DS5010 - Introduction to Programming for DS Project Proposal

Title: *Python Package for Mathematical Model Analysis*
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Summary: Mathematicians use MATLAB to perform all the analysis of a model, and have to write rather complex scripts to perform an analysis. MATLAB is an expensive software as compared to Python, which is an open source platform. Proposed package intends to make building and analysis of any mathematical models simpler.

Proposed Design: For the proposed package, existing libraries like numpy, matplotlib, scipy, pandas and sympy will be used in order to simulate Ordinary differential equations for the Lotka-Voltera model.

The **Lotka - Voltera model**, also known as predator-prey model, describes the variation in populations of two species which interact via predation. This is a classical model to represent the dynamic of two populations used to predict changes in both with time.

Let $\alpha > 0$, $\beta > 0$, $\delta > 0$ and $\gamma > 0$. The system is given by:

$$\frac{dx}{dt} = x\,(\alpha \ - \ \beta y)$$

$$\frac{dy}{dt} = y\,(-\ \delta \ + \ \gamma x)$$

where x represents prey population and y represents predator population. It's a system of first-order non-linear ordinary differential equations.

A typical solution to this system is given by x and y being periodic and out of phase. Prey grow exponentially, then predators feed on the overpopulated prey and grow exponentially until local prey are exhausted. The predators die off, then prey are able to return and the cycle repeats. If we assume there's a finite carrying capacity K for the prey then the prey evolution equation becomes

$$\frac{dx}{dt} = \alpha x\,(\ 1 \ - \ \frac{x}{K}) \ - \ \beta y$$

In this case, the system's oscillations are damped, eventually an equilibrium pre/predator population is reached.

Different functions in the *class Lotka_Voltera* to be written to define the system of equations, find the steady states, analyze the stability, plot phase planes and nullclines.

Challenges we might face are plotting the nullclines and analyzing steady state using phase plots.

Initial Idea is to perform all the analysis for above mentioned model, and later on add more models like Chemostat, Chemical Reaction Network, SIRS etc.