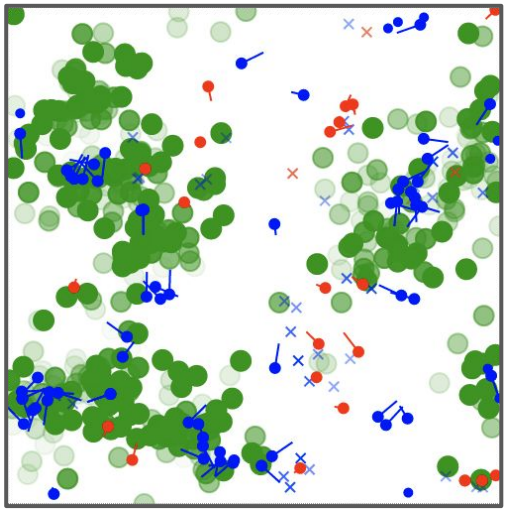
University of Amsterdam
Informatics Institute

Herding prey in an Agent-Based Model



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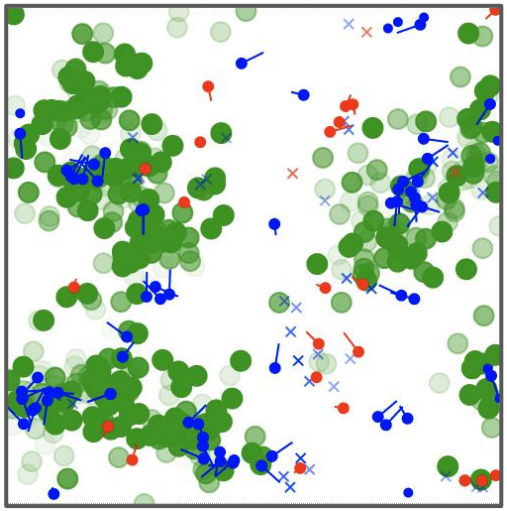
Motivation

- **Why an ABM?**
- **Why this problem?**
- **Research question**
  - In what way does herd mentality improve the survival rate of prey in an agent-based prey-predator model?

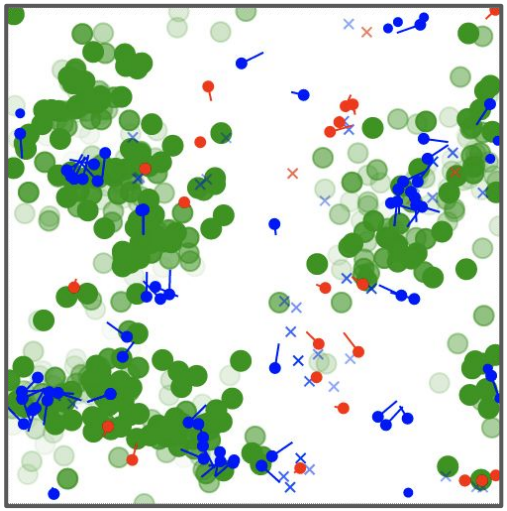
Entities

- **Prey**
  - Gains energy from grass
  - Low energy: search for grass
  - High energy: reproduce
- **Predator**
  - Gains energy from eating lonely prey
  - Low energy: search for prey
  - High energy: reproduce
- **Grass**
  - Generated during startup
  - Depletes when eaten, regrows in same spot.



Environment

- **Continuous space**
  - 500x500
  - torus
- **Discrete time**
  - perform action very step.
- **Stochastic**
  - Incorporate random animal behavior

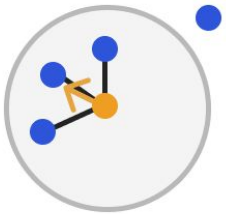


Prey movement

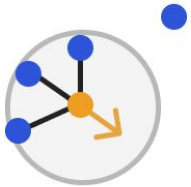
- Inspired from Boids model[1]
- Direction determined by 4 elements

[1] Reynolds, Craig W. "Flocks, herds and schools: A distributed behavioral model." *Proceedings of the 14th annual conference on Computer graphics and interactive techniques*. 1987.

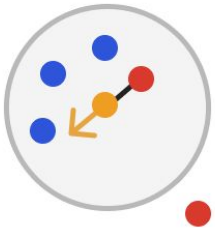
Prey movement



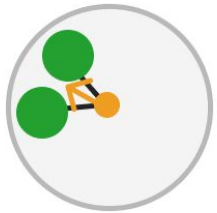
Coherence
Move towards other prey



Separation
Move away from very close prey



Separation from predators
Move away from predators



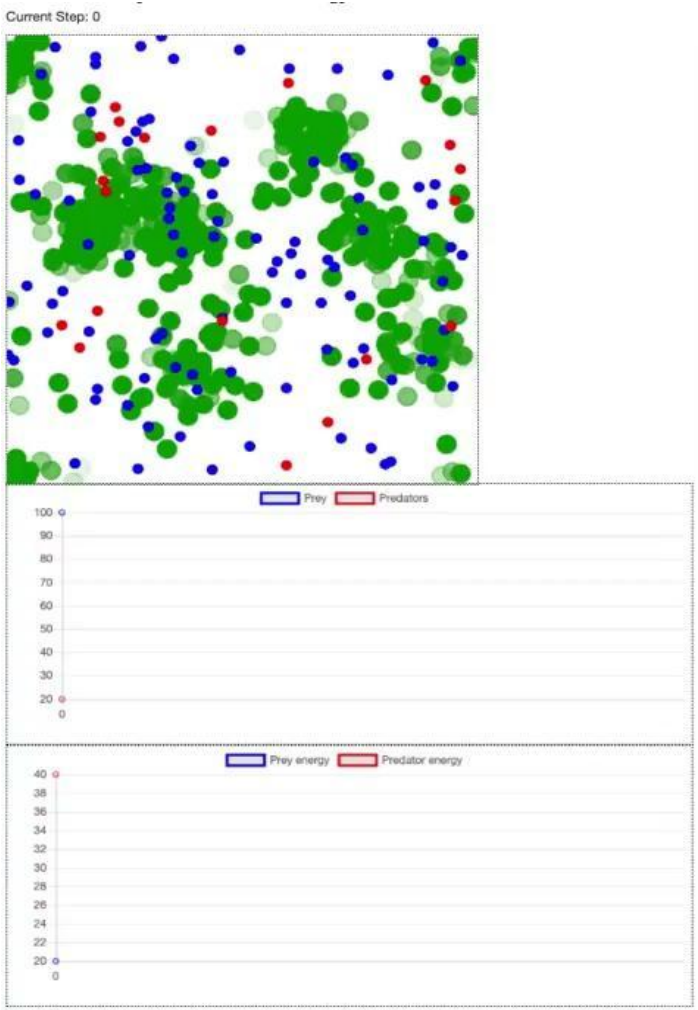
Food search
Move towards food

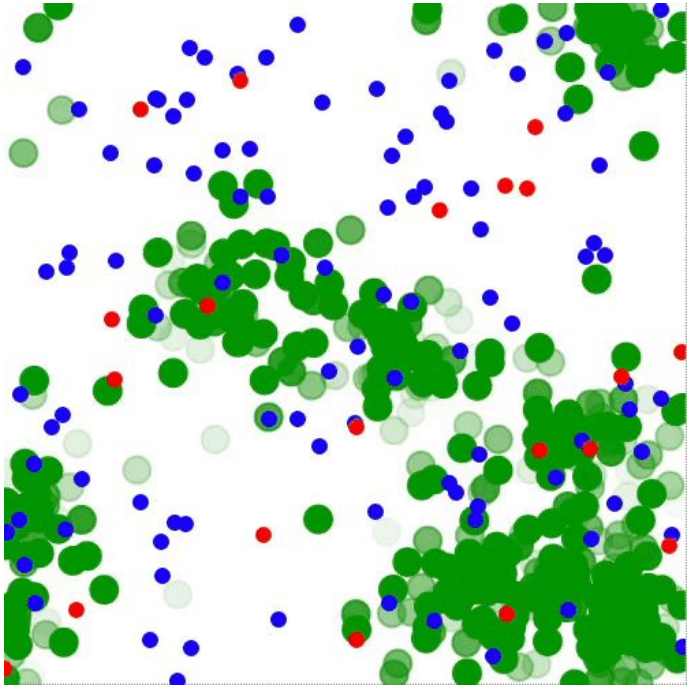
Prey movement

```
direction = prey_coherence_factor          * cohere_vector +
            prey_separate_factor           * separate_vector +
            prey_seperate_predators_factor * separate_predators_vector +
            prey_food_search_factor        * food_search_vector
```

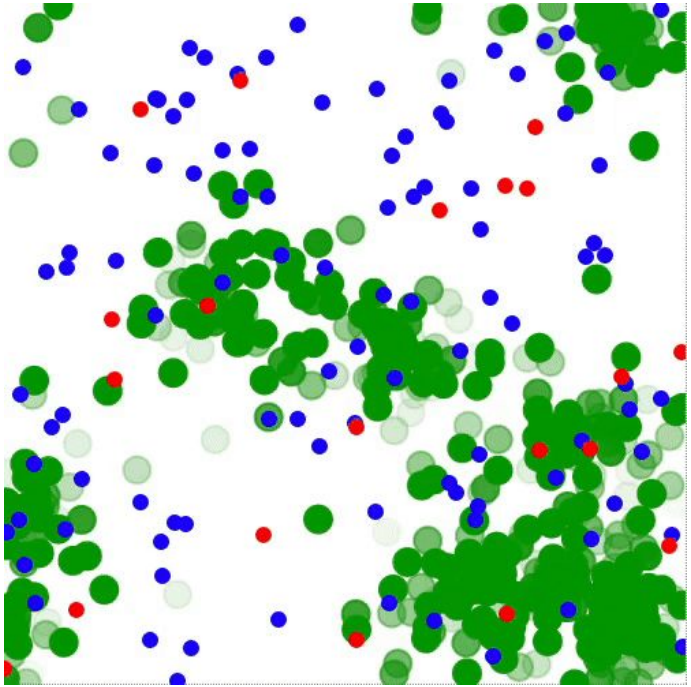
Example run observations

- **Prey**
  - Herding
  - High reproducibility
  - Fleeing from predators
  - Staying as much as possible around grass
  - Survive around 300 time-steps using herding
- **Predator**
  - Hunt for prey
  - Scattered around the environment
  - Reproduce quickly as they find their food source





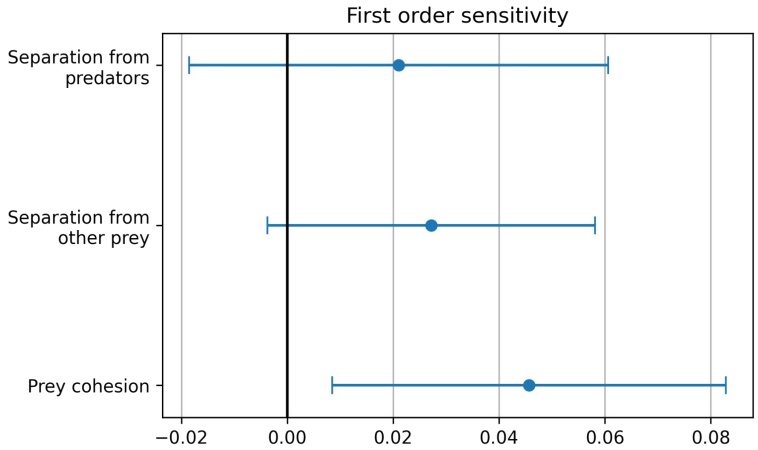
Without herding

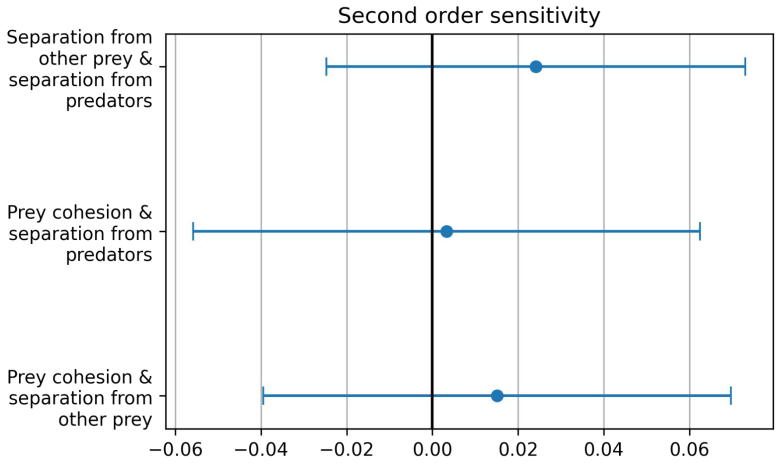


With herding

Global Sensitivity Analysis

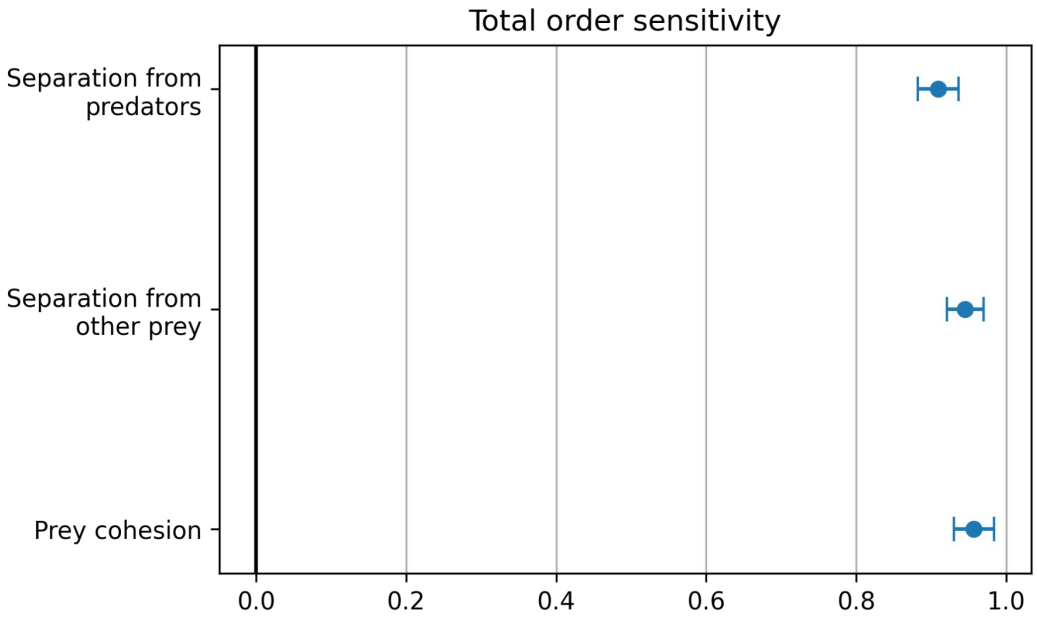
- Only parameters relevant to research
- Other parameter values kept constant
- 512 distinct samples, 10 iterations
- Variance in survival rate of prey





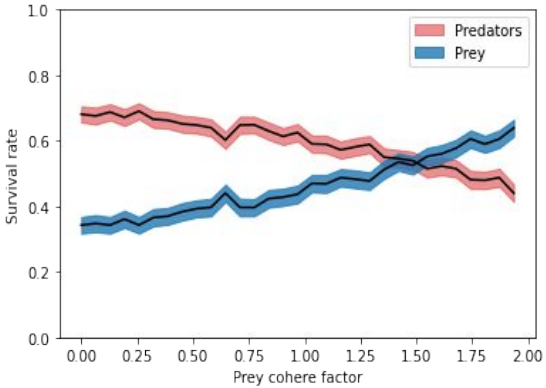
Global Sensitivity Analysis

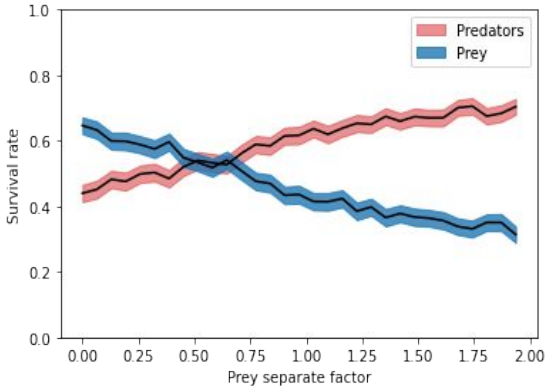
- Total order close to 1 - all parameters play a role
- Third order interaction dominant

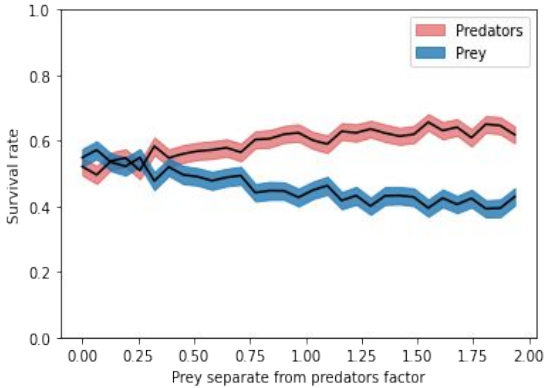


Results

- Same data used as global sensitivity analysis
- Survival rate: rate of simulations where the species survive







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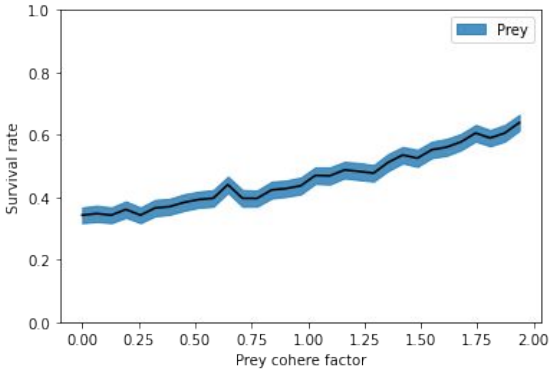

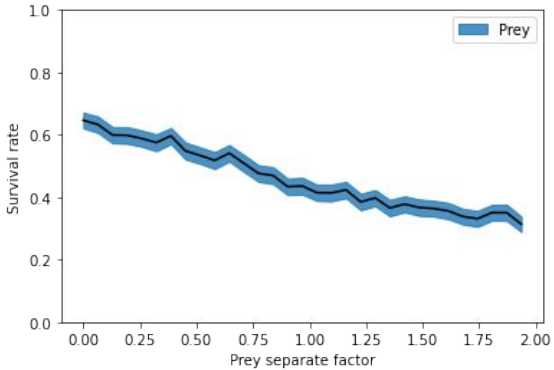

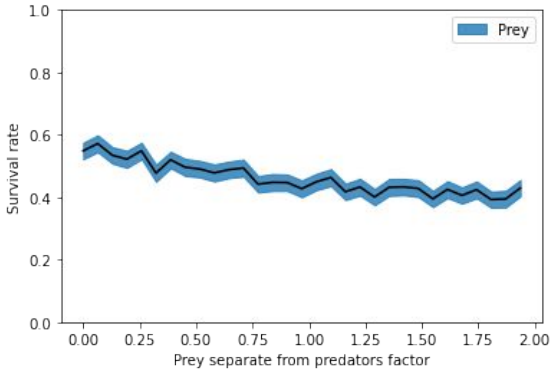

Conclusion & Discussion

- Herd mentality advantageous for survival
- Herds are sustainable
- More important to stay in herd than to run away

- Future work:
  - Individual based factors
  - Evolutionary model, what behaviour would emerge?

Questions?