CMSC/BIOL 361: Emergence

Computer Exploration 1: Chaos

This week we are going to explore Chaos and Chaotic systems by working through an "experience" on Serendip, a long-standing web resource (started way back even before I first became an undergraduate in 1995) hosted here at Bryn Mawr College. If you've never explored Serendip before, start by going to its home page (http://serendip.brynmawr.edu/exchange/) and taking a quick look around. There are a lot of good resources here and we will be most likely coming back again!

Once you are satisfied, let's move on to this week's tasks. We are going to explore 3 Serendip "Experiences," each of which is hyperlinked from this document. Serendip is a great resource, and one aspect of it is that each section will have many links leading to outside resources that provide additional information. Feel free to venture as far as you like.

On Beyond Newton: from Simple Rules to Stability, Fluctuation, and Chaos

http://serendip.brynmawr.edu/complexity/newton/

This Serendip experience will work you through the population growth model that we've been talking about and allow you to manipulate and visualize the output of the system and various incarnations of the bifurcation diagram.

What I would like you to do is just to work through the first four sections (we are going to be hitting on the "On Beyond" over the next few weeks, so don't worry about it) of this experience, in order and...talk with your partner and amongst yourselves about what you observe.

Then address the following:

1. How well do you think this population growth model represents the real-world system? Does it predict patterns we see if real-life? Is it an effective model or is it too sensitive to starting conditions? Consider biological robustness: if biological processes are so sensitive, how can they function efficiently in face of perturbations to the system environment? What are alternate explanations (besides the internal dynamics) might exist that can lead to oscillations or equilibrium in population size?

2. What is the difference between deterministic and non-deterministic unpredictability?

Order Dependent on Randomness: Fractals

http://serendip.brynmawr.edu/complexity/sierpinski.html

This Serendip experience will let you work the basic "magic" of fractals. You can supplement this exercise on your own time with an exploration of a variety of types of fractals using some Mathematica modules downloadable from the website.

Then address the following:

3. Now, having completed this experience, do you have any new insights into question #2? If so, what?

4. In your own words, define the following terms: random, ordered, chaotic, disordered.

Chaotic Dynamic Systems
http://serendip.brynmawr.edu/chaos/

This experience is a set of JAVA applets written by Bryn Mawr students (some in prior incarnations of this same class) that illustrate some chaotic systems. Play around with all of them and discuss what you observe. Print out the system state you found to be most interesting or to be the best representative or explanation of the behavior of the system

Three Body Problem
http://astro.u-strasbg.fr/~koppen/body/ThreeBody.html

This is a great applet of the problem of estimating planetary orbits (not hosted at Serendip). Play around with this as well (or if it is too complicated, look through the explanations and help for some great screen shots). Again, print out the system state you found to be most interesting or to be the best representative or explanation of the behavior of the system.

Then address the following:

5. For each of the dynamical systems answer the following:
    a. How and why is the system chaotic?
    b. How does the use of a simulation help clarify the working of the system? Do you think this understanding would be possible without the use of a computer model?
    c. Consider your printout – why did you choose this outcome? Why was it interesting or clear example of the system behavior?