DS5010 - Introduction to Programming for DS Project Report

Title: *Python Package for Mathematical Model Analysis*

Authors: *Group G* - Abhilasha Jain, Sakshi Suman, Pankti Gosar

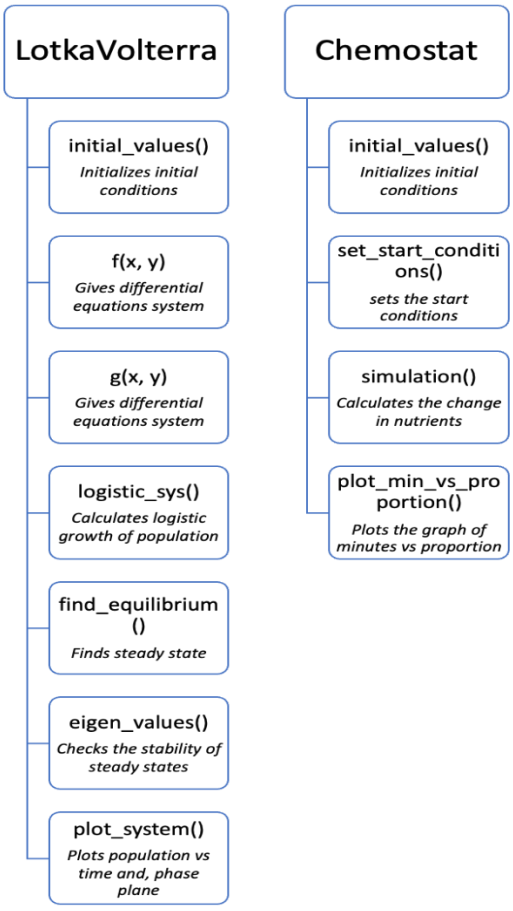
GitHub: https://github.com/AM-Abhi/mathmodel/

Summary: The goal of this package is to examine a Mathematical Model (currently limited to the Lotka-Volterra and Chemostat Models) given the initial conditions. Mathematicians utilize MATLAB to carry out all model analyses, which necessitates the creation of complex scripts. MATLAB is more expensive when compared to Python, which is an open-source platform. This package seeks to make the development and analysis of mathematical models as simple as possible.

Scripts for these analyses are written with libraries like scipy and sympy, however with this package, large scripts would be reduced to single statements for each function.

Different Modules with classes for each model have been built, each with functions for charting systems, finding stable states, examining nullclines, and determining steady state stability.

Design:



Usage: The test code can be used to access the main code for the Lotka-Volterra Model, which is in math model.py in the class Lotka_Volterra. The code that integrates the equations with exponential growth is tested in test_lotka_volterra.py.

Chemostat's core source code is written in Chemostat.py in the class Chemostat, and it may be accessed through the Chemostat test.py test file. The test file's parameter values can be adjusted to plot the graph according to the experiment.

Discussion: This package includes modules for analyzing the Lotka-Volterra System and the Chemostat Model, which are the two models that have been studied so far. This package is simple to use because we can get the graphs, we need by altering the test files. Other models, such as mutualism and competition, can be added to this program in addition to predator-prey models. More functions can be added for further analysis.

The Lotka-Volterra Model is used to predict the growth of two predator and prey populations. Their birth and death have an impact on the rest of the population.

The chemostat model is used to figure out what kind of relationship two species have. The interaction is a predator-prey type if it results in a scenario where two microbial species reside in the same medium and both decline over time. It is a competition if one species thrives at the expense of another. Mutualism is the form of relationship in which both species benefit from interaction.

The Matlab libraries are used to analyze these models, with many more graphs that can be generated. But python is more affordable as compared to MATLAB and having these models coded in python makes it more accessible to everyone.

Statement of Contributions: Abhilasha – mathmodel.py ; Pankti – Chemostat.py ; Sakshi – All the test cases and debugging of mathmodel.py and chemostat.py

References:

- NumPy (see http://www.numpy.org)
- matplotlib (see http://matplotlib.org/)
- os (see https://docs.python.org/3/library/os.path.html)
- Sys (see https://docs.python.org/3/library/sys.html)
- Smith, H. L., Waltman, P., Cannings, C., & Cambridge University Press. (1995). The Theory of the Chemostat. Cambridge University Press.
- Zhu, C., & Yin, G. (2009). On competitive Lotka–Volterra model in random environments. Journal of Mathematical Analysis and Applications, 357(1), 154–170. https://doi.org/10.1016/j.jmaa.2009.03.066