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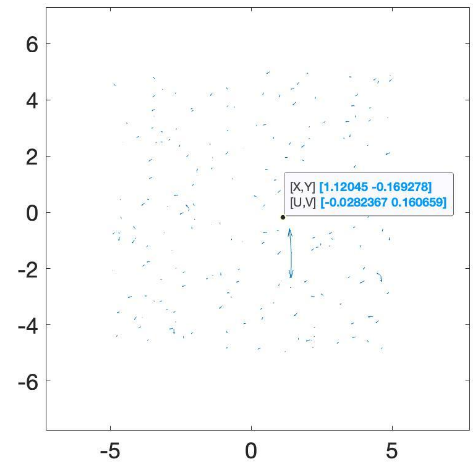
CSCI 4314

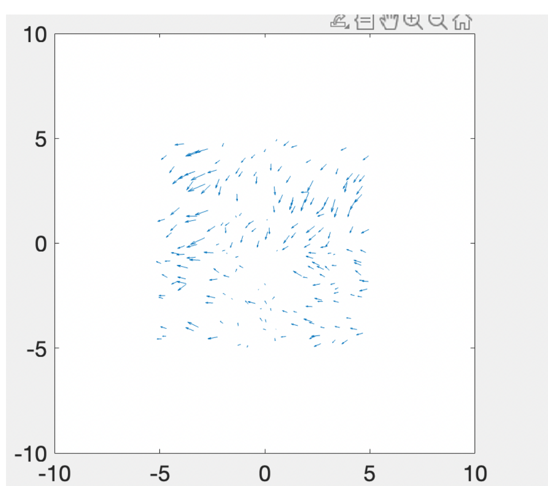
(1) Scaling Factor

(a) <u>Attraction Scaling Factor</u> *(c1)*

(i) We notice that when we decrease the attraction scaling factor, say to 0.00000001, the flock becomes less uniform and is more spread out; there are large widths between individuals. This is because, by reducing the attraction factor, the individuals are not pulled to the center thus further away from one another. This makes it harder to achieve velocity alignment

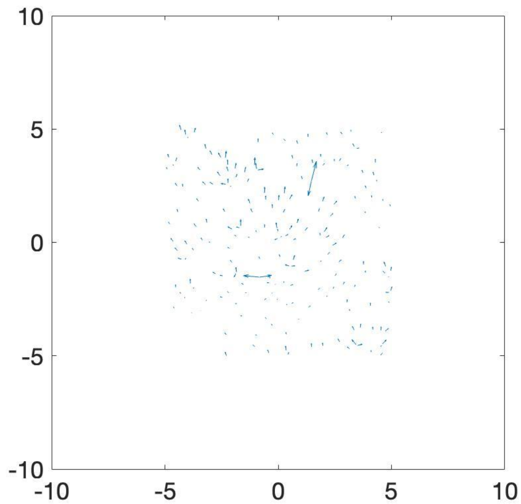


(ii) When we increase the attraction scaling factor to 0.01,we notice that the flock moves in a spiral formation and collides, because individuals are greatly attracted to each other. This circular formation is the result of high attraction.

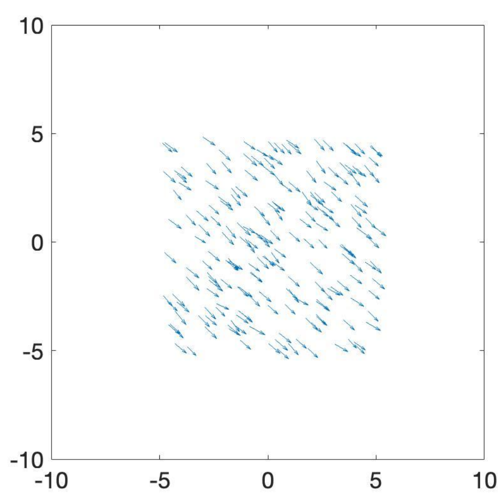


(b) <u>Repulsion scaling factor (*c2*)</u>

(i) When we increase the repulsion scaling factor, we see a similar behavior as when we decrease the attraction scaling factor (*c1)*: the flock is spread out and not positioned uniformly. Also notice that the vectors themselves are pointing in the opposite direction, which is the direct effect of repulsion. This makes it harder to achieve velocity alignment

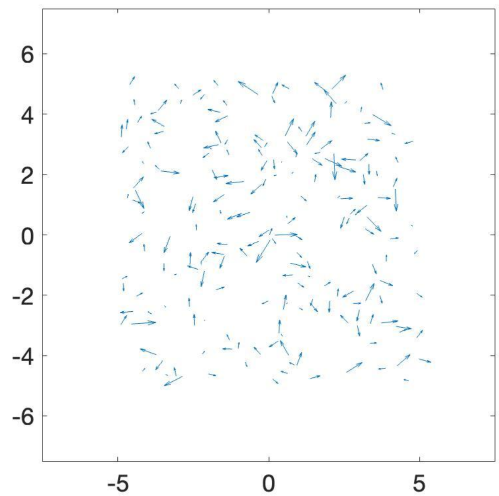


(ii) When we decrease the repulsive factor, we see a similar behavior as when we increase the attraction factor: the flock is closer together and **colliding** with each other and creating crowds of boids.

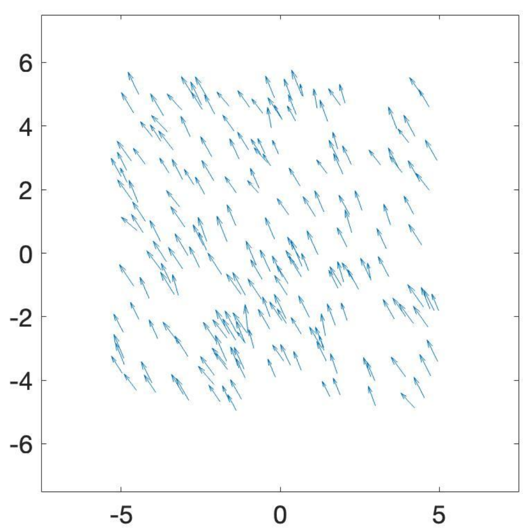


(c) <u>Heading Scale Factor</u> *(c3)*

(i) When we <u>decrease</u> *c3* we see no velocity alignment and the flock individuals have no uniform behavior. The cluster of boids is out of alignment, because the boids are not **steering** towards the average heading of local boids. Thus we see a cluster of vectors pointing in different directions.

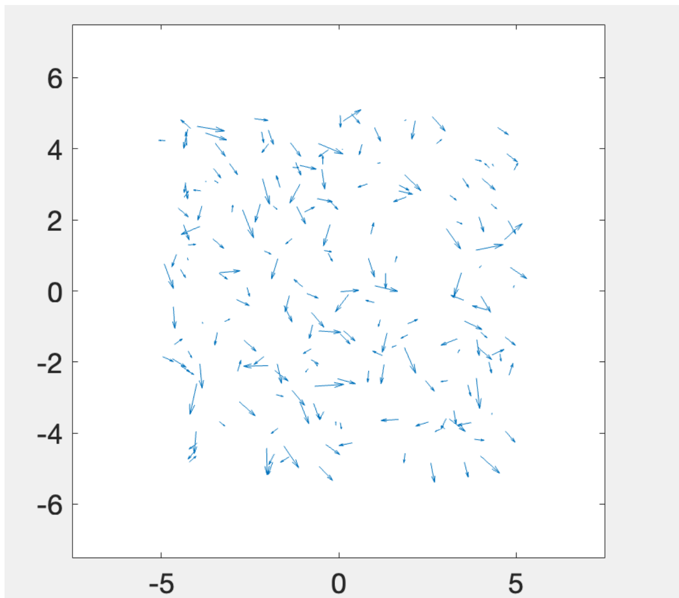


(ii) When we <u>increase</u> c3, we notice a strong alignment between all the boid vectors. This is a direct effect of increasing our alignment factor as it makes individual boids steer (shift velocity) highly towards the local average heading of the flock

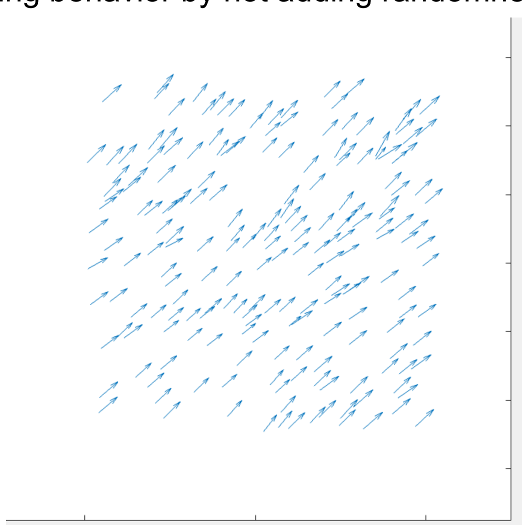


(d) Random Velocity *(c4)*

(i) When we increase the random velocity scaling factor, we notice a similar effect as when we decrease the alignment: the boid vectors pointing in random directions because we have added randomness to the acceleration of the boids.

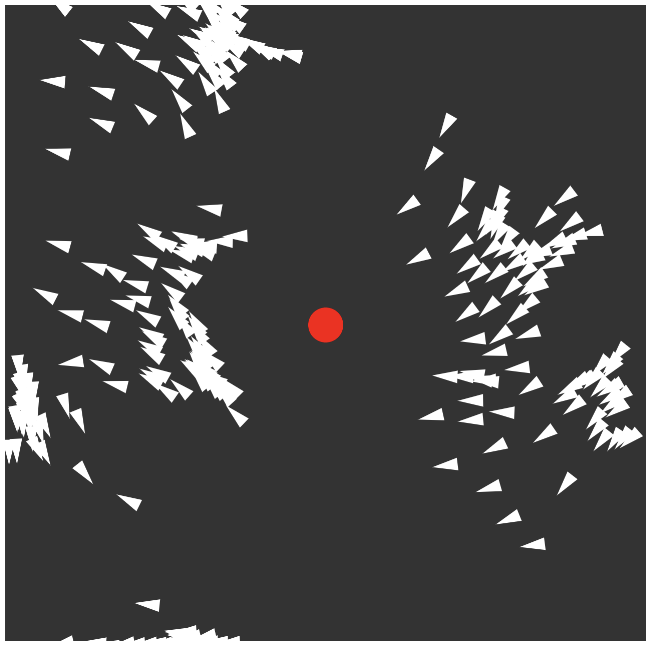


(ii) When we decrease the random velocity scaling factor, we do not see a noticeable change in the flocking behavior; it is rather uniform as before. This is because we are not changing the behavior of the flocking behavior by not adding randomness.



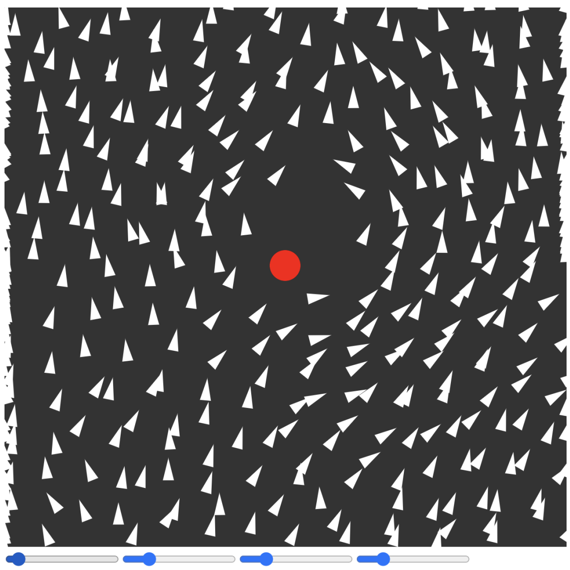
(2) Introducing Obstacles

Note: For this part I use my JavaScript simulation, as it was easier to merge the flock and obstacle using classes. Notice that there are local flocks, rather than one huge flock. This is necessary to visualize how local flocks influence other local flocks. I use a specified radius to define a local flock



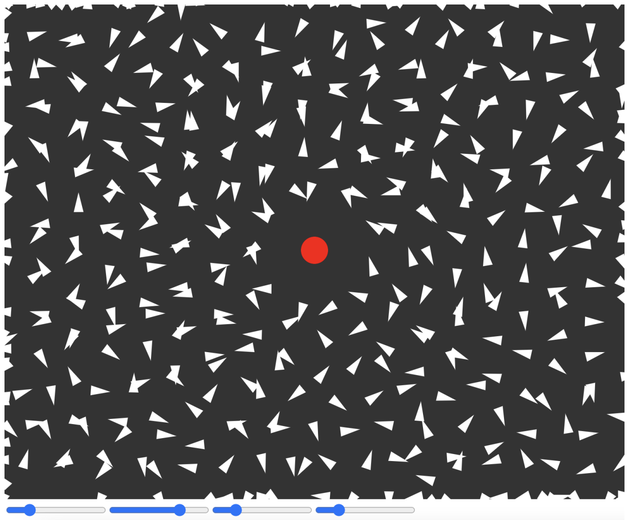
The emergent behavior of the flock when adding this obstacle is that the flock will continue to stay together while avoiding the obstacle. With a low attraction scaling factor, the boids are more spread out and simply circumvent the obstacle without regarding the rest of the flock. With a high attraction scaling factor the boids stay close together:

<u>Decrease Attraction:</u>

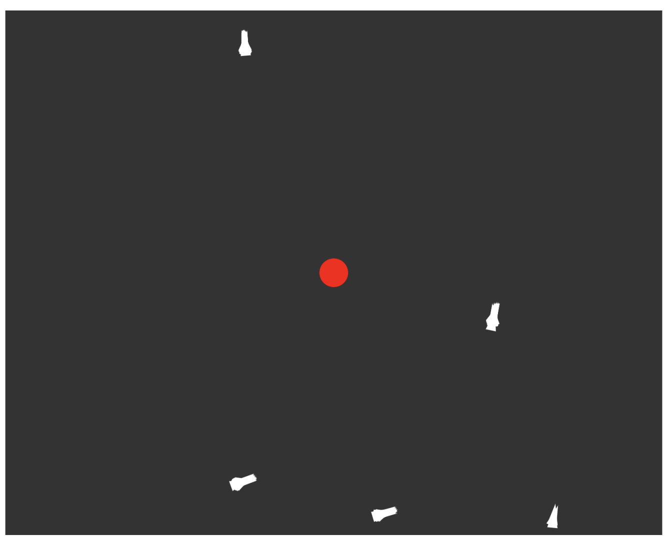


<u>Increase Attraction:</u>

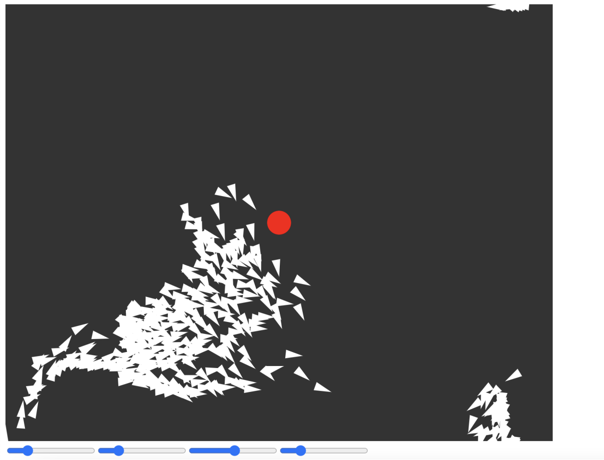
Increase Repulsion:



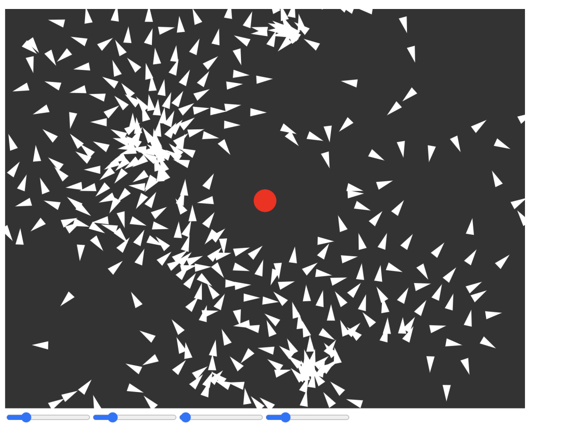
Decrease Repulsion (crowding of local flocks)



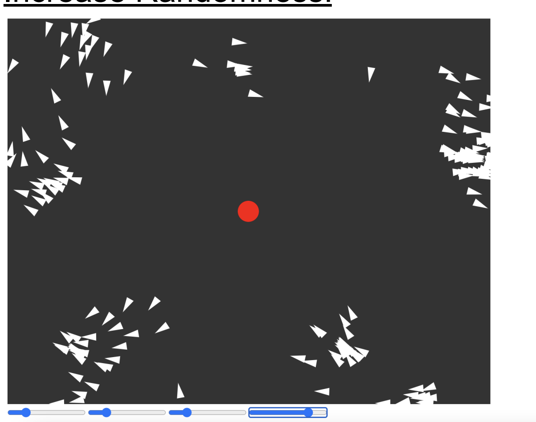
Increase Alignment:



Decrease Alignment:



Increase Randomness:



Decrease Randomness:

No noticeable change, because not adding randomness will not affect the behavior of a boid flock. The three main components are attraction, repulsion, and alignment.

Paper Review

Solving the shepherding problem: heuristics for herding autonomous, interacting agents

1. **What do you feel the main contribution of this paper is?**

The main contribution of this paper is to propose a model/algorithm that answers the question of how flocks use heuristics induced by a single agent to make individual decisions, which in turn affect other individual behavior and produce a homogenous herd. This paper also explores how the shepherd agent uses a self-propelled algorithm to gather the flock towards a destination.

Since there is not much information on what algorithm/model is used by shepherding agents, this paper aims to research this phenomenon.

2. **What's the essential principle that the paper exploits?**

This paper exploits how determining factors such as repulsion, attraction, and adaptive switching between collecting agents are key heuristics used in shepherding and provide a model that can predict flocking movements relative to the individual agents and the single shepherd agent (pretty cool). The algorithm proposed is if the shepherd is within 3r_a from any flocking agent, it will not move at the current time step. Otherwise, the shepherd will either:

- Aim towards the driving position (P_d) directly behind the flock relative to the target, that is if <u>all</u> the agents are within a distance *f(N)* from their global center of mass. This is called driving behavior.
- Aim for the collecting position (P_s) directly behind an agent, if there is at least one agent that is further away than *f(n)* from the global center of mass. In essence, the shepherd is collecting agents that are far away from the rest of the flock.

Collecting can be visualized by zig-zag movement while driving can be visualized by straight movement. All of this, however, is determined by the adaptive switching of the shepherding agent, as this behavior reduces the probability of the herd splitting up and allows the shepherd to move the flock towards the target. In other words, the shepherd uses cohesiveness as a heuristic to guide the flock.

3. **Describe one major strength of the paper**

This paper does an excellent job of highlighting the true behavior of animal herding in response to threat, which was the ultimate goal. This behavior is modeled in a way that simplifies the mathematical calculations and summarizes the response through heuristic measures. It gives the reader a comprehensive understanding of behavior of the flock through the proposed algorithm. This paper also provides implications of how robots based agents could be used for herding.

4. **Describe weakness of the paper**

This study could have utilized control groups to address their algorithm failure. Since this study only focused on a flock group of 46, it is hard to analyze the point of failure without control groups.

5. **Describe one future work direction you think should be followed.**

As stated in the paper's discussion, future work can be targeted to gather further evidence using eye-tracking systems to determine shifts in the dog's visual attention. This would provide evidence of another heuristic such as peripheral vision. Other work could conduct experiments with multiple dogs and how this would improve herding performance. Researchers could also analyze how predators move when targeting a tightly packed flock, and how they isolate flock members from one another.