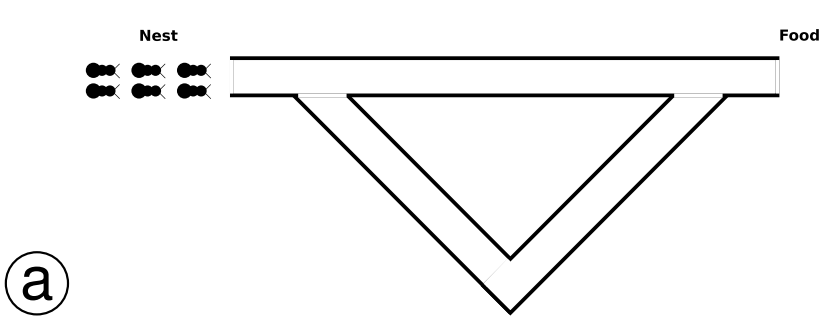
- Swarm intelligence
- Inspired by the creation of trails of pheromones
- [Dorigo and Di Caro, 1999, Blum, 2005]

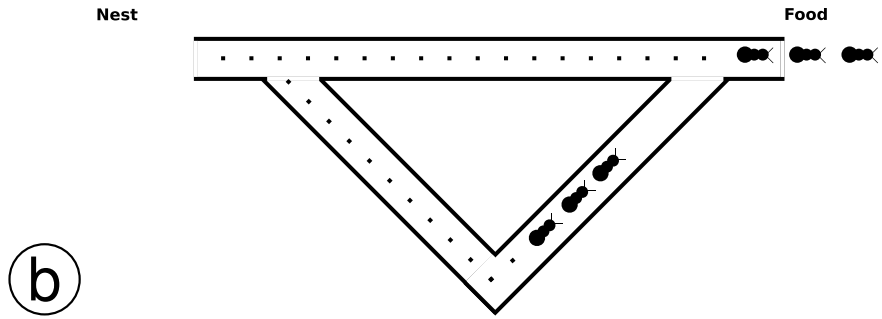
## More specifically

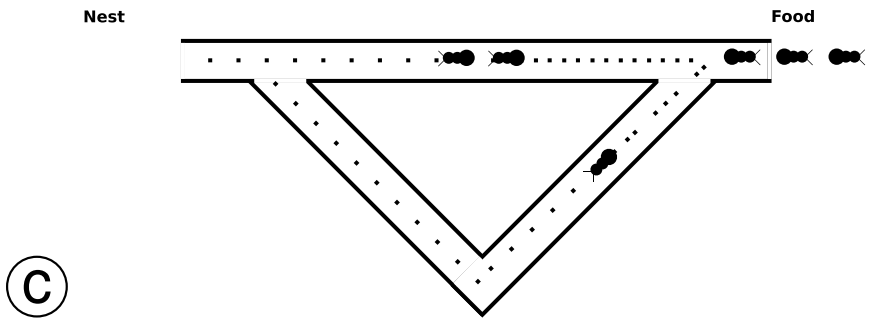
- Taking inspiration from Ant Systems
  [Dorigo et al., 1991, Dorigo et al., 1996]
- Adding a heuristic information

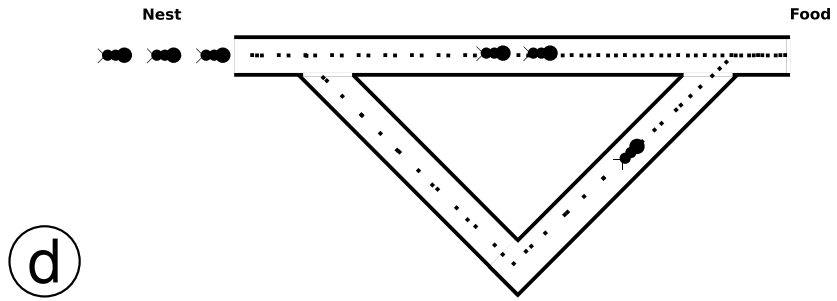
# Principle

Double-Bridge Experiment[Deneubourg et al., 1990]



# Principle

## General principle

- Swarm intelligence, more precisely Ant Colony Optimization
- Inspired by the creation of trails of pheromones
- [Dorigo and Di Caro, 1999, Blum, 2005]

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- Taking inspiration from Ant Systems
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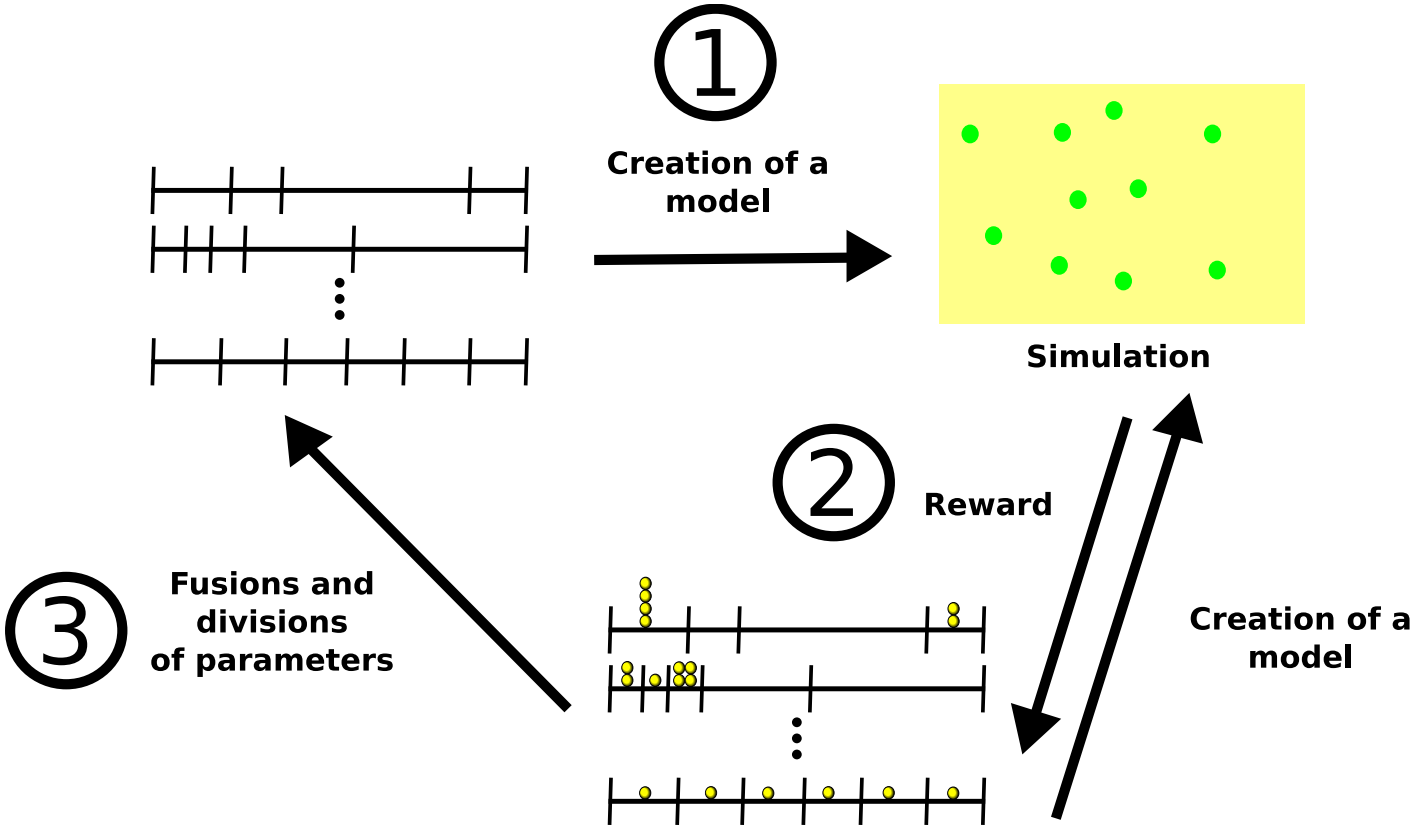
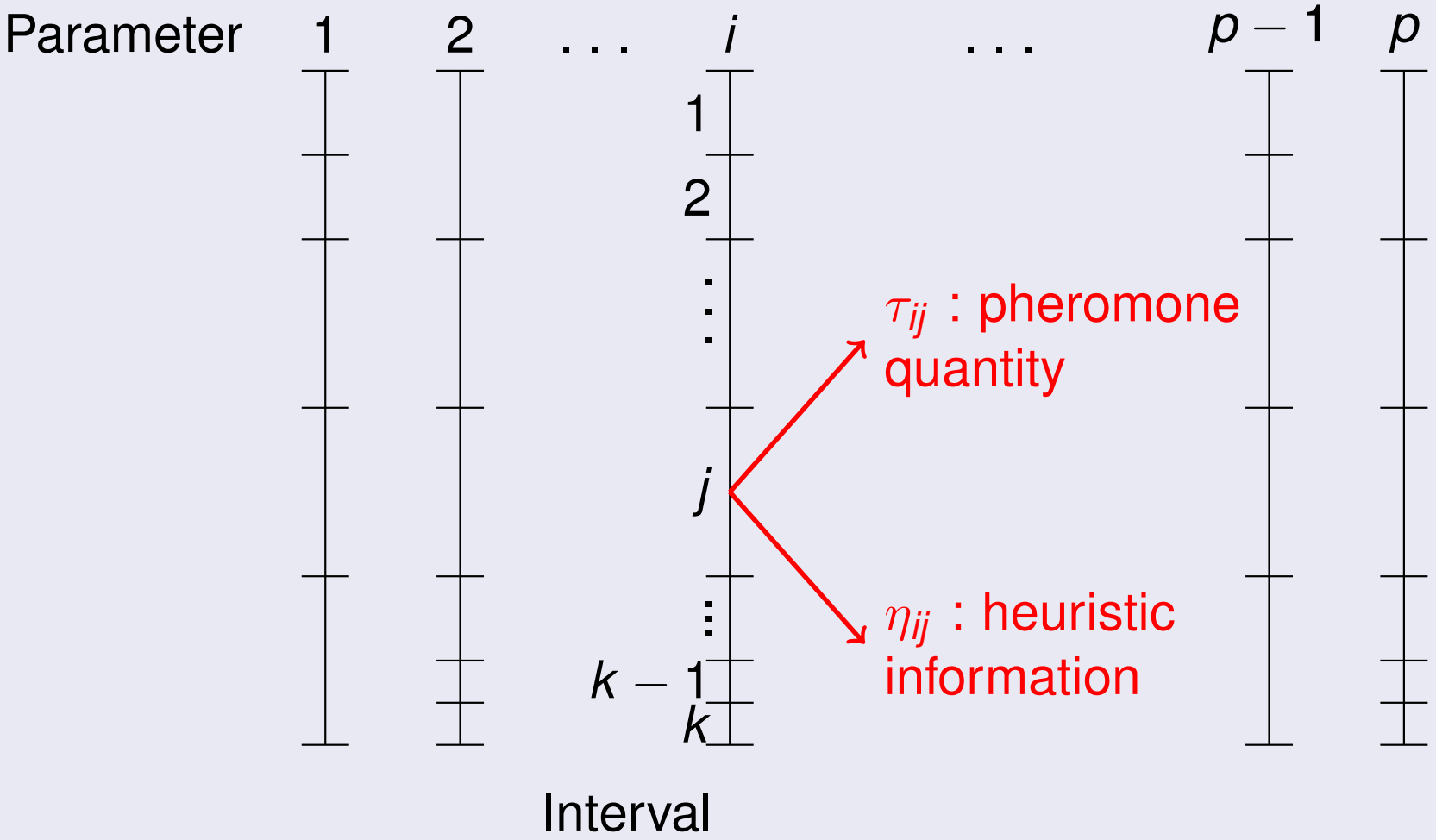
- Adding a heuristic information

# ① Creation of a model : Agent initialization



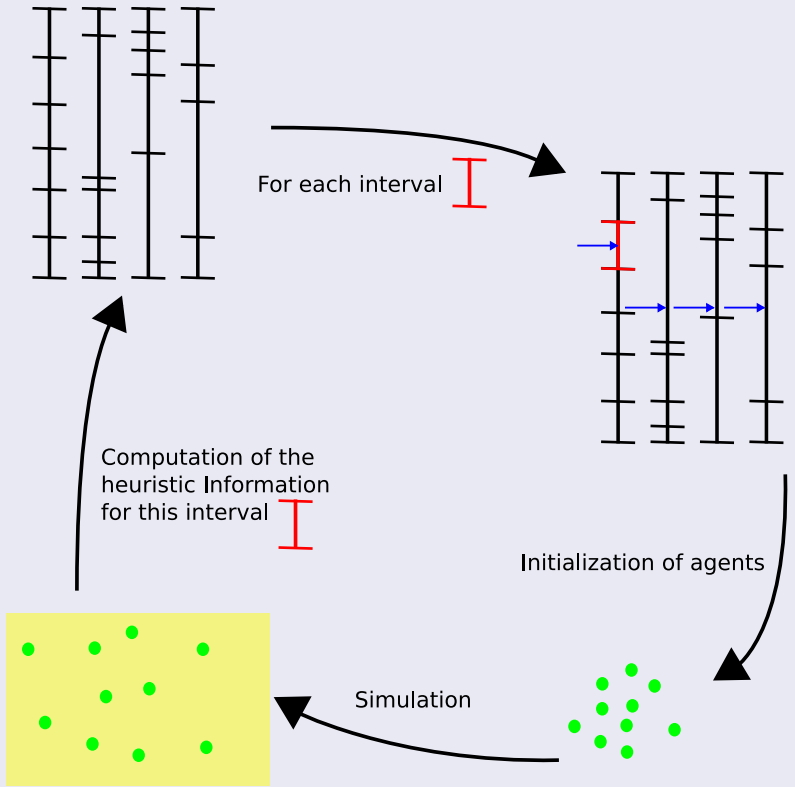
# ① Creation of a model : Agent initialization

## Interval



# ① Creation of a model : Agent initialization

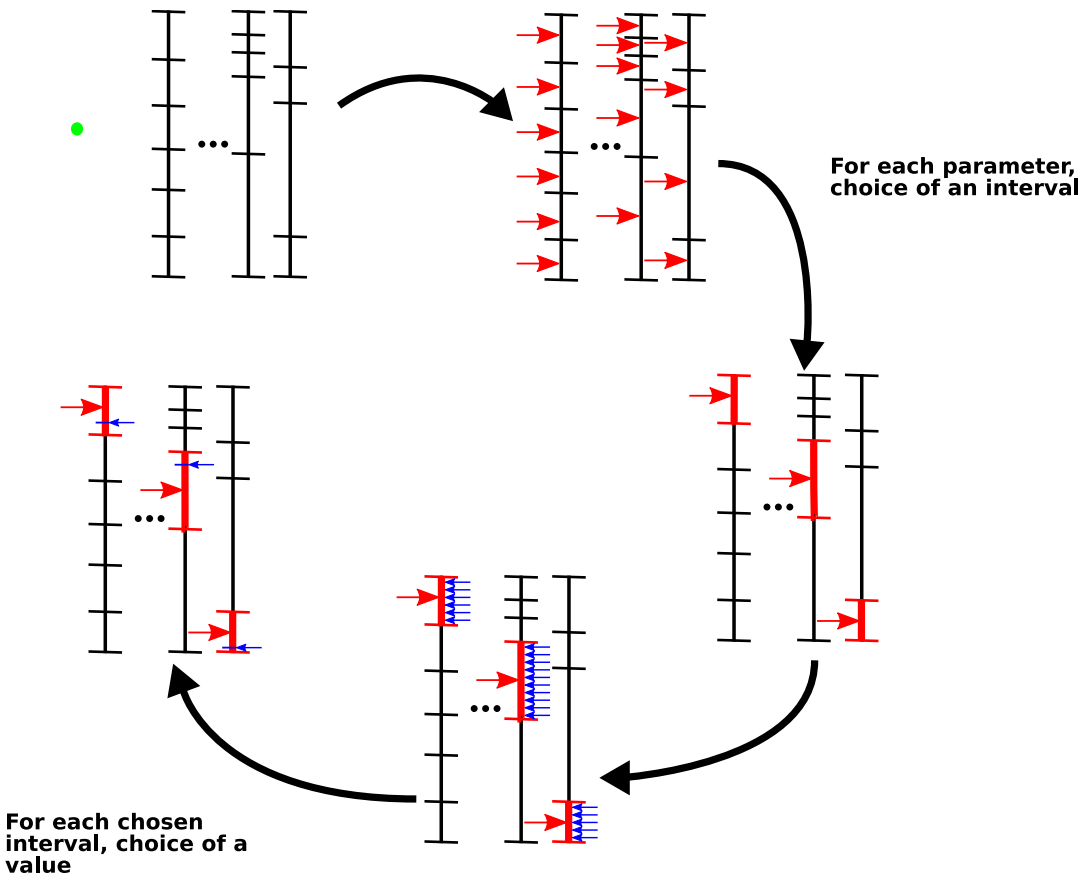
## Schema of the heuristic computation



# ① Creation of a model : Agent initialization

- Probability of the choice of an interval :

$$[\tau_{ij}]^{\alpha} \times [\eta_{ij}]^{\beta}$$



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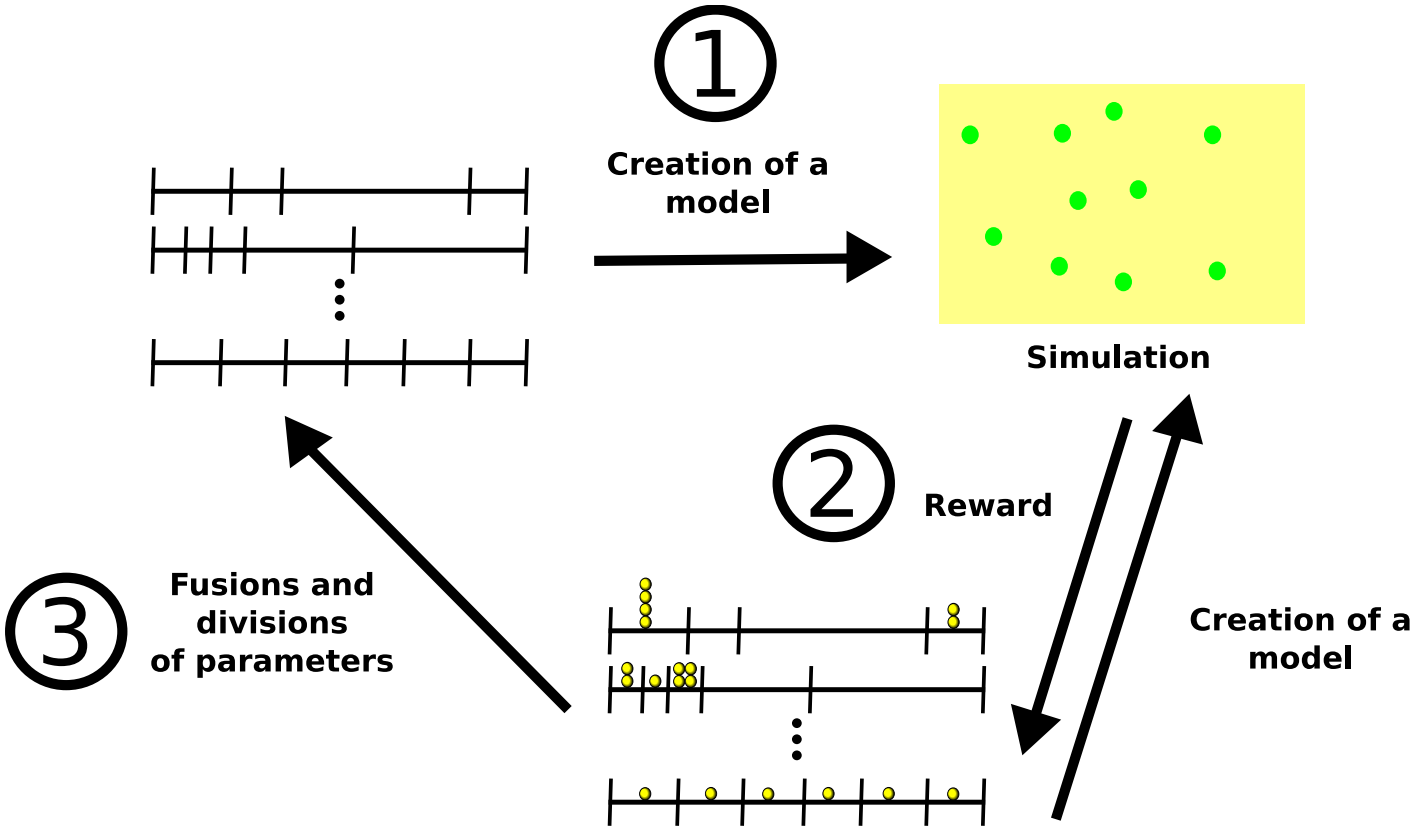

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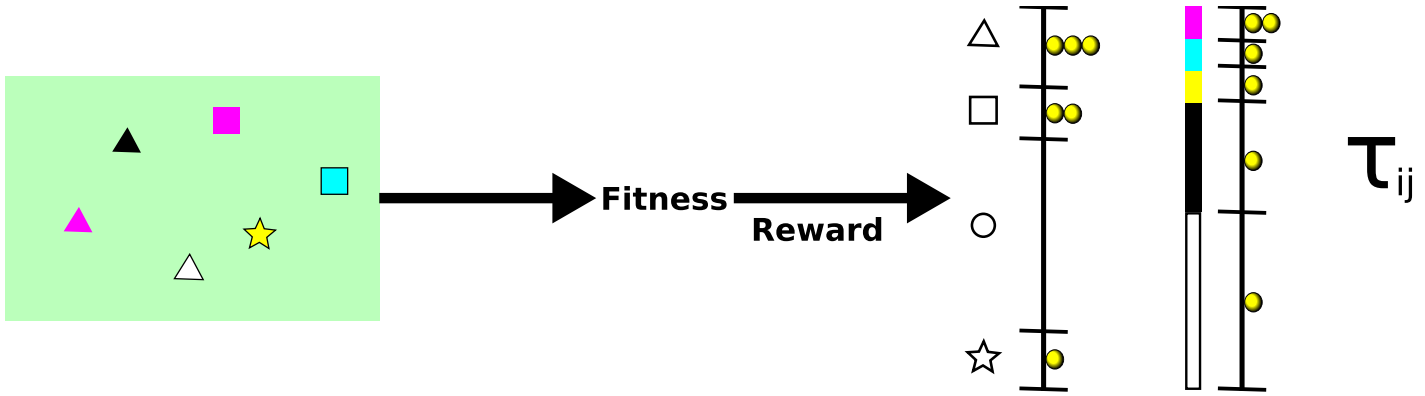

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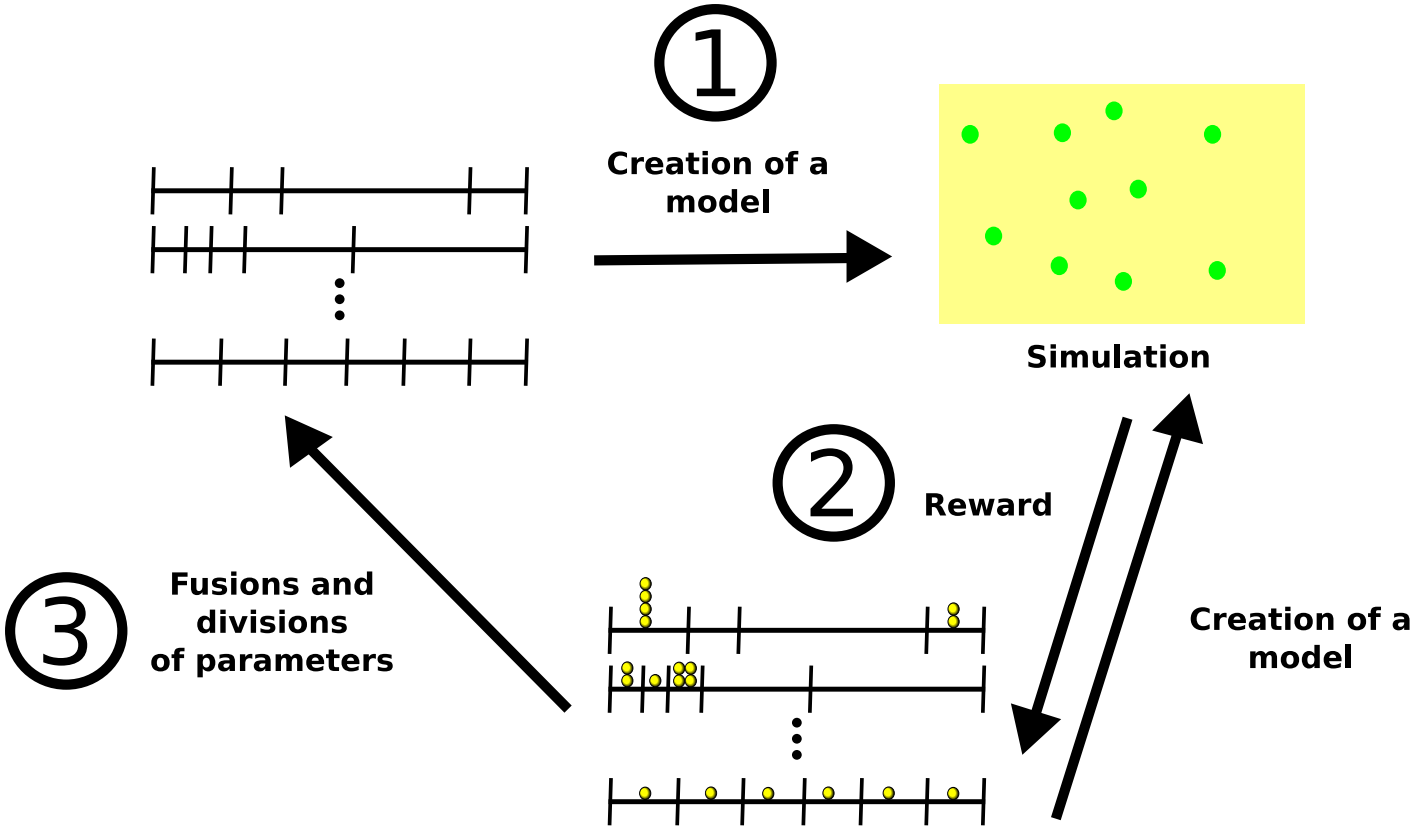


# ③ Fusions and divisions of parameters

- Division :

$$\tau_{ij} > \overline{\tau_i} + 2 \times \sigma_i$$

- Fusion :

$$\tau_{ij} < \overline{\tau_i} - \sigma_i$$

# Plan

# Model and parameters

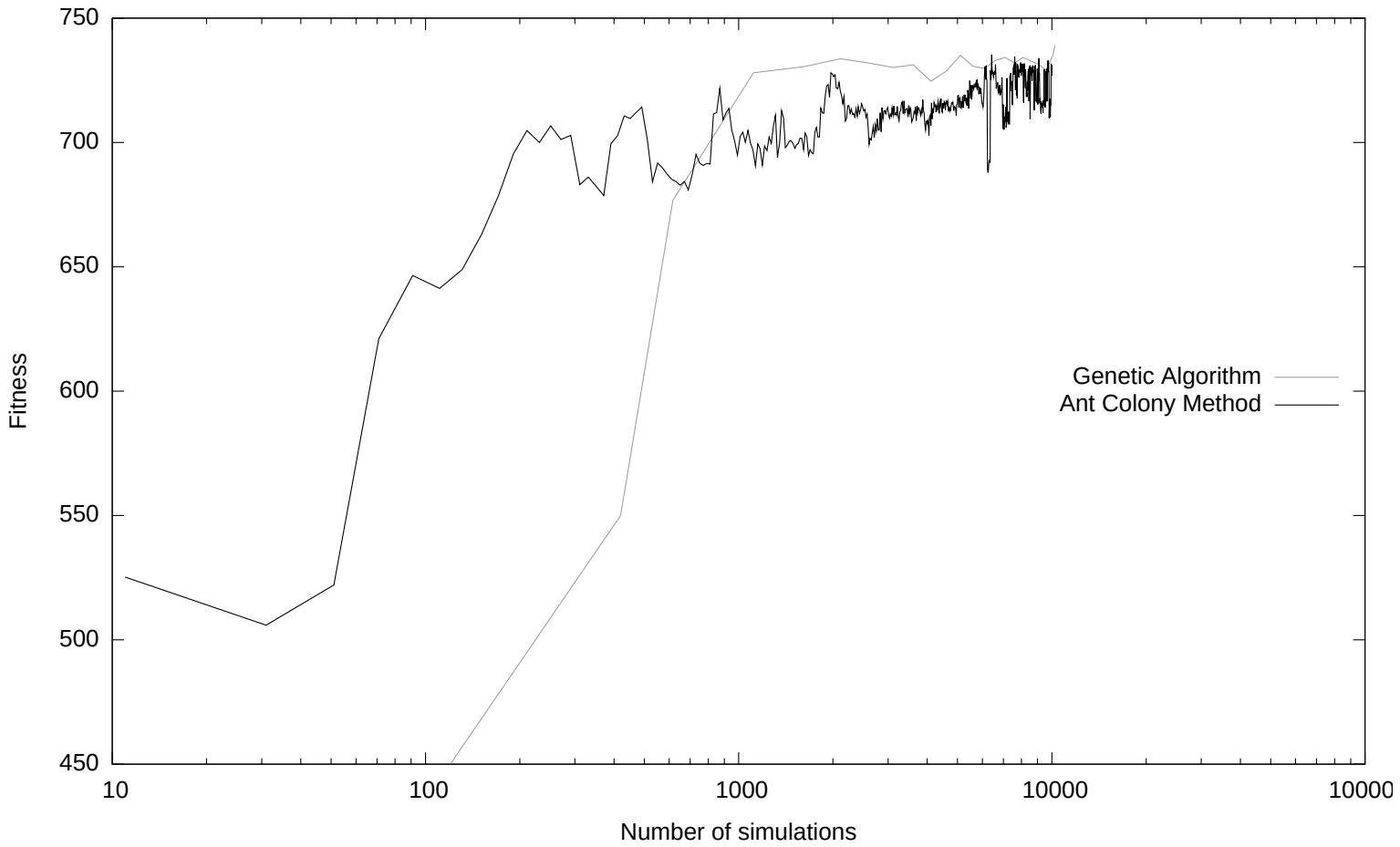
- Model : `Ants` provided by the modelling environment platform `Netlogo` [Wilensky, 1998]
- 25 ants
- 500 simulation steps
- Fitness : quantity of food brought back to the nest at the end of the simulation

# Model and parameters

## Parameter

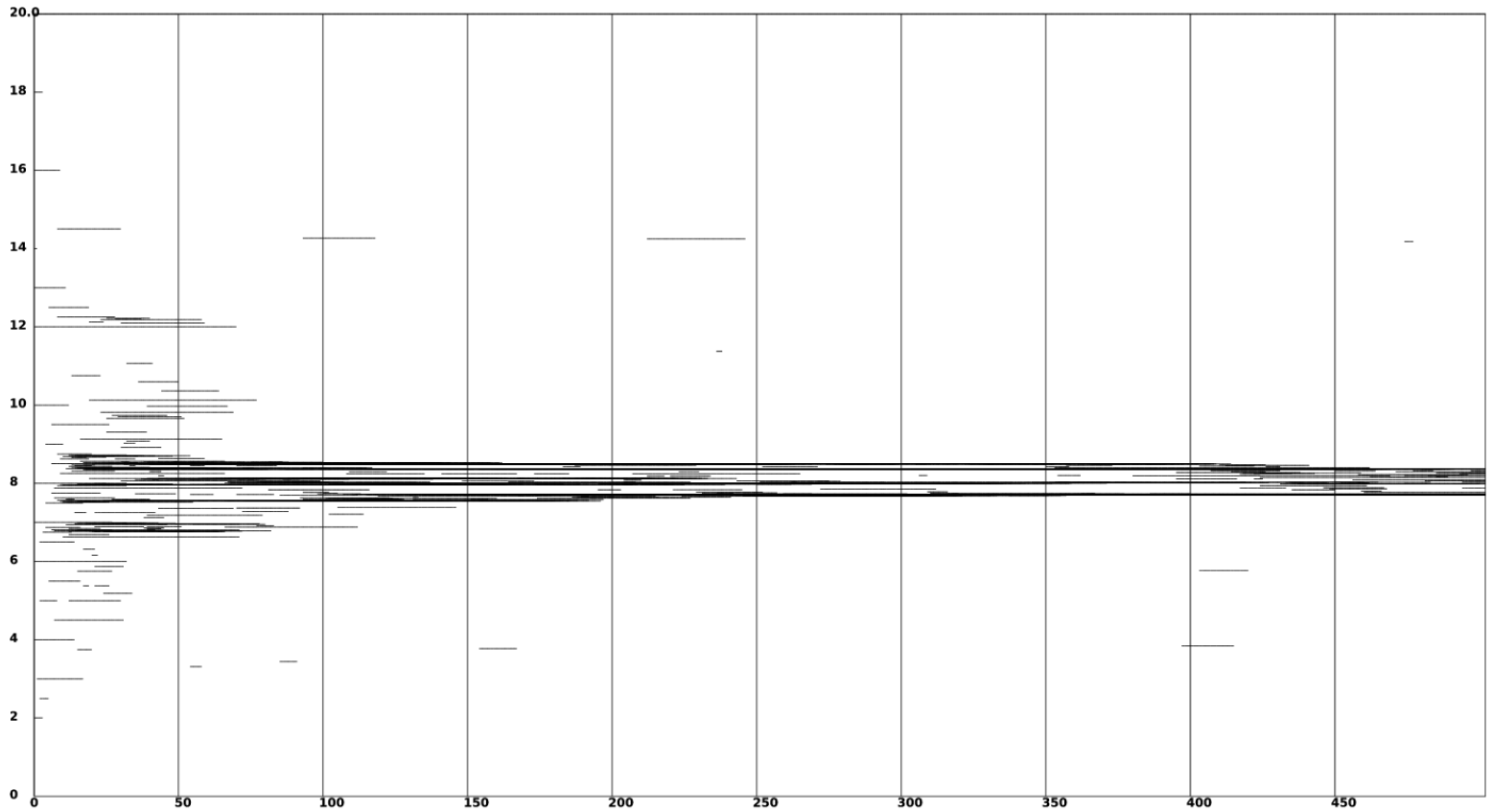
- `speed` : this parameter characterizes the speed of an agent. It varies between 0 and 20 patches per simulation step.
- `patch_ahead` : this parameter characterizes the number of patches looked ahead to “sniff” the chemical. It varies between 0 and 10 patches.
- `angle_vision` : this parameter characterizes the angle of vision. It varies between 0˚and 360˚.
- `drop_size` : this parameter characterizes the initial quantity of chemical that the agents drop in the environment when they come back to the nest with items of food. It varies between between 0 and 200.

# Fitness evolution



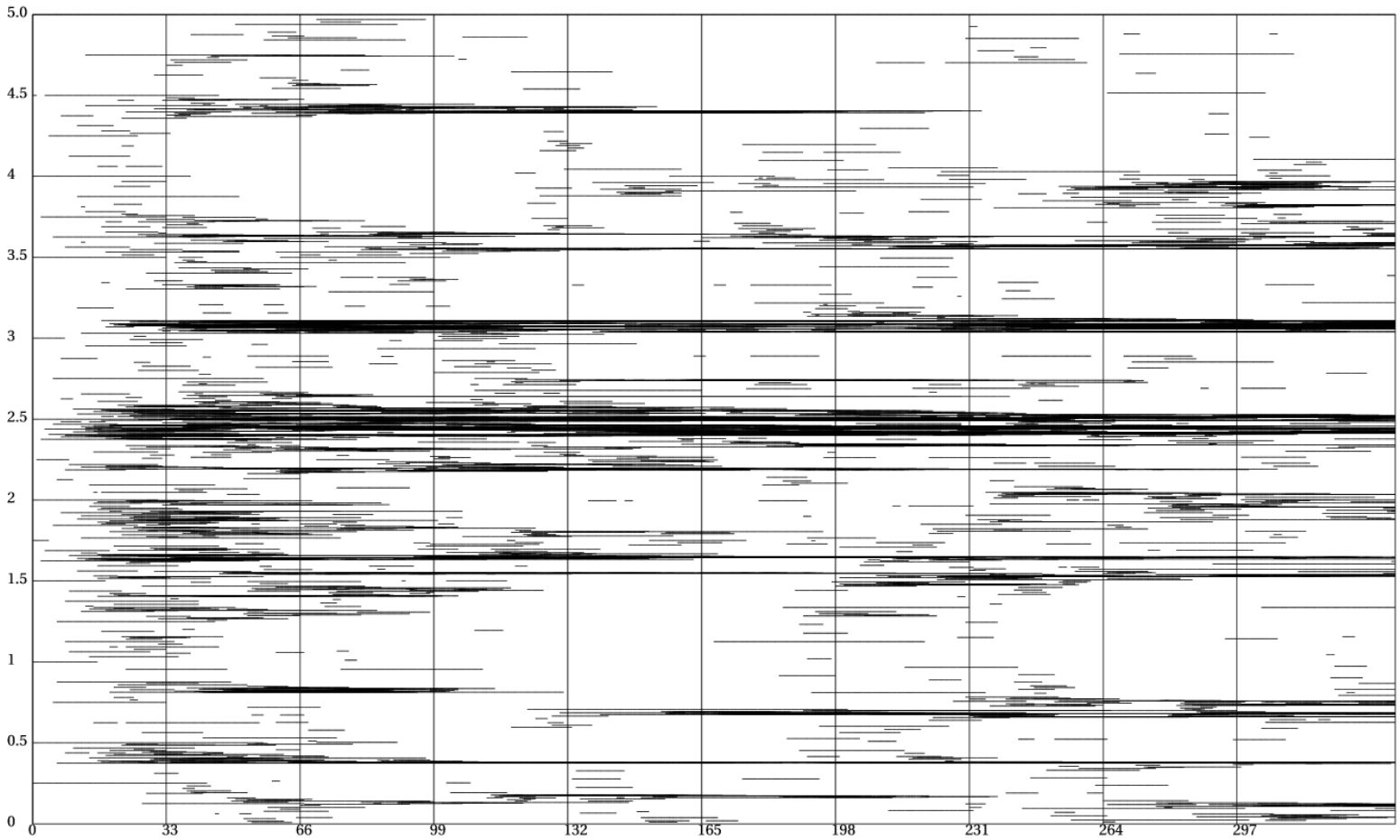
# Parameter evolution

## Speed parameter



# Parameter evolution

## Artificial parameter



# Plan

# Conclusion

Aim : Automatic exploration of the parameter space of an agent-based-simulation

- Presentation of a new approach :
  - Very fast convergence with few simulation runs
  - “A kind of cartography” of the parameter space
- Validation of the approach on a simple model

# Perspective

- Mix of different methods :
  - Begin with ADO method
  - From the parameter division, continue with the genetic algorithm
- Analysis of the cartographic result
- Application to “real” models

Thank you for your attention.

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