Lab exploration 7: Self-organizing systems II: Swarming
Math 309 Fall 2022
Deadline: 14 November

- Conduct experiments as indicated.
- **Journal entry.** Respond to each of the "journal queries." Using *concise and clear sentences*, incorporate data, symbols, and illustrations into your text. Have an audience in mind. Focus on *developing* an explanation or argument that stems from your simulations.
- Submit 300-400 words double-spaced to the Beachboard dropbox.
- **Recommended.** Work in groups of 2 or 3. Submit one journal entry for the group.
- **Suggestion.** Before running the simulations, read the "What is it?" and "How it works" sections under the Info tab.

Model: Flocking. (Location: Models Library/Biology.) Here we have a model for flocking birds, schooling fish, or what?? The parameter settings are:

> vision: how far a bird can see
>
> minimum-separation: how close two birds can be
>
> max-align-turn: how sharp of a turn a bird can make in order to match its direction with that of a nearby bird
>
> max-cohere-turn: how sharp of a turn a bird can make in order to move toward a nearby bird that's not too close
>
> max-separate-turn: how much of a turn a bird can make in order move away from a bird that's too close.

Try testing the parameter settings for turns by putting two of the parameters at zero and the third at the maximum value. Run a simulation with two birds and observe the results.

7.1 Journal query.

Experimentally find a setting for the turning parameter values so that two birds will fly in a "loop" with one chasing the other. With the parameters set, gradually increase the number of birds. Does the loop flying behavior persist? (You might have to let the simulation run for a bit.) If so, to what extent does the looping occur? If not, when—in terms of number of birds—does it disappear entirely?

7.2 Journal query.

Keep the turning parameters as they are and now let the number of birds be fairly large—at least 100. Does the flocking behavior look realistic? Why or why not? Can you get more realistic-looking action by reducing vision and minimum-separation values? Briefly explain what you find.

Model: Ants. (Location: Models Library/Sample Models/Biology.)

This model simulates an ant colony whose members forage and gather food. Beginning at the nest (colored region at the center), ants disperse randomly as they search for food (the three colored regions). When a piece of food is discovered, the ant collects it and then immediately carries it to the nest. As the ant travels to the nest, it leaves a pheromone trail that other ants can follow. The speed with which the pheromone spreads (diffusion-rate) as well as the length of time it takes the chemical to evaporate (evaporation-rate) are variable settings.

The task is to optimize the time required to collect all the food; that is, find the minimum number of time steps (ticks) that a fixed population of ants takes to gather the food. Set the population at 100. You have two parameters to adjust: diffusion-rate and evaporation-rate. The idea is to set one of the rates at a fixed value and then vary the other rate—say, by five units at a time—from one extreme to the other. Then increment the value of the first rate—again, by five units—to a new fixed value and then vary the second rate as before. For each pair of settings, record the rate values and the amount of time (ticks) it takes for the ants to gather all of the food.

7.3 Journal query.

Display the data in a table showing the values for the two rates and the completion time for those rates. It would be a good idea to take several runs for a set of rate-values and then take the average. What rate-values produce the lowest completion times?

7.4 Journal query.

Briefly discuss the interplay between pheromone diffusion and evaporation that might explain your findings.

Model: Termites. (Location: Models Library/Sample Models/Biology.)

The behavior here is simple: a number of termites wander randomly in a space a certain percentage of which is occupied by wood chips. When a bug bumps into a chip, it picks up the chip and carries it around—again, in a random fashion—until it makes contact with another chip at which point it drops the chip next to the one it just ran into. Then it goes off to repeat the process.

7.5 Journal query.

Run the model with density at 10% and number at 200. Since the emergent properties can take a while to appear, you might want to run at a faster rate. After it's run for a while—something like 15-30 minutes, does a stable state emerge? What is it? Can you be sure that it's truly stable?

7.6 Journal query.

If, at some point, there are just two piles remaining—one larger than the other, how should the system evolve? Do you expect one pile (which?) to shrink and the other to grow?