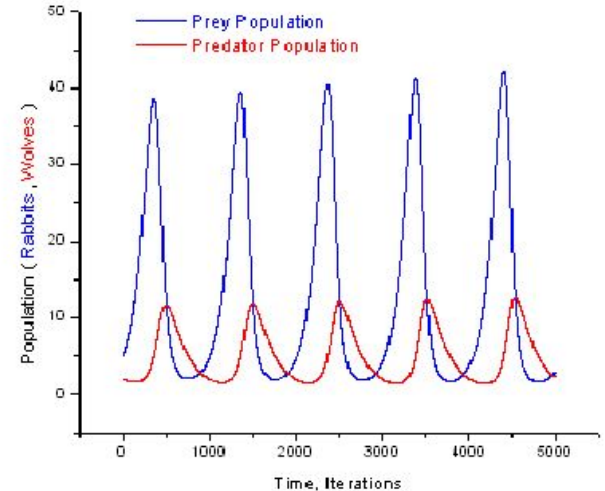# Assignment 2

Gr. King

Recap

Lotka-Volterra Models

- Used to describe evolution in N discrete random vars (Malcai et al., 2002) – here, 2

- Ecological dynamics between populations

- Optimal state: Stable Cooexistence

Purpose of Simulations

- Gain deeper understanding of the nature of the model
- Explore the model's behavior under different scenarios:
  - Energy vs energy free
  - Flocking vs no flocking (in rabbits)
  - Infer any relation to performance

Research Question, Hypothesis

RQ: Does flocking behavior in prey influence the performance of a competitive predator-prey Lotka-Volterra model?

Hypotheses:

H_0: Flocking behavior has no impact on the model's overall performance

H_A: Flocking influences the model's overall performance in some way

Methodology

Recap Methodology

Energy-free

Config:

- Init populations & params (fox death, reproduction, and predation rate, rabbit birth rate)

Fox Class:

- Wander until encounter rabbit, when in proximity, chance to kill
- If it kills, reproduce
- Die randomly from natural causes (age)

Rabbit Class:

- Wander randomly, reproduce occasionally

Energy

Config:

- Same params mostly, but also: init energy, energy from rabbit, reproduction energy cost

Fox Class:

- Wander until rabbit, when close, chance to kill
- If kills, replenish energy
- No energy (depletes w time) → death
- Random death from natural causes (age)

Rabbit Class:

- Same as other ver, but every 10 seconds without reproducing, raise p to 0.5 and try again
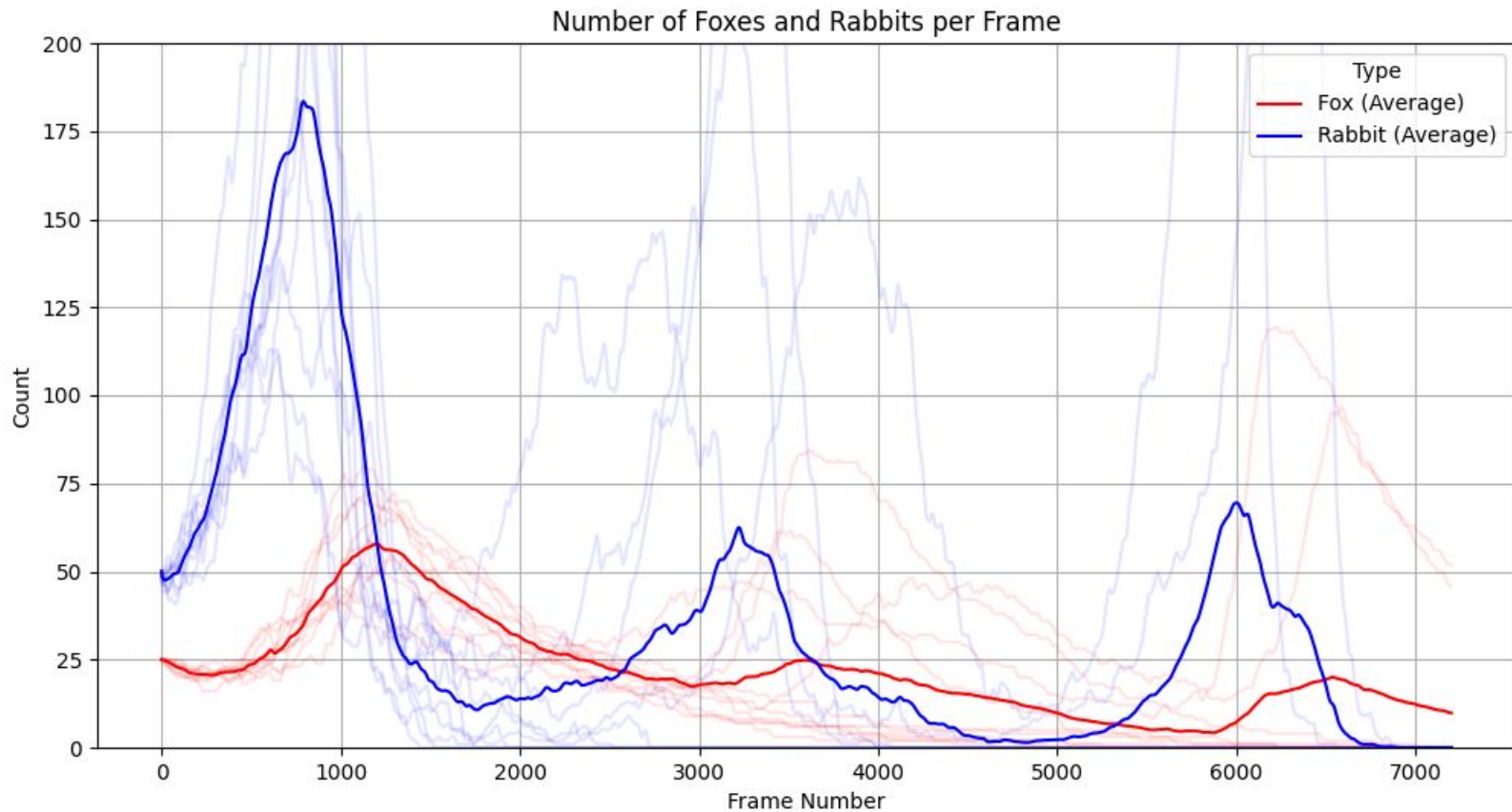
Flocking

Additions:

- Added Cohesion behaviour
  - Rabbits flock together to a "center of mass"

- Added Separation behaviour
  - Rabbits redirect themselves if they are too close to one another

- Added Alignment behaviour
  - Rabbits align themselves in an average direction based on the direction of each bird.

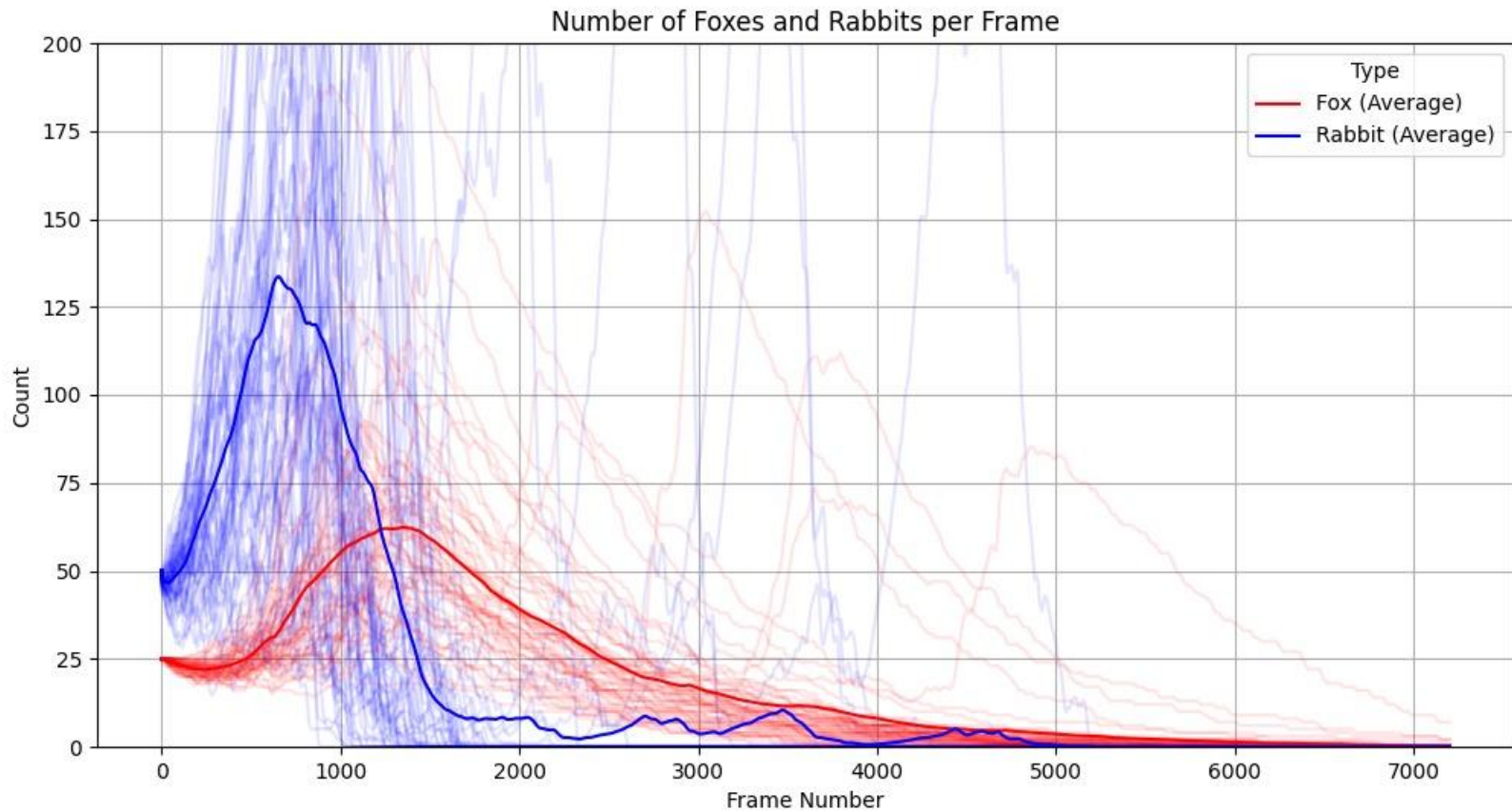- Added weight parameters to influence their impact on the rabbits.
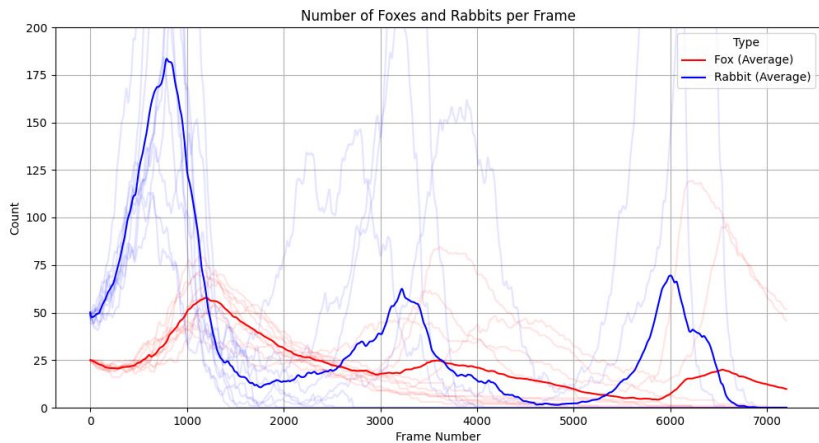
Results

Energy, no flocking

Number of Foxes and Rabbits per Frame

Energy, flocking

Number of Foxes and Rabbits per Frame

Comparison

Energy, No Flocking

Number of Foxes and Rabbits per Frame


```
fox_initial_energy: float = 20
fox_energy_from_rabbit: float = 10
fox_reproduction_energy_cost: float = 100
rabbit_birth_rate: float = 0.4
fox_natural_death_rate: float = 0.05
```

Energy, Flocking
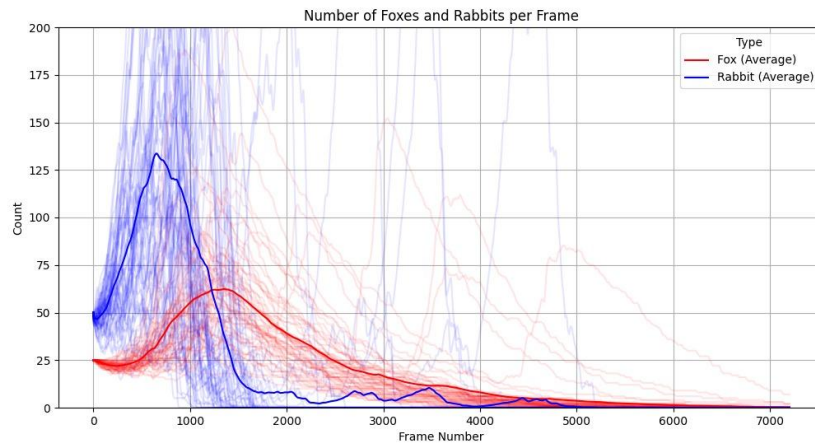
Number of Foxes and Rabbits per Frame


```
fox_initial_energy: float = 20
fox_energy_from_rabbit: float = 10
fox_reproduction_energy_cost: float = 100
rabbit_birth_rate: float = 0.4
fox_natural_death_rate: float = 0.05

alignment_weight: float = 1.0
cohesion_weight: float = 0.5
separation_weight: float = 0.6
```
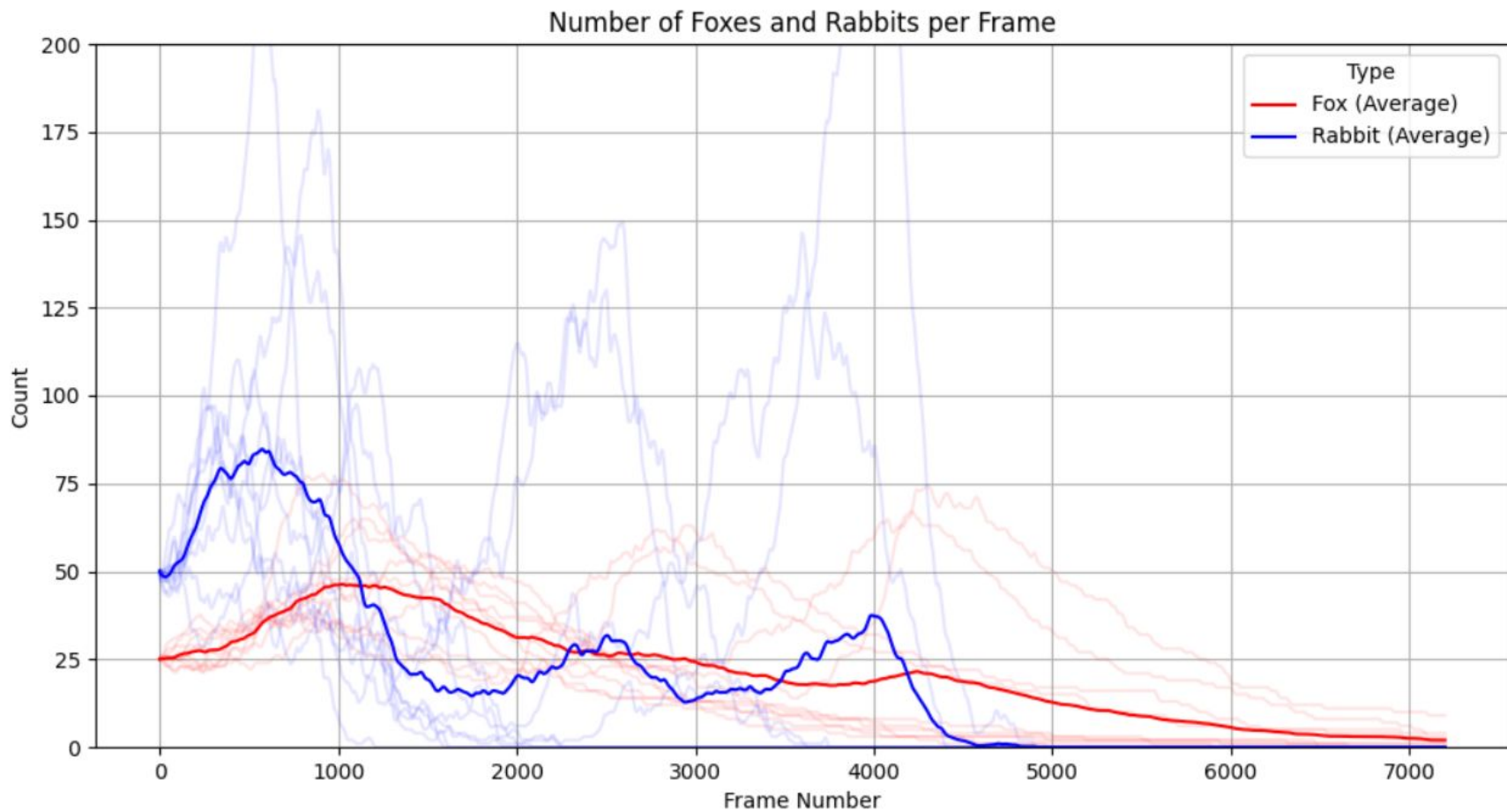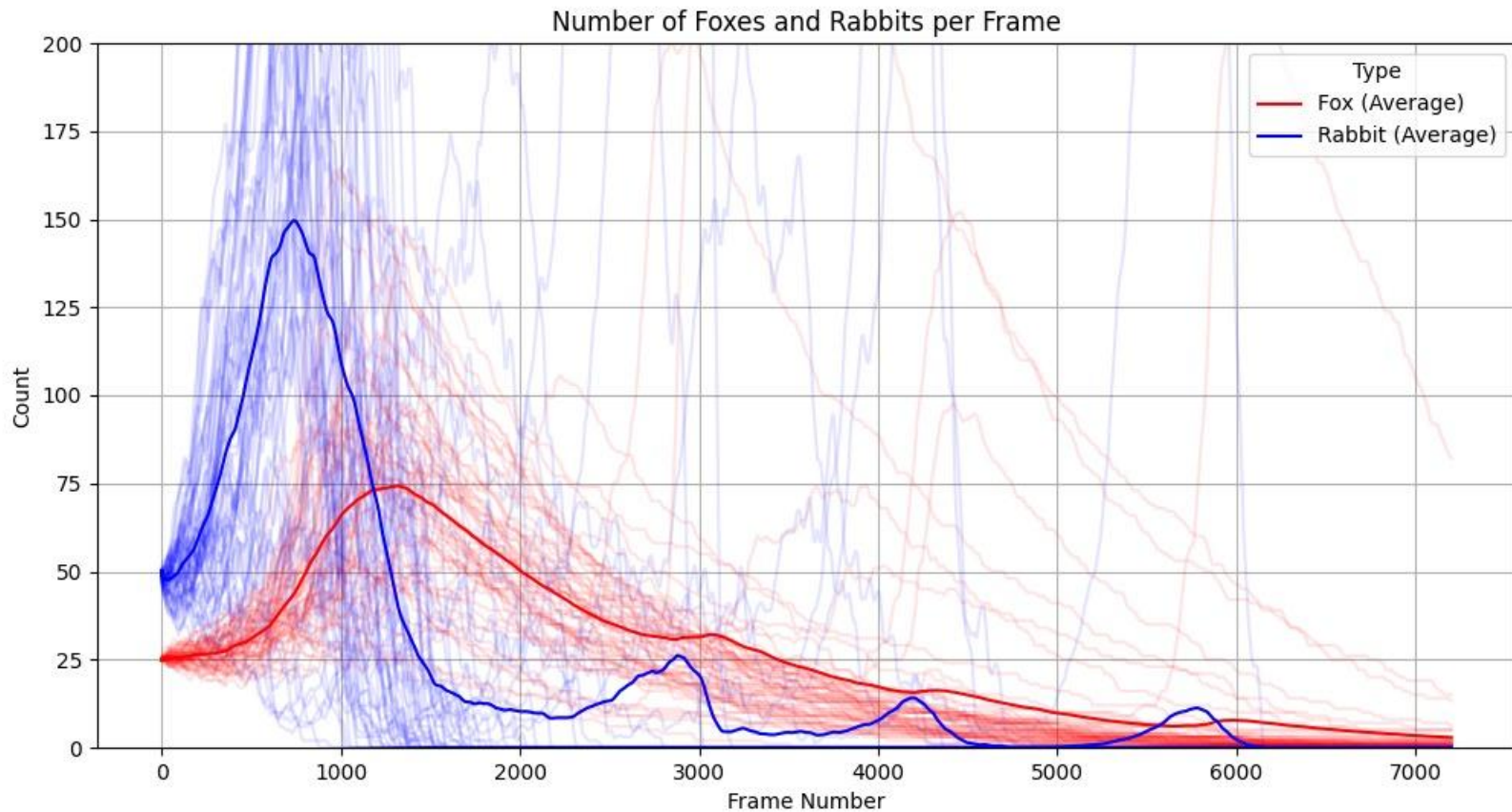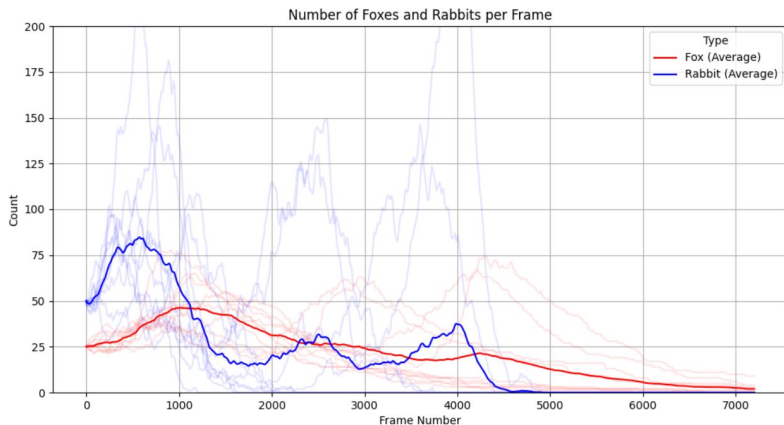
Energy-free, no flocking

Number of Foxes and Rabbits per Frame

Energy-free, flocking

Number of Foxes and Rabbits per Frame

Comparison

Energy-Free, No Flocking

Number of Foxes and Rabbits per Frame

```
rabbit_birth_rate: float = 0.4
fox_natural_death_rate: float = 0.05
predation_rate: float = 0.4
fox_reproduction_rate: float = 0.1
```

Energy-Free, Flocking

Number of Foxes and Rabbits per Frame
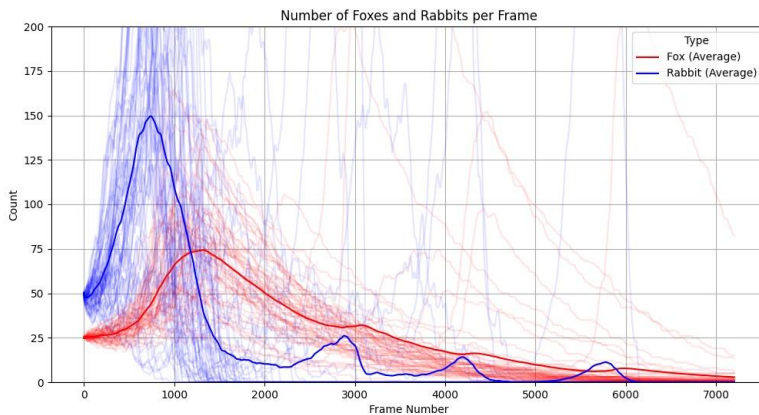
```
rabbit_birth_rate: float = 0.2
fox_natural_death_rate: float = 0.06
predation_rate: float = 0.12
fox_reproduction_rate: float = 0.08

alignment_weight: float = 1.0
cohesion_weight: float = 0.5
separation_weight: float = 0.6
```

Research Question, Hypothesis

RQ: Does flocking behavior in prey influence the performance of a competitive predator-prey Lotka-Volterra model?

Hypotheses:

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Conclusion

Conclusion

- Flocking → Increased Variance
  - Difficult to assess true average performance

- Flocking → More deterioration of populations in general
  - More peaks in the flocking-free versions
  - Flocking – smoother drop in numbers

- Overall, the implementation of flocking behavior seems to hinder Lotka-Volterra predator-prey model performance
  - Therefore, as referenced before, flocking does have an effect on the performance of the predator-prey model

Future Work/Research

- Parameters, Parameters, Parameters

- Adding additional features:
  - Rabbits having an energy function (grass)
  - Sexual reproduction for foxes and/or rabbits

  Subjectively, most interesting to further research and delve into

- Finding statistical significance / difference between the simulations
  - Can be done by measuring how long populations last in the different scenarios.

Bibliography

Malcai, O., Biham, O., Richmond, P., & Solomon, S. (2002). Theoretical analysis and simulations of the generalized Lotka-Volterra model. *Physical Review. E, Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics*, *66*(3).

Pont, M. T. S., Chamizo, J. M. G., Mora, H. M., & Pascual, J. M. (2013). *Resilience modeling by means of a set of recursive functions*. https://doi.org/10.1109/dsnw.2013.6615536