

Implementation Summary

Objective

Implementing the SEIRV model with immunity waning in a population of 70 Million individuals and calibrate the parameters to match the daily COVID-19 reported cases in Karnataka during 16th March'21 and 26th April'21.

Furthermore, I predicted the daily number of cases from 27th April'21 to 31st December'21 using the parameters obtained in the previous step. We establish Open-Loop and Closed-Loop control on the Reproduction Ratio depending on the predicted average number of Daily Cases in the preceding One week. Finally, I plot pertinent graphs to display my results.

Libraries Used

Numpy, Pandas, Matplotlib, Datetime

Procedure

- Imported the required libraries and extracted the data from the csv file provided.
- Defined the Global Parameters and parameter bounds as provided.
- Imported the data and pre-processed it. The results were stored in 2 separate data frames which are employed in problem 2 and 3 respectively.
- In the pre-processing step, I calculate the Daily New cases, Daily people administered with First Dose and the daily number of test cases. Additionally, I calculate the rolling mean of daily new cases and daily test over a week's period.
- Func: **SEIRV_model**(beta,S0,E0,I0,R0,epsilon,i)
 - Beta: Reproduction Ratio
 - S0: Number of Susceptible people on 16th March'21.
 - E0: Number of Exposed people on 16th March'21.
 - I0: Number of Infected people on 16th March'21.
 - R0: Number of Recovered people on 16th March'21.
 - Epsilon: Vaccine Efficacy
 - i: index of the days starting from 16th March'21.
 - Returns: Change in S,E,I,R on given ith day.
 - W0 and del_V are estimated according to the instructions
- Func: **loss_func**(beta,S0,E0,I0,R0,draw=False)
 - Returns the Mean Squared Loss between the Daily Confirmed running Avg. and the running Avg. of Δi .
 - For the specified range, iteratively calculate the value of S,E,I,R of current day using the values of the previous day and adding the returns values of SEIRV_model func.
 - Found del_i using the formula provided, and thereafter, calculated bar_del_I.
 - The curves of Daily Confirmed Running Average and bar_del_I are plotted if 'draw' is set to True

- Next, I initialized the values of S,E,I,R,beta,CIR as on 16th March. These parameters are trained using the gradient descent algorithm as provided in the instructions. Each of the parameters are perturbed and their effects on the loss function are used to calculate $\partial_p l(p(j))$ for all p in P.
- This training is continued till the loss is below 0.01. It is observed that the loss is highly sensitive to beta and CIR_0.
- Now, I established open loop and closed loop on the parameter beta and predict the running average of daily cases until 31st Dec'21.
- The trained parameters are used for this prediction. The immunity waning and the vaccine efficacy are treated as instructed.
- I plotted the predicted running average of new cases with the different values of beta. Additionally, I also plotted the predictions obtained from the closed loop control of beta. Also, the number of new reported cases in Karnataka until 20th September'21 is plotted on the same graph
- Finally, I generated a plot showing the evolution of the fraction the susceptible population in all the five scenarios.

Results

The parameters obtained after optimization are as follows:

Parameter	Value
β	0.4132
S0	49846000
E0	77000
I0	77000
R0	20000000
CIR_0	13.1681
Loss	0.0064225132



