CDS 130 - 003 -- Fall 2010
Computing for Scientists

Project 1: Predator-Prey Model Simulation

Assignment Date: Sep. 30, 2010
Due Date: Oct. 14, 2010

1. Introduction

The objective of the project is to train students to solve scientific problems using a computer. Students are required to write a computer program in Matlab/Octave to solve the predator-prey model and study the evolution of populations with time. In this project, students will work though the scientific processes of (1) understanding the scientific model, (2) developing the corresponding mathematical model, (3) using a computer model to solve the mathematical equations developed, and (4) understanding the results.

2. Description

Predator-prey models are arguably the building blocks of the bio- and ecosystems as biomasses are grown out of their resource masses (ref.1). Species compete, evolve and disperse simply for the purpose of seeking resources to sustain their struggle for existence. Depending on their specific settings of applications, predator-prey models can take the forms of resource-consumer, plant-herbivore, parasite-host, tumor cells (virus)-immune system, susceptible-infectious interactions, etc. They deal with generalized win-loss interactions and hence may have additional applications outside of ecosystems. (ref.1).

In this project, consider a closed ecosystem that consists of rabbits and foxes only on an island. The science model, which is based on observations, can be described as follows:

(1) Change in number of rabbits **(R)** per year
- *increases* in proportion to the number of rabbits (**R)** (breeding like rabbits!) with an increase or birth rate of **(BR_R)**
- *decreases* in proportion to (number of rabbits **R**) x (number of foxes **F**) with a death rate of **(DR_IT)** due to predator-prey interaction
- Does not depend on rabbits dying of natural death

(2) Change in population of foxes **(F)** per year
- *decreases* in proportion to the number of foxes (more competition for food) with a death rate of **(DR_F)**
- *increases* in proportion to (the number of rabbits R) x (the number of foxes R) with an increase or birth rate of **(BR_IT)** due to predator-prey interaction

Project requirements

(1) You are required to develop a mathematical model in a set of equations to represent the scientific model described above. In the mathematical model, there are two variables: **R** (rabbit number) and **F** (fox number), which change with time. In the equations, you should note the variables in the iterative form, e.g., **R(i)** representing the number in current year, and **R(i+1)** the number in next year. There are also four coefficients, which are **BR_R** (birth rate of rabbits), **DR_IT**(death rate of rabbits due to interaction), **DR_F** (death rate of foxes) and **BR_IT** (birth rate of foxes due to interaction). These four coefficients are constant in any instance of simulation, e.g., in one particular island. However, the coefficients may be different for different instances of simulation, e.g., considering the system on a different island.

(2) Write a program in Matlab/Octave to study the changes of the number of rabbits and foxes. The period of calculation is of 40 years, requiring 40 iterations, or, i = [1:40]

(3) Calculate the population evolution over the period of 40 years for the following set of parameters, which defines one instance of simulation (that is, one particular island):

```
R(1)=100.0      number of rabbits in the first year
F(1)=20.0       number of foxes in the first year
BR_R=0.5        % birth rate of rabbit
DR_IT=0.02      % death date of rabbit (prey) due to interaction
DR_F=0.1        % death rate of fox
BR_IT= 0.001    % birth rate of fox (predator) due to interaction
```

You need to (1) make a figure to show the evolution of the number of rabbits over 40 years; and (2) make a second figure to show the evolution of the number of foxes over 40 years.

(4) Repeat step **(3)** for a different instance of simulation (that is, a different island):

```
R(1)=100.0      number of rabbits in the first year
F(1)=20.0       number of foxes in the first year
BR_R=0.3        % birth rate of rabbit
DR_IT=0.01      % death date of rabbit (prey) due to interaction
DR_F=0.1        % death rate of fox
BR_IT= 0.005    % birth rate of fox (predator) due to interaction
```

(5) Repeat step **(3)** with your own chosen set of parameters

3. Submission

You are required to write a project report that summarizes your results. The report shall include (1) a brief description of the scientific model; (2) your mathematical model; (3) the population-evolution figures you generate, and a brief discussion of each of the figures to demonstrate that you understand the computed results (Note that there is an online simulator on predator-prey model (ref. 2), but the mathematical model is different); and (4) the file of the Matlab/Octave program code you wrote that was used to generate the population-evolution figures in your report (NOTE: The output of your code must match exactly with the computed results displayed in your figures).

Your project report must be submitted electronically to Dr. Marr, as an email attachment, and also in class, on the due date, as a hard copy.

4. Grading Criteria

- Correct mathematical models: **25 pts**
- Correct computer implementation of mathematical models (that is, correct Matlab or Octave codes): **25 pts**
- All graphs labeled: **20 pts.**
- All elements described in Section 3 “Submission”, are in the report: **20 pts.**
- Fewer than 5 grammatical errors and/or typos: **10 pts.**

TOTAL: 100 pts.

References:

(1) http://www.scholarpedia.org/article/Predator-prey_model
(2) http://home.messiah.edu/~deroos/CSC171/PredPrey/PRED.htm