Computational Epidemiology – Assignment 1

The spread of Covid-19 in the state of Karnataka was simulated using SEIR Modelling.

Implementation

The given time dynamics were implemented using Euler's Method, which is a first order numerical procedure for solving ODEs. Time was modelled as discrete with a step size of 1 day.

Hence, the difference $\Delta s[t]$ was approximated to s[t+1] - s[t]

Since N is very large (=70,000,000) we approximated N-1 ~ N. The discrete time dynamics equations given in the Assignment, were then divided by N to obtain equations in terms of fractions.

Let s[t], e[t], i[t], r[t] respectively denote the fractions of the population in the susceptible, exposed, infected and recovered state. Then, the following equations were obtained:

s[t+1] - s[t] = - $\beta i[t]s[t]$

e[t+1] - e[t] = $\beta i[t]s[t]$ - αe[t]

i[t+1] - i[t] = αe[t] – γi[t]

r[t+1] - r[t] = γi[t]

Where: α = $\frac{1}{5.8}$, γ = $\frac{1}{5}$ and β was found by trial and error

An infection was seeded on Day Zero, that is -

s[0] = $1 - \frac{100}{70{,}000{,}000}$; e[0] = $\frac{100}{70{,}000{,}000}$

Similarly, infection was seeded for the subsequent 6 days.

Using for loops, the evolution of the disease over 500 days was simulated.

The number of daily reported cases were estimated using the formula

Cases = $\frac{\alpha\, e[t]\, N}{CIR}$, where CIR = 40

Results

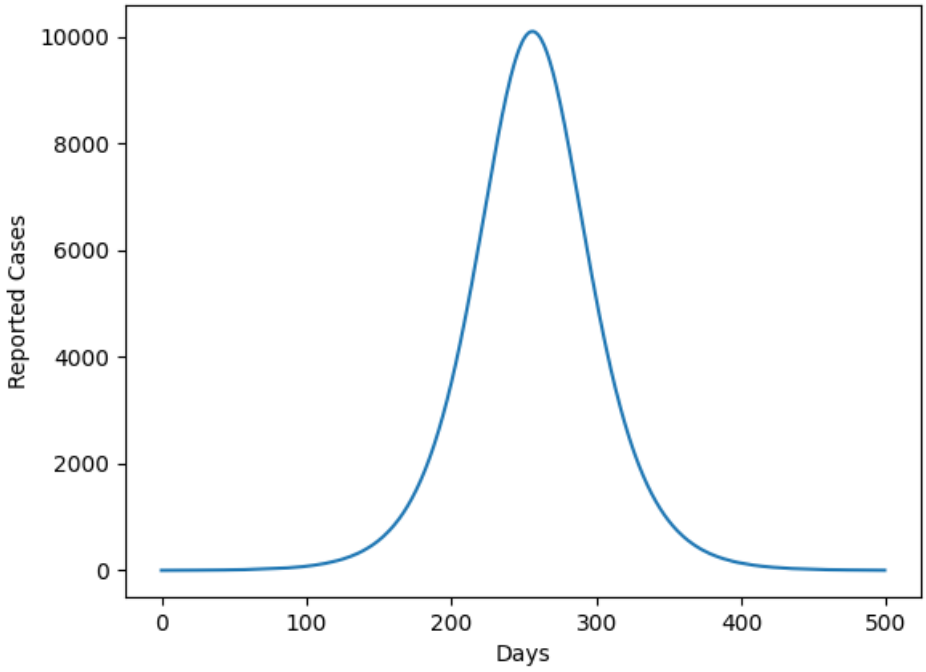
A graph of the estimated number of daily reported cases was plotted against time (in days). As per our knowledge about the evolution of the pandemic, we know that the number of cases started from zero, increased to a peak and then died down. We are given that the number of cases at the peak was about 10,000 in the state of Karnataka.

The height of the peak predicted by our model depends on the contact rate β, and a larger value of β lead to a higher peak, as expected.

Thus, by trial and error, the value of β that causes a peak of about 10,000 cases was found to be 0.298

It was found that the peak occurred 256 days after the seeding of the first infection. Hence, given that the peak in Karnataka was on 11 October 2020, the model predicts that the first infection occurred on 29 January 2020.

The duration of the wave (number of days with thousand or more cases) was found to be 184 days (from day 165 to day 348)



Discussion

Through this SEIR modelling, we were able to simulate the evolution of cases in the first wave of the pandemic in Karnataka with reasonable accuracy. The shape of the obtained graph resembles Karnataka's case curve quite well. With an appropriate choice of contact rate, a peak of about 10,000 cases was obtained, in accordance with real Covid data.

However, there are many limitations in the model. For instance, the model predicts 265 days to reach the peak, with the first case being on 29 January, while in reality the first case in Karnataka was on 8 March, meaning the peak occurred sooner.

There are many factors which might contribute to discrepancies in our model's predictions:

- The seeding of infections, while providing an accurately shaped curve of cases, is quite arbitrary and isn't in accordance with real data.
- We are using a constant contact rate β, but in reality, β is a variable and specifically, its value would have decreased as the pandemic progressed, with the implementation of lockdowns and other interventions.