

CS 8, Winter 2015
Homework Assignment #? (draft)

Assignment Overview

This assignment is for you to practice more with Turtle Graphics, loops and lists.

Background

Late 18th-century biologists began to develop techniques in population modeling in order to understand dynamics of growing and shrinking populations of living organisms. Thomas Malthus was one of the first to note that populations grew with a geometric pattern while contemplating the fate of humankind. One of the most basic and milestone models of population growth was the logistic model of population growth formulated by Pierre François Verhulst in 1838. The logistic model takes the shape of a sigmoid curve and describes the growth of a population as exponential, followed by a decrease in growth, and bound by a carrying capacity due to environmental pressures (from Wikipedia: https://en.wikipedia.org/wiki/Population_model). The model is described mathematically as

$$\frac{dP}{dt} = aP\left(1 - \frac{P}{K}\right)$$

While this is a differential equation, you do not have to have learned Calculus to understand this equation. We will rewrite the equation without the derivative symbols below:

$$\frac{P_{t'} - P_t}{t' - t} = aP_t\left(1 - \frac{P_t}{K}\right)$$

Basically, the equation is used to predict the population at a later time (t') based on that at an earlier time (t). a is the population growth rate and K is the carry capacity. The equation states that the rate of growth of population at time t is proportional to the growth rate (a) and the size of the population at time t (P_t), when $P_t \ll K$. This represents an exponential growth model. However, the exponential growth cannot be sustained when the population grows to close to the carry capacity (K) of the environment. When that happens ($\frac{P_t}{K} \sim 1$), the growth will slow down and the population reaches a steady state.

Assignment Specifications

You are to simulate this logistic growth model graphically, using the equation:

$$P_{t'} = P_t + aP_t\left(1 - \frac{P_t}{K}\right)(t' - t) = P_t\left(1 + a\left(1 - \frac{P_t}{K}\right)\right)$$

Where we fix the simulation step size ($t' - t$) at 1. Your task is to evaluate the size of population over time until the population reaches a steady state (i.e., carrying capacity) or when the maximum number of iteration is reached. You will implement one function:

```
def growthModel(iniPop, CC, rate, maxIter = 1000)
```

- iniPop : the initial population (must be a positive integer),
- CC: carrying capacity of the eco-system (a positive integer),
- rate: growth rate (a positive real number), and

- maxIter: number of max iterations

You are to plot the calculated sizes of population as a function of time.

Assignment Deliverables

The deliverable for this assignment is the following file:

growthModel.py – the source code for your Python program

Be sure to use the specified file name and submit it for grading via the **turnin** system before the project deadline.

Assignment Notes

- The initial population must be positive (we can argue if it can be 1 or have to be at least 2 or more). It can be more or less than the carry capacity of the environment.
- You have to use some loop structure to iterate through time. Which loop structure should you use? (Hint: do you know how many iterations are needed to reach a steady state?)
- Mathematically, the carrying capacity can never be reached (it is the horizontal asymptote of the population curve) if you start at an initial population different from the carrying capacity. It is important in your simulation to guard against such infinite loop – that is why a maximum iteration number is imposed. What other mechanism can you use to terminate iteration early?
- Your graph must include axes labels (time and population) and must draw and label the horizontal carry capacity line, the initial population, the growth rate, and other warning messages.

Sample Outputs



