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Conflict solution in cellular models

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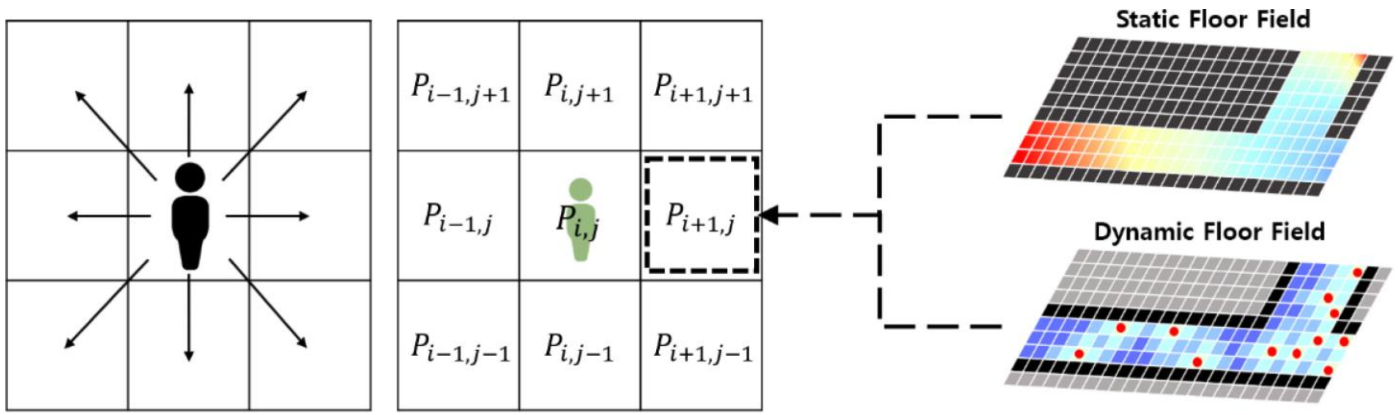
Overview

- Floor-field model
- Proposed strategies
- Choice of cell
- Implementation
- Simulations
- Sensitivity analysis

Floor field model

- Uncoordinated as optimal solutions are not the goal
- Sensitivity parameters:
  - **kS** – static potential
  - **kO** – occupancy
  - **kD** – diagonal movement
- Global friction parameter **μ**



Proposed strategies

- The movement of agents depends on:
  a) who wins the conflict
  b) who participates in the conflict
- Choice of parameters means everything
  - Meaningful parameter range
  - Understand the relations between parameters
- Total evacuation time as the only observed value?
  - Formation of structures
  - Local flow

Proposed strategies

Who wins the conflict?

Strategy A

Strategy B

- Aggressivity introduced by Hrabák and Bukáček
  - **γ** in range [0, 1]
- Agent/s with highest **γ** can win the conflict
  - friction **μ** creates stochastic blocking occasions
  - conflicts are desired but sometimes **jamming** happens when it shouldn’t
- None of the agents enter the cell with $P=\mu(1-\gamma)$

Proposed strategies

Who wins the conflict?

Strategy A

Strategy B

- Agents with same low **γ** create irrelevant blockings near the exit
- Solution: **all** agents enter the conflict
  - Probability Pi is proportional

$$P_i = \frac{\gamma_i}{\sum_{j \in k} \gamma_j}$$

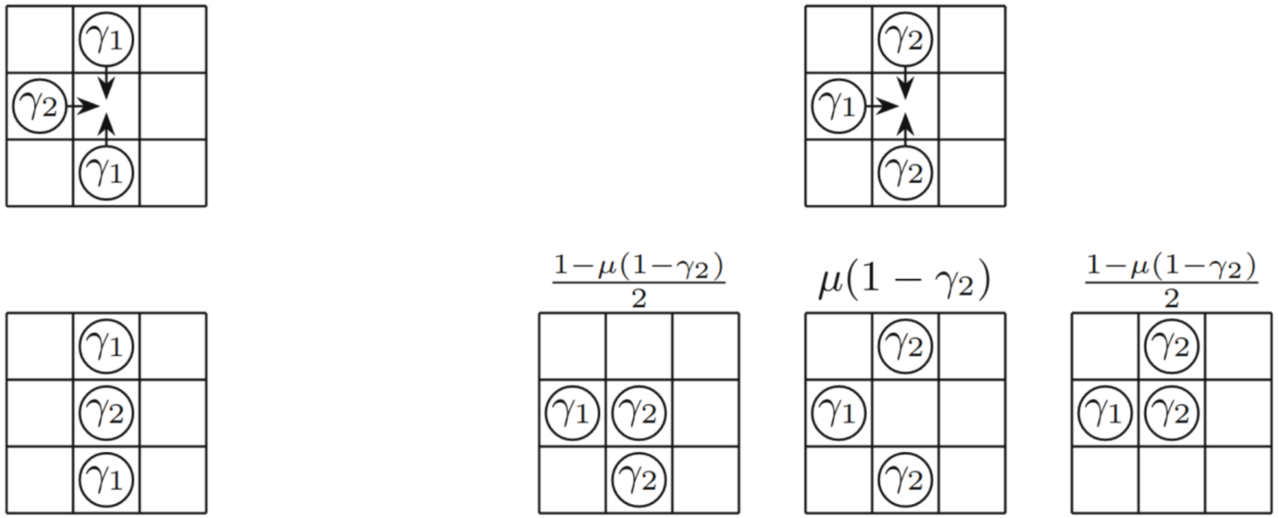
Proposed strategies

Who wins the conflict?

Strategy A

Strategy B

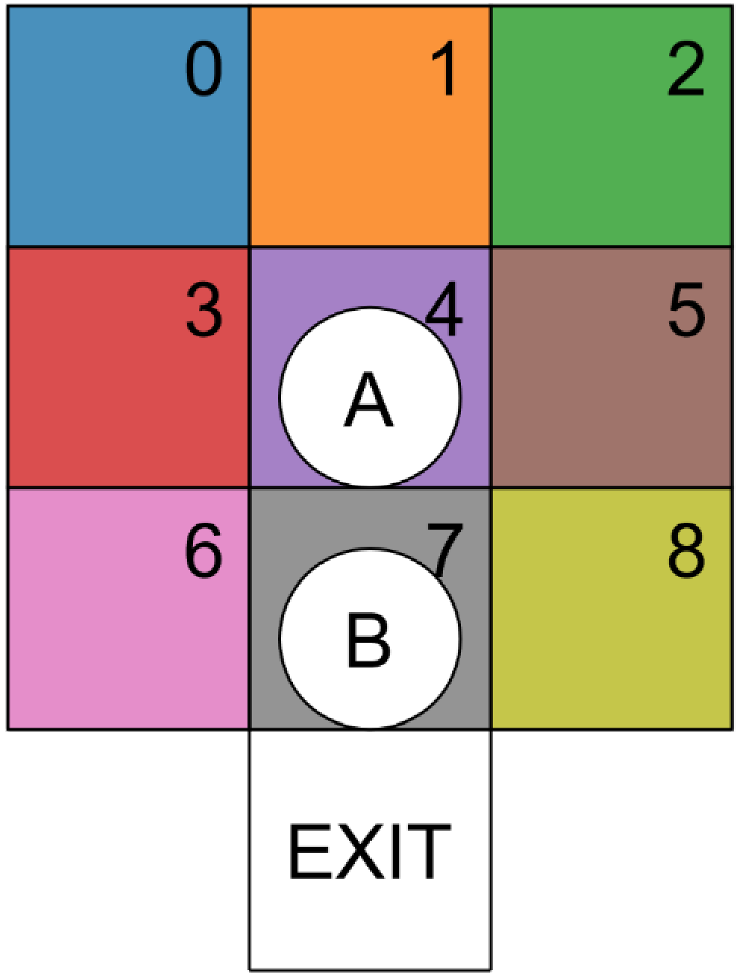
- Drawback is that blocking occasion still depends on highest **γ**
  - P = $\mu(1-\gamma)$
- Strategy did not bring improvement
- Proportional probabilities are a valid approach



Proposed strategies

Who participates?

- Selection of destination cell is crucial
- Is the influence of parameters predictable?
  - we need to adjust the model to our liking
- How to measure the influence?



Proposed strategies

Who participates?

Strategy A

Strategy B

- Proposed by Pavel Hrabák and Marek Bukáček
- Probability **P** of agent, who is in cell **x**, moving to adjacent cell **y** ∈ **N**
- Attractivity (nominator) of cells is normalized –› probability
- Only **kS** ∈ **R**, high influence

$$P(y \leftarrow x \mid N) = \frac{\exp(-k_S S(y))(1 - k_O O(y))(1 - k_D D(y))}{\sum_{z \in N} \exp(-k_S S(z))(1 - k_O O(z)(1 - k_D D(z))}$$

Proposed strategies

Who participates?

Strategy A

Strategy B

- Focuses on the sensitivity to the occupancy of cells **kO**

$$P(y \leftarrow x \mid N) = k_O P_O(y) + (1 - k_O) P_S(y)$$

- **Ps** takes into account the static potential
  - Agent moves in correct direction
- **Po** focuses on occupancy
- Individual attractivities are more predictable, easier to interpret

Proposed strategies

Who participates?

Strategy A

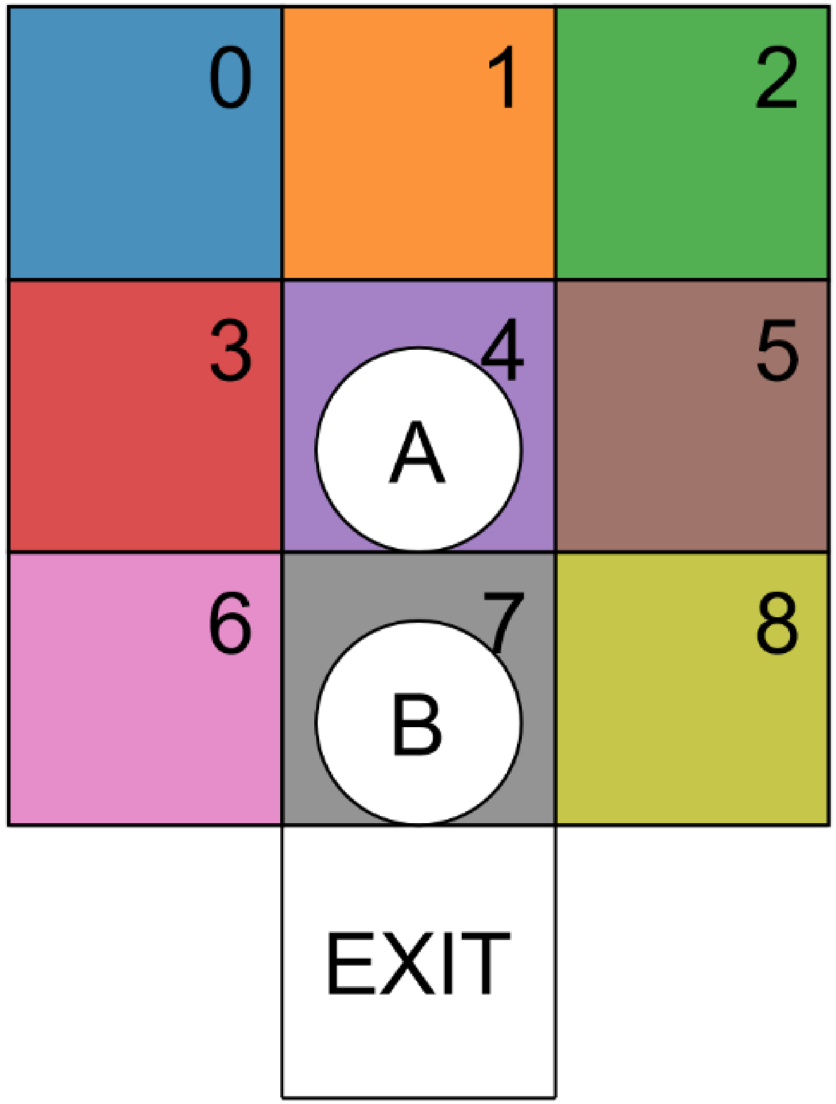
Strategy B

- **Po** doesn't use the **kO** parameter

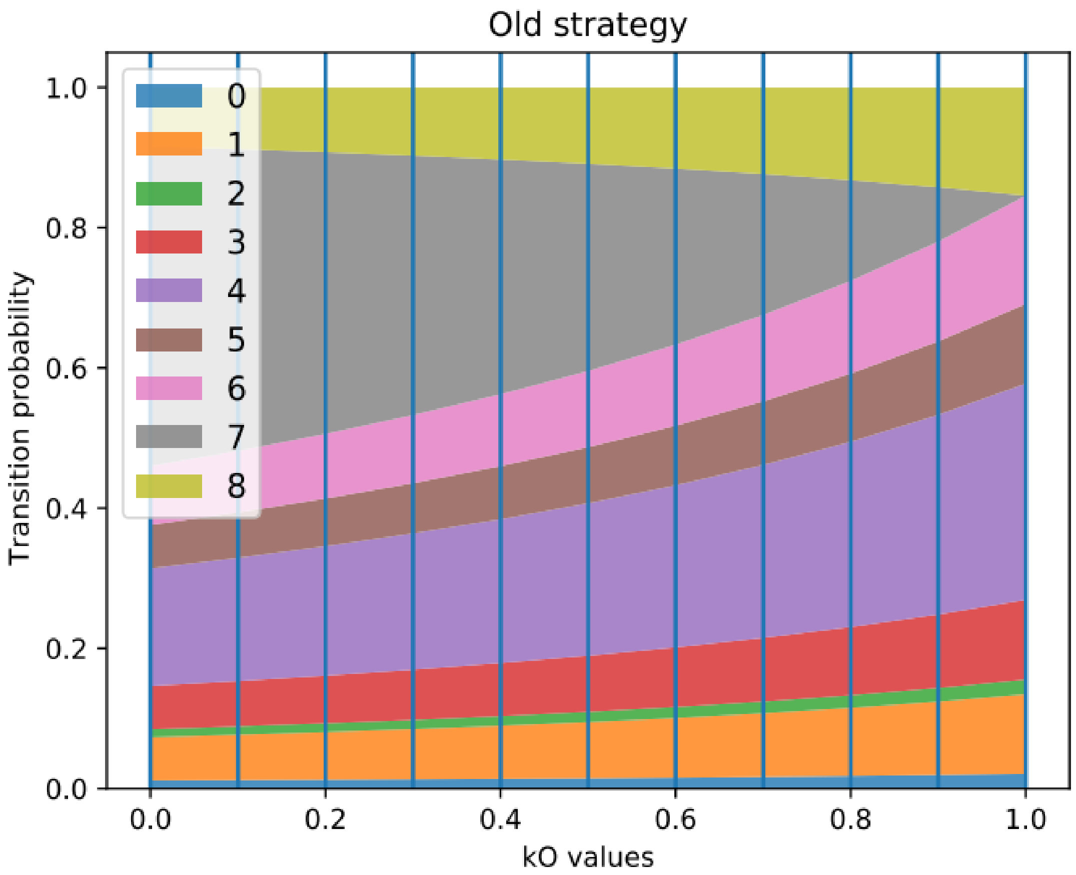
$$P_O(y) = \frac{\exp(-k_S S(y))(1 - O(y))(1 - k_D D(y))}{\sum_{z \in N} \exp(-k_S S(z))(1 - O(z)(1 - k_D D(z))}$$

$$P_S(y) = \frac{\exp(-k_S S(y))(1 - k_D D(y))}{\sum_{z \in N} \exp(-k_S S(z))(1 - k_D D(z))}$$

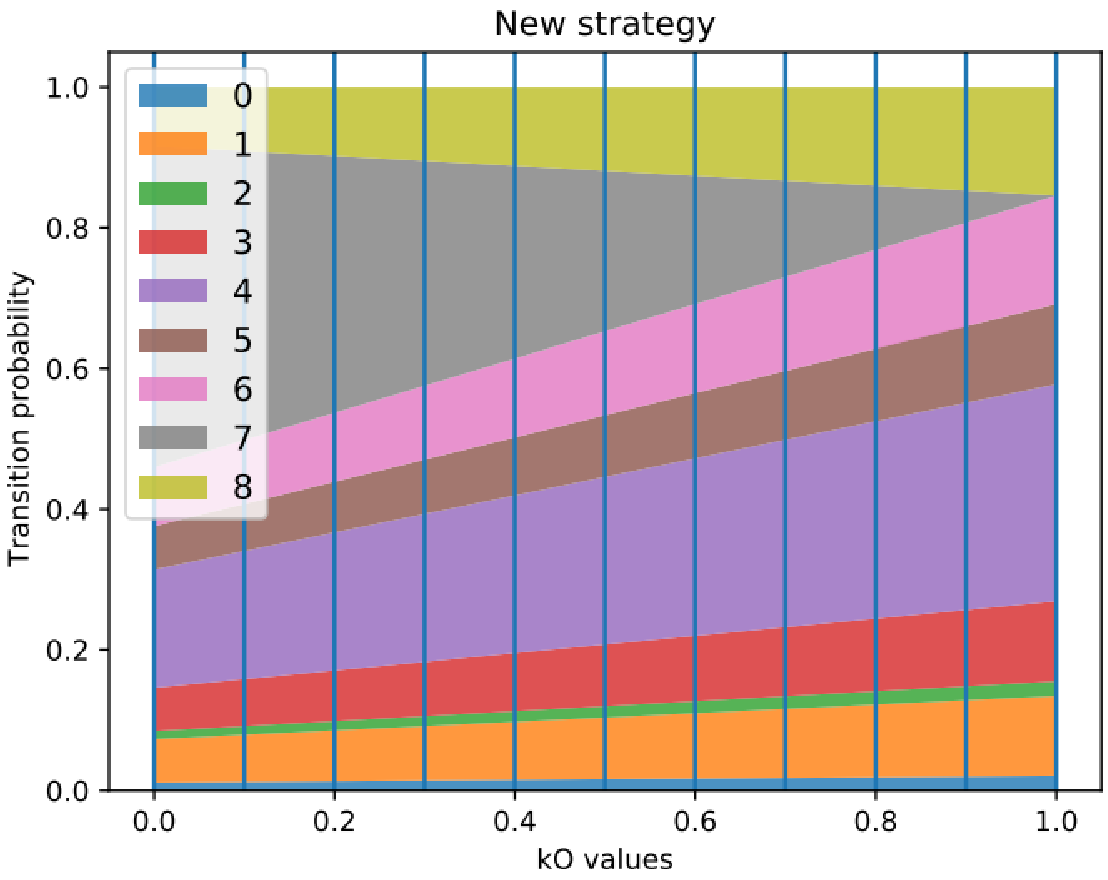
1. Agent A wants to get closer to exit.
2. He is aware of agent B in front of him.
3. He calculates attractions of all neighborhood cells.
4. Stochastic selection chooses one cell.
5. In case of conflict, stochastic process selects a winner.



Old strategy A



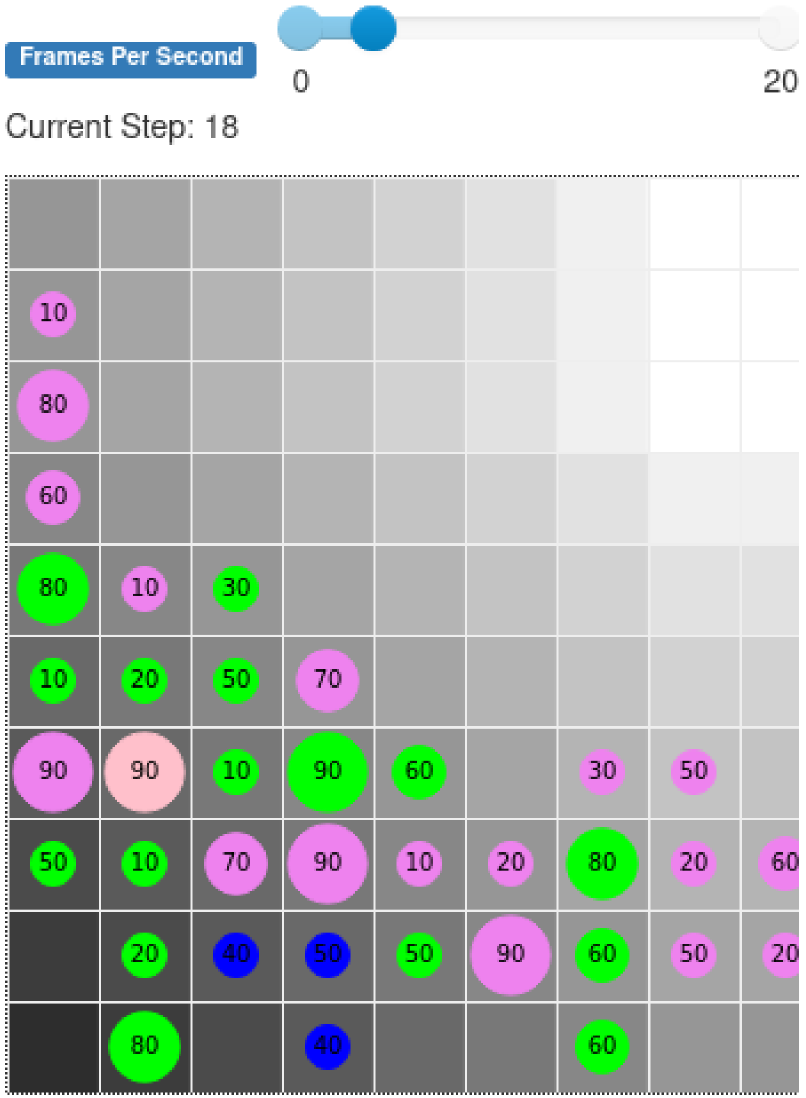
New strategy B

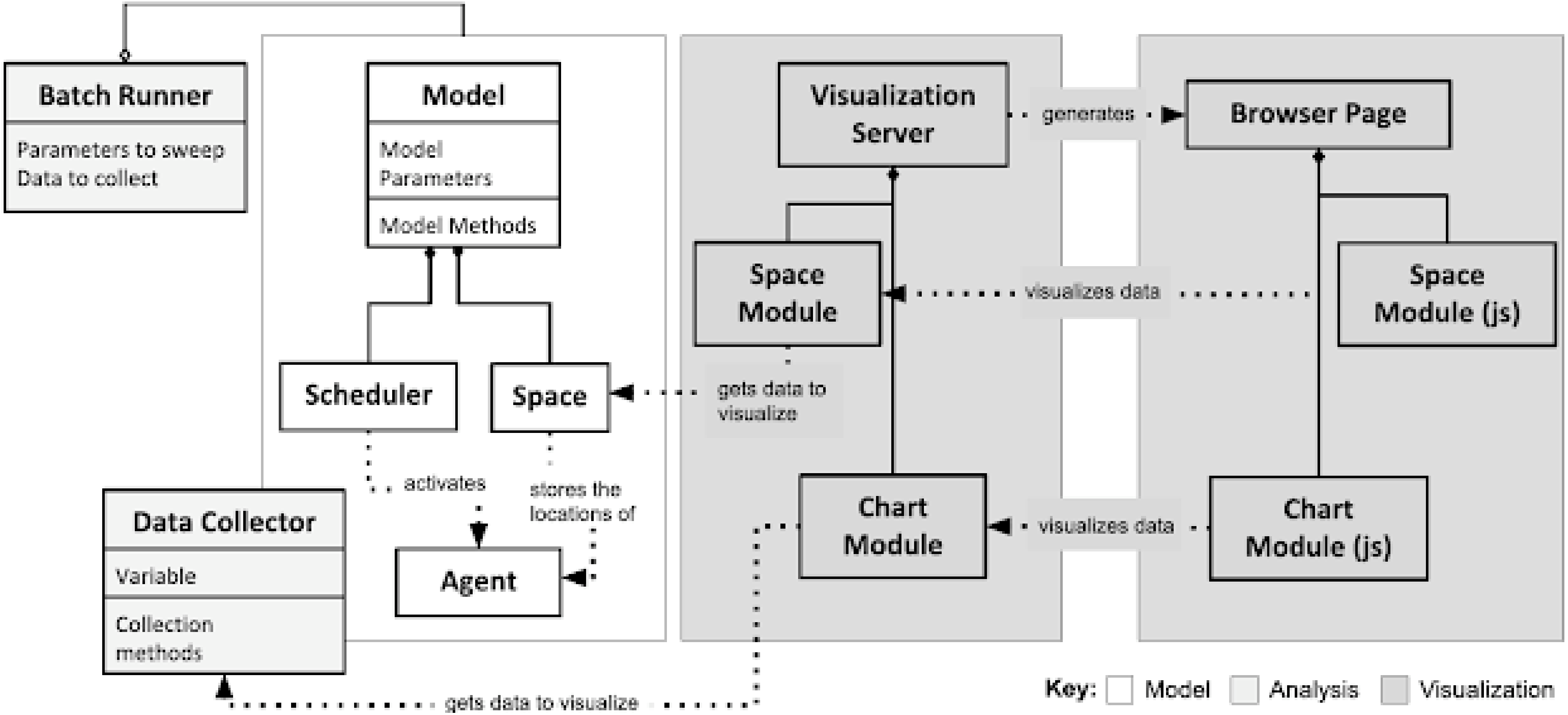


Increasing **kO**, the influence on attractivity of cells.

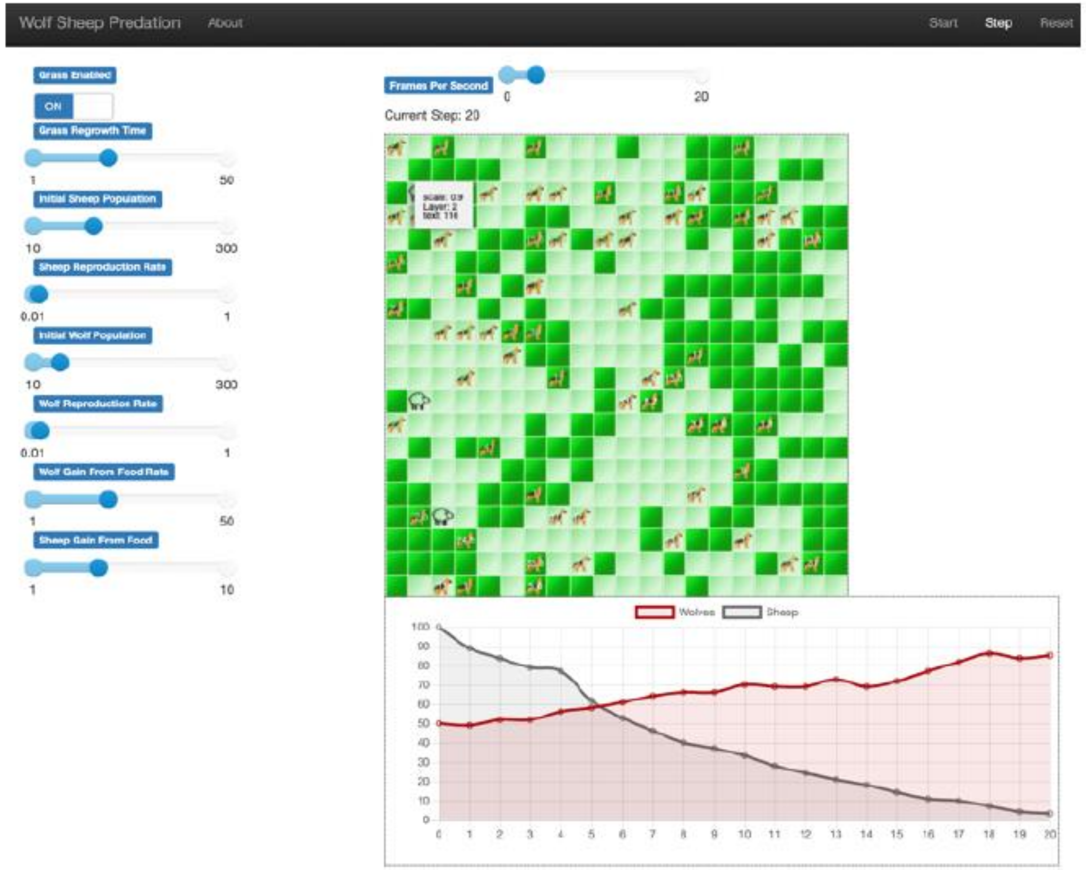
Implementation

- Python
- Mesa ABM framework
  - Modularity and data-analysis
  - Graphic output
- Pseudo RNG for stochastic selection
- Non-cooperative agents

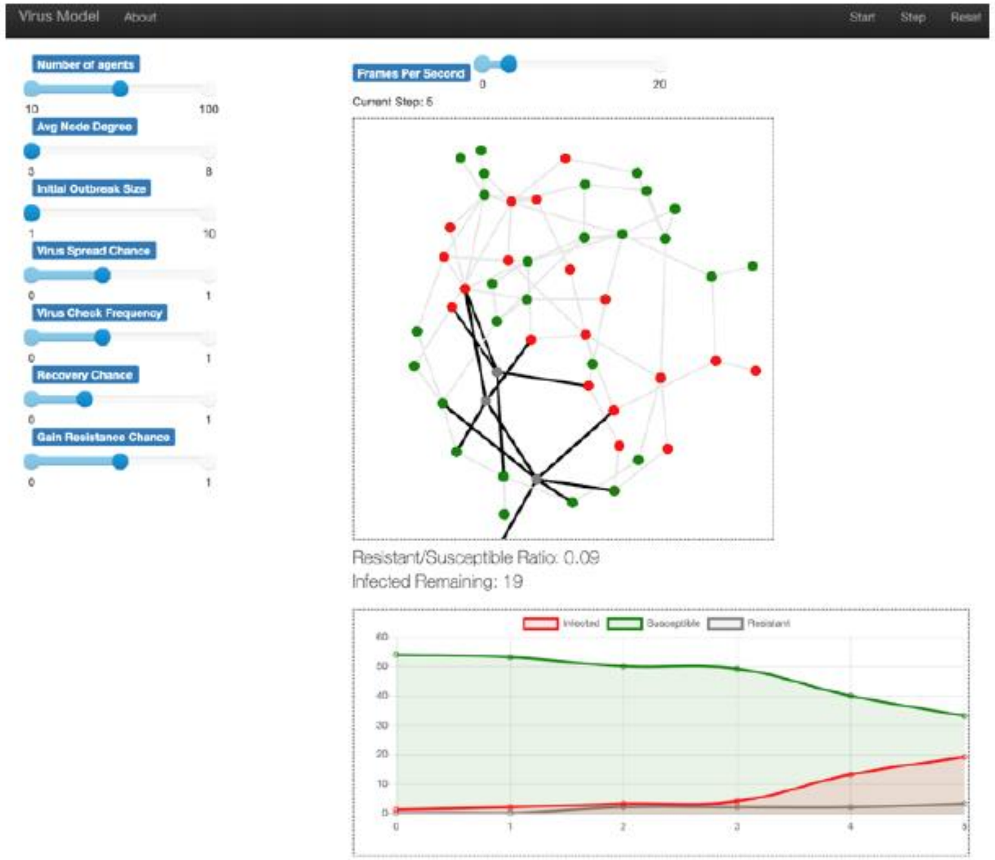




Taken from:
gisagents.org/2020/05/utilizing-python-for-agent-based.html



A

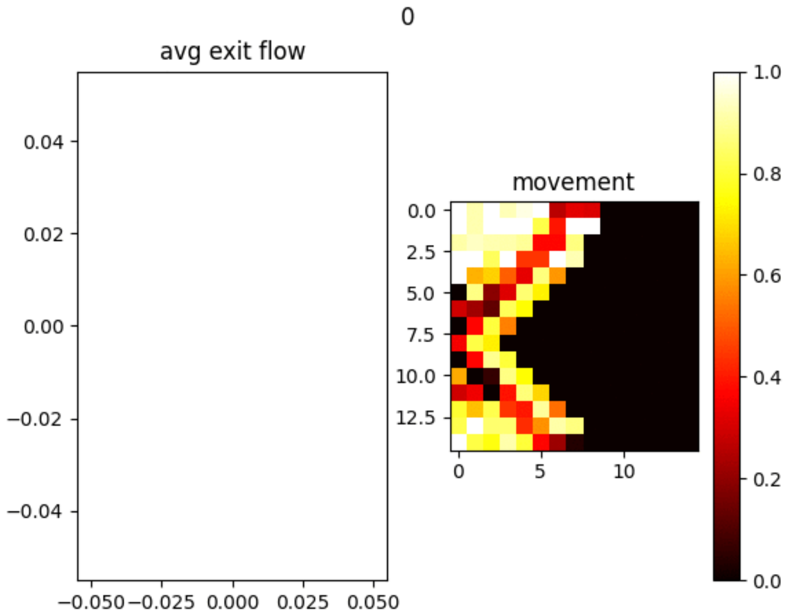


B

Taken from:
gisagents.org/2020/05/utilizing-python-for-agent-based.html

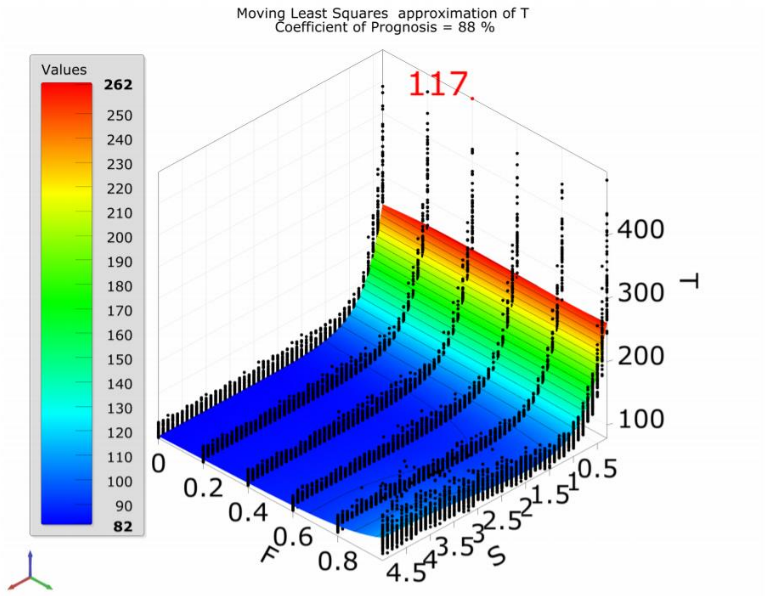
Analysis of the model

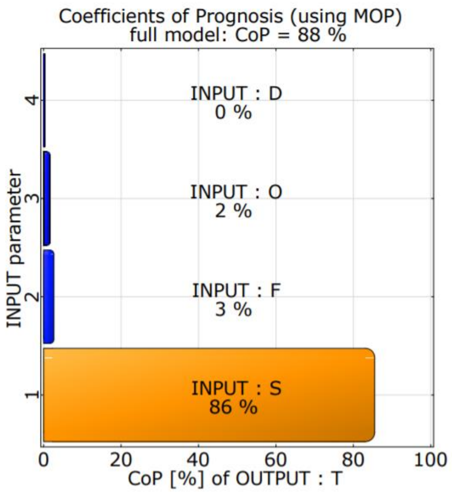
- PRNG allow parallel batch running with varied parameters
- **Quantitative analysis**
- Contribution of individual parameters to the variance in observed values
  - Total evacuation time **T**
  - kS, kO, kD, μ
- **Qualitative analysis**
- Number of agents
- Formation of structures
- Heterogeneity



Sensitivity analysis

- OptiSLang by Dynardo GmbH
- How much variance in **T** can be attributed to parameter x?
- Analysis brought additional result:
  Interval of **kS** should be limited to approx. [1.5, 4.5]

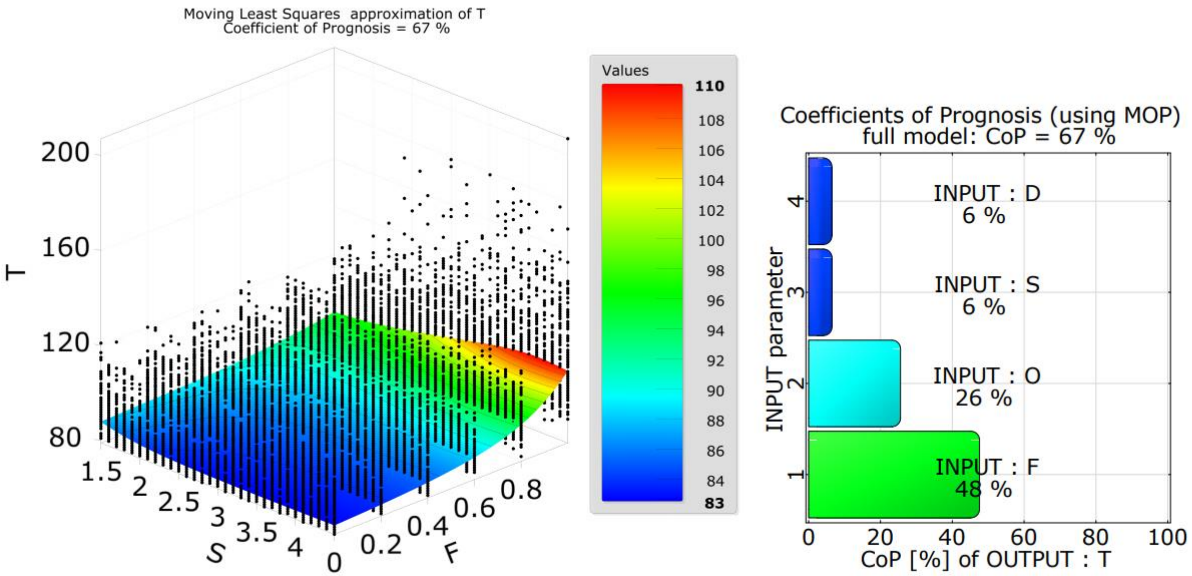




Sensitivity analysis

COP, variable **kS**

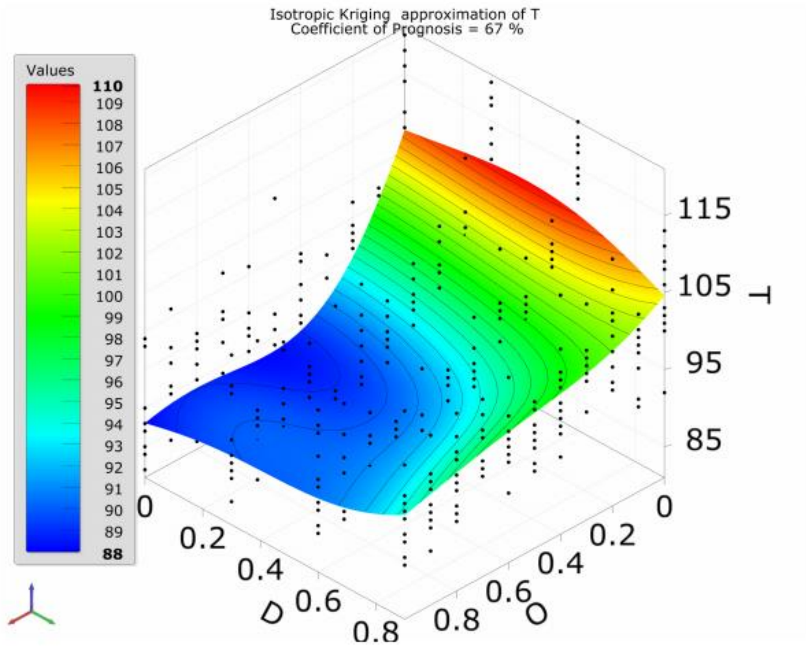
- COP graph, on the right, show the total sum of parameters contribution is higher than total COP
  - 67 != 6+6+26+48
  - Parameters affect each other
  - **kD** influence is low

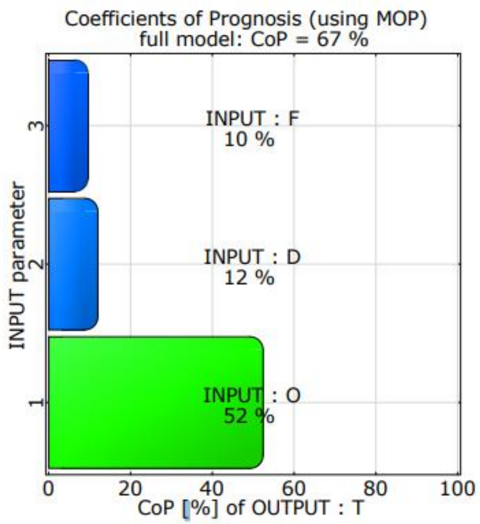


Sensitivity analysis

constant **kS=1.5**
microscopic influence

- low **kS = 1.5** allows other parameters to influence the process
- Microscopic behavior affected by **kD**, but **T** not so much
  - COP is 12%, 8%, 5% for **kS** ∈ {1.5, 3.0, 4.5} in order
  - agents can overtake the queue more often

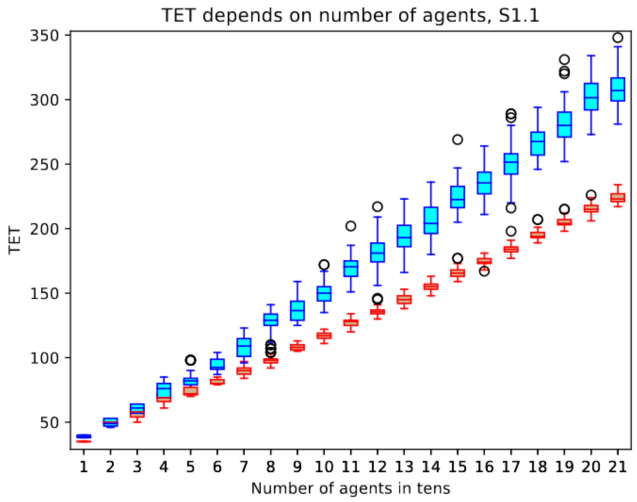


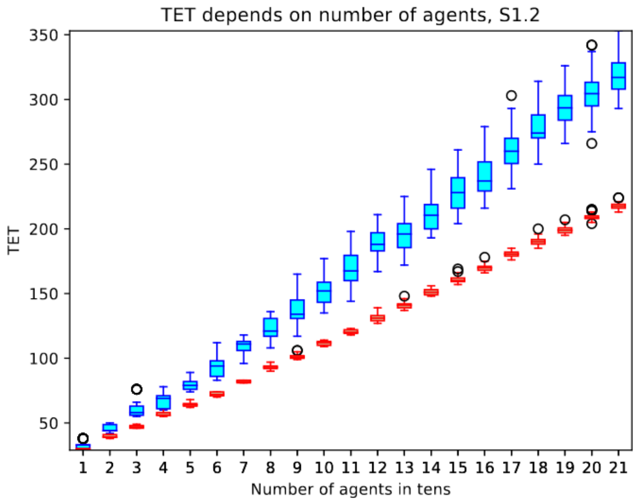


Qualitative analysis

T depends on number of agents

- With increasing number of agents, **T** increases **linearly**
- Red boxplots are simulations with low friction
- Blue boxplots are simulations with high friction
- Top: **kS=1.5**
- Bottom: **kS=1.5**

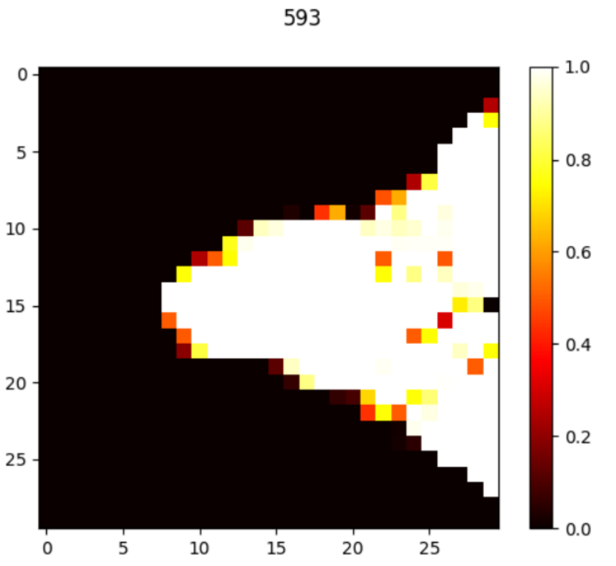


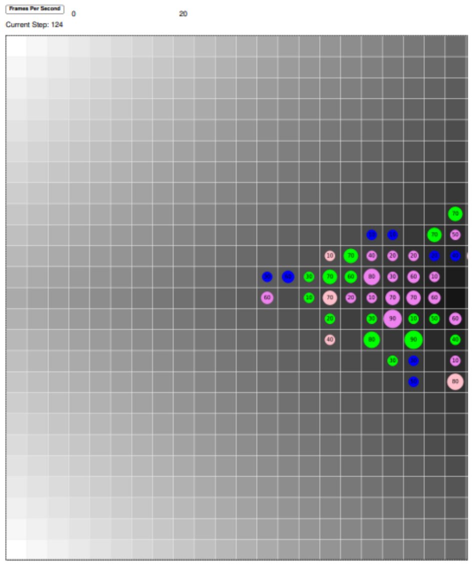


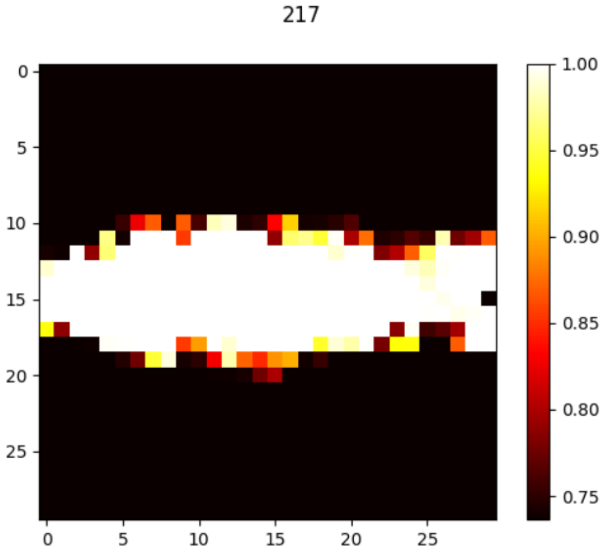
Influence of **kO** on macroscopic structures

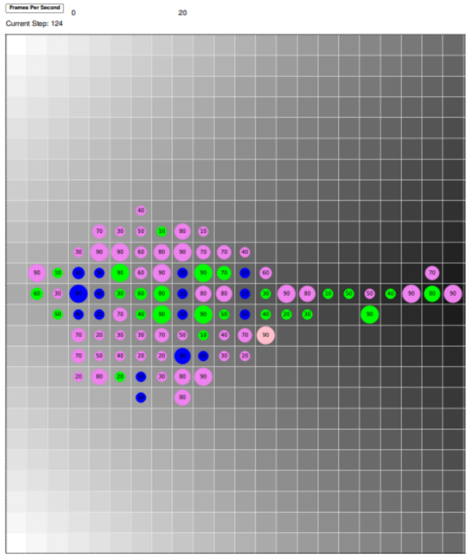
Top: high **kO** allows agents to form cones

Bottom: low **kO** forms a queue









Thank you for your attention.