MATH1070 Prac 2: Complex Systems in NetLogo

In this prac you will be exploring agent-based models in NetLogo. You will have already seen some of the models in lectures.

Some NetLogo Basics:

1. The agents that move around are called turtles.
2. The world is two-dimensional and is divided up into a grid of patches. Each patch is a square piece of "ground" over which turtles can move. (Patches can't move, but otherwise they're just as "alive" as turtles.)
3. The world of patches isn't bounded, but "wraps" — so when a turtle moves past the edge of the world, it disappears and reappears on the opposite edge.
4. The Interface consists of buttons, sliders, graphs and the world view.
5. Typically models need to be set up by clicking the 'Set-up' button.
6. Models are started by clicking the 'Go' button and stopped by clicking it again.
7. Sliders are used to change the parameters of a model and typically take effect even if the model is running. An exception to this is changing the number of turtles, which only takes effect before the model is set up. Sliders are linked to input variables in the model.
8. Plots are linked to output variables in the model and update as the model runs.
9. Programs in NetLogo consist of a number of 'procedures'. Each procedure has a name, preceded by the keyword 'to'. The keyword 'end' marks the end of the commands in the procedure. Comments are preceded by a semicolon.
10. The program can be viewed (and then changed) by clicking on the 'Procedures' tab (at top).
11. The 'Information' tab (at top) contains useful information as well as questions about the model. Make sure you read the 'Information'.
12. NetLogo contains many models already written, which can be opened by clicking on the 'File' heading and then 'Models Library'.
13. To open a model not included with the original software, click on 'File', 'Open' and then locate the model. NetLogo files have the extension 'nlogo'.

Once you open a model it is a good idea to read the 'Information'.

Mathematics :: Mousetraps
This model is included because it is a simple model to get started with and because I would love to actually try this out in the real world.

Things to do:
- Describe the shape of the "Traps triggered" plot.
- Describe the shape of the "Balls is the air" plot.
- What is the relationship between the two plots?
- On average, what value of max-distance results in the most traps triggered?

Biology :: Termites
As demonstrated in Lectures.

Things to do:
- Use the sliders to create a situation where no pile will form. Explain why.

Biology :: Slime
As seen in lectures.

Things to do:
- Is this model deterministic or stochastic? Describe how feedback operates in this model.
- Experiment with the number of turtles to find the critical number for clusters to form with evaporation at 0.9. Leave the other sliders at the default values.
- Now open the 'Procedures' and change the evaporation rate from 0.9 to 0.95 (just delete 0.9 and replace it with 0.95). Click 'Compile' and run the model again.
- Experiment with the model again and find the critical number of turtles.
- Now change the evaporation rate to 0.85 and find the critical number.
- How does evaporation change the critical number? List the critical values you found in a table.
- Now experiment with the density of turtles. Set all sliders to their default values and evaporation to 0.9.
- Right-click on the world view and record the default values of 'Screen Edge X' and 'Screen Edge Y'.
- Change the Screen Edges both to 20 and then determine the critical number of turtles.
- Change the Screen Edges both to 30 and then determine the critical number of turtles.
- How does the area change the critical number? List the critical values you found in a table.

Biology :: Flocking (and Download - Flocking colour)
As seen in lectures.

Things to do:

- Deterministic or stochastic?
- How does the total number of agents affect the behaviour of the flocks?
- Is it possible to get the agents to move with constant velocities? How? (Velocity is speed and direction.)
- How does the average number of flockmates compare to the average group size? Explain how this is possible.
- Describe the long term behaviour of this model in terms of direction of the agents, size and stability of the final flock(s) and individual behaviour of agents.

Biology :: Virus
Many analytical methods (such as differential equations) are used to model the spread of viruses. This is an excellent example of an alternative agent-based approach.

Things to do:

- Describe the most unrealistic feature(s) of this model.
- Read the information and set up the Ebola virus with (90,10,10,150). Run the model a few times and describe what happens.
- Set up the model for AIDS. What parameter settings did you use? What happens?
- How does the size of the initial population effect the simulation?
- What settings would you use for the influenza virus?
- Create a situation in which every person becomes infected. What happens?
- Is it possible to create a situation where the three populations stay almost constant rather than cycling? If so, what are the values?
- Can you create an 'aperiodic' situation? With what values?

Chem/Phys :: DLA
As seen in lectures.

To create more than one 'seed' right click on the world view and select 'inspect patch'. In the entry for 'pcolor' type 'green' press 'enter' and close the inspection window.

Things to do:

- Turn 'use-whole-screen' off (mainly for speed). Create two structures, one using a very low 'wiggle-angle' and one using a very high 'wiggle-angle'. What is the main difference between the two structures?
- What happens if you start with more than one 'seed' patch? Start with the seeds close together and then far apart. Make sure 'use-whole-screen?' is on, else new particles will only be generated around the central seed.
- Find the command 'neighbors' and replace it with 'neighbors4' in the 'Procedures'. Compile the program by clicking 'Compile' in the 'Procedures' view. Now particles can only 'stick' in the orthogonal directions (N,S,E,W). What do the resulting structures look like? How do they compare to the original structures?

Chem/Phys :: Chem Reactions :: BZ

Things to do:

- What happens to the spirals after a long time?
- Is this model stochastic or deterministic?
- What colour do white cells turn at the next time step?
- What colour do black cells turn at the next time step?
- Set the slider 'g' to 56. How does this compare? What about g=14? (Compare the state of the 'world' at t = 100 or t = 200.)

Social :: (unverified) :: Scatter

Things to do:

- Find two combinations of rules which produces segregation.
- What settings cause Orange not to settle down?
- What is the best way to produce a highly ordered patten with just Blues? What happens when these parameters are used with just Violet? Why?
- Describe the difference between an all Brown pattern and an all Pink pattern? Can you think of any real world situations like this?

Biology :: Fur

Things to do:

- How does the ratio slider affect the final pattern? (You can change it on the go.)
- How does the initial-density affect the final pattern?
- Produce other interesting patterns such as stripes or large blobs.

Social Science :: Segregation

Things to do:

- What should the initial overall Percent Similar be just by chance?
- Describe how the agent density affects the ability of the system to 'settle down'.
- If each turtle wants at least 40% same-color neighbors, what percentage (on average) do they end up with?

Social Science :: Voting

Things to do:

- Describe how the four different switch combinations affect the behaviour from the initial conditions.

Chem/Phys :: Ising

Things to do:

- What happens when the temperature slider is very high?
- What happens when the temperature slider is set very low?
- What happens when the temperature is near, but above the transition point?
- What happens when the temperature is near, but below the transition point?

Social Science :: Traffic Basic
As seen in lectures.

Things to do:

- In this model there are three variables that can affect the tendency to create traffic jams: the initial NUMBER of cars, SPEED-UP, and SLOW-DOWN. Look for patterns in how the three settings affect the traffic flow. Which variable has the greatest effect? Do the patterns make sense? Do they seem to be consistent with your driving experiences?
- Set SLOW-DOWN to zero. What happens to the flow? Gradually increase SLOW-DOWN while the model runs. At what point does the flow "break down"?
- Is the model stochastic or deterministic?
- Explain how feedback works in the model.

Social Science :: (unverified) :: Gridlock

Things to do:

- Is the model stochastic or deterministic?
- Is there any pattern (i.e. periodic) to when "grid lock" happens?

Download from MATH1070 website - randomsandpile

- Run the model until it becomes critical then clear all the data. Now run the model for at least 1000 generations in the critical regime. Use 'Export - Output' to create a csv file. Import the file to MATLAB (File-Import data) and plot a frequency count of the data on a log-log plot using markers. You will need to use `histc` in MATLAB. To use bins of size 5, use something like: `edges=1:5:max(output)` in the `histc` command. To get the scaling right use `edges` for the x-axis when you plot the data.
- Label the plot.
- Advanced: fit this plot using trial and error to find A and b.
  Can you suggest a better way to fit this data?
- What observable becomes critical in this model? Estimate the critical value.
- In MATLAB, calculate the mean and median of the avalanche sizes, the maximum avalanche size, and the number of avalanches of size one. Interpret these statistics and discuss how they are represented in your plot.