A photograph of a large flock of white sheep grazing in a green pasture. In the background, there is a line of tall, thin trees under a clear sky.

Sheep Flocking with Predator using Boids Model

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Project Description

- Simulate sheep and sheepdog
- Agent-based simulation using Boids model
- Goal
 - Exam how well a sheepdog form a flock of sheep
 - Vary number of sheep per sheepdog
 - Vary frequency of sheepdog barking

Model

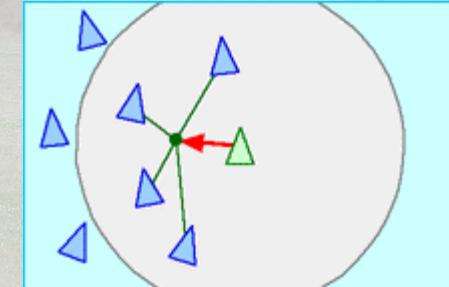
- Boids Model: model of coordinated animal motion
 - Such as bird flocks and fish schools



Boids Model

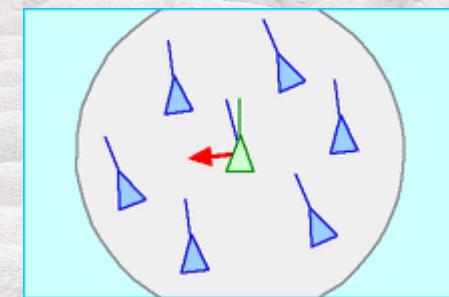
- **Cohesion**

- They want to get closer to their friends.
 - Get closer to the center of mass



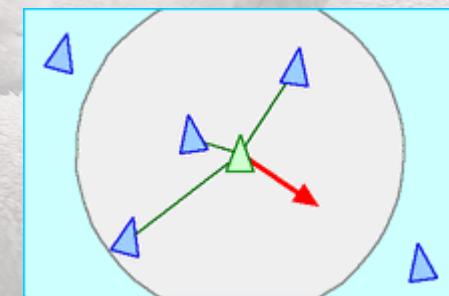
- **Alignment**

- They want to go to the same direction with their friends
 - Align direction of velocity vector



- **Separation**

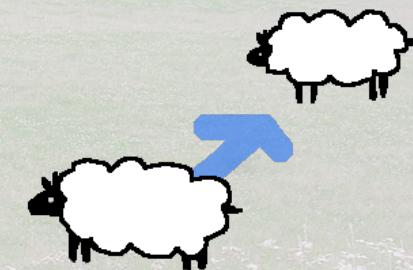
- They want to avoid getting too close to their friends.
 - If too close to any friends, get farther.



Each feature is adjusted by a parameter (modifier)

Our Model -Boid Parameters

- Applied Boids to three different relationships
- **Sheep from other Sheep**



- **Sheep from Sheepdog**
 - Cohesion parameter = negative
 - Alignment parameter = zero

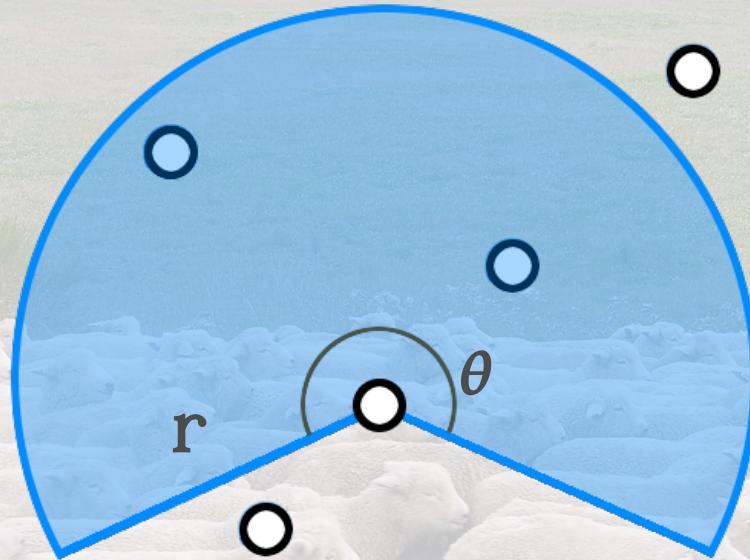


- **Sheepdog from Sheep**
 - Cohesion parameter = strong



Our Model -Other parameters

- Sights



- Max Speed

V_{max} (sheep)



V_{max} (dog)



Our Model -State of Agents

- Each sheep and sheepdog has multiple states
- **State of Sheep**
 - Normal
 - Agitated (frightened by sheepdog: dog too close or dog barked)
 - Cohesion and alignment from sheep stronger
 - Cohesion from wolf more negative
- **State of Sheepdog** (all from user input, like dog owner's orders)
 - Normal
 - Stop
 - Slow down
 - Move closer to sheep
 - Return Home
 - *Bark (agitate all the sheep)*
 - Rotate to left of stock
 - Rotate to right of stock

Simulation Flow

```
While(true):
    For each agent (a):                                // agents = sheep and sheepdog
        Update_state(a)
        Update_boids_modifiers(a)

    For each sheep (s):                                // update sheep velocity/position
        v1 = cohesion_sheep-sheep(s)                   // each v is from normal distribution
        v2 = alignment_sheep-sheep(s)
        v3 = separation_sheep-sheep(s)
        v4 = cohesion_sheep-dog(s)
        v5 = alignment_sheep-dog(s)
        v6 = separation_sheep-dog(s)
        s.velocity = s.velocity + v1 + v2 + v3 + v4 + v5 + v6
        s.position = s.position + s.velocity * Δt

    v1 = cohesion_dog-sheep(dog)                      // update sheepdog velocity/position
    v2 = alignment_dog-sheep(dog)
    v3 = separation_dog-sheep(dog)
    dog.velocity_new = dog.velocity_old + v1 + v2 + v3
    dog.position = dog.position + s.velocity * Δt
```

Experiment

- How well sheepdog makes a flock of sheep?
 - Can be measured by standard deviation of sheep position away from center of mass
- We varied how often the sheepdog barks

Data so far

- n



A photograph of a large flock of white sheep grazing in a green pasture. The sheep are densely packed, filling the frame. In the background, there is a line of tall, thin trees under a pale, overcast sky.

Time for a simulation

Conclusion

- So far
 - We experimented with frequency of barking
- Next step
 - Vary other properties to exam more
 - Number of sheep, Boids parameters, etc
 - Validate our data comparing with some paper of sheep behavior