Lab exploration 6: Self-organizing systems II: Cascades & flocking
Math 309 Fall 2016
Deadline: 12N Friday 18 November
Late deadline: 12N Friday 2 December

- 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 2-3 pages double-spaced in **hard copy**.
- **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.

6.1 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?

6.2 Journal query.

Keep the turning parameters as they are and now let the number 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: Sandpile. (Location: Models Library/Chemistry & Physics.)

The model simulates the dynamical behavior of an idealized 3-dimensional sandpile: when the number of grains on a cell reaches four, a slide occurs in which the four grains are distributed to the four adjacent cells. The grains-per-patch value determines how many grains of sand are placed on each cell when setup uniform is selected. Note that each cell gets the same initial number of grains. The color of a patch—from dark to light—indicates the number of grains it contains—from 0 to 3.

6.3 Journal query.

Start with each cell having no grains and run the process with drop-location: random selected. Let things run until some significant slides (called avalanches in the model) occur. (Since this can take a large number of steps—equal to the number of grains placed, you might want to speed up the process.) You can see the slides by switching on animate-avalanches. Check the plots of Avalanche sizes. How closely do the data conform to a power law?

6.4 Journal query.

Put three grains on each cell and set the process to drop grains on the cell at the center. Before hitting go once, try to predict what will happen when the grain drops. Continue to drop grains manually and look for patterns to emerge. Does it make sense to call the state of the system *critical* at this stage? Is the behavior here similar to what takes place when water freezes?

For fun: In automatic drop mode, let the process continue for many steps—say around 10,000.

6.5 Journal query.

Start again with a uniform distribution of three grains. Now drop grains randomly and repeat for many steps and slides. What sort of configuration eventually emerges? Briefly explain.

6.6 Journal query.

Briefly discuss some ways in which the sandpile model exhibits behavior that's similar to what occurs in biological evolution. In particular, what role might the transition to a critical state play in species change?

Model: Fire. (Location: Models Library/Earth Science.)

The model follows a simple rule for the spread of a forest fire: if an unburned tree is next to a burning tree, the unburned tree burns. Also, once a tree burns, it doesn't burn again. When the simulation is initialized, every cell is randomly selected as either a tree or empty (empty spaces don't burn) according to the value of density.

6.7 Journal query.

Beginning with the density low, gradually increase—by increments of 5%—the value until a density C is reached where the fire reliably burns at least 80% of the forest. (Make several runs for each density value and then average the fraction burned.) Plot the averaged burn-fractions as a function of density up to C. Describe the behavior of the burn-fractions when the density gets close to C. Does this seem to involve a critical transition? How does the dynamics of fire propagation compare to that of sand-slides?