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SIR Model Covid Delhi

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1 INTRODUCTION

The first case of the COVID-19 pandemic in the Indian capital of Delhi was reported on 2 March 2020. Delhi has the sixth-highest number of confirmed cases of COVID-19 in India, after Maharashtra and Tamil Nadu. The total number of cases reported as of 9 May 2021, is 1,323,567 consisting of 19,344 deaths and 1,217,991 who have recovered.
On 22 March, Delhi observed a 14-hour voluntary public curfew (the Janata curfew) along with 75 districts in India, at the directive of the Prime Minister. A nationwide lockdown was later issued for 21 days from 24 March.
Thousands of "stranded migrant workers" from Uttar Pradesh and Bihar gathered in the Anand Vihar Bus Station on 29 March 2020, trying to get back home after the nationwide lockdown was imposed. More than 3000 people from a religious gathering in the Nizamuddin Markaz Mosque (in the Nizamuddin West area) were quarantined after suspicions that they had come in contact with infected people. 1300 Tablighi Jamaat were part of this crowd, including foreigners in Markaz.
It was reported that air quality index of Delhi improved on 28 March 2020, after the lockdown had reduced traffic. On April 2021, with cases increasing daily, CM Arvind Kejriwal announced a weekend curfew in Delhi every weekend. Notably, the traffic in the capital city decreased by a large amount. On 19 April 2021, Delhi turned the weekend curfew to a week-long lockdown. The lockdown was extended several times - on April 25, May 2, May 9 , May 15 till May 24 (as updated on May 19). Now lockdown is unlocked on 8 June.

2 SIR EPIDEMIC MODEL

The SIR model is one of the most basic models for describing the temporal dynamics of an infectious disease in a population. It compartmentalizes people into one of three categories: those who are Susceptible to the disease, those who are currently Infectious, and those who have Recovered (with immunity). At its most basic level, the SIR model is a set of equations that describes the number (or proportion) of people in each compartment at every point in time. The SIR model is often represented with the following flow diagram that shows the three states (S, I, and R) and arrows depicting the direction of flow between the states.

2.1 Susceptible, S(t)

They are all the people that are capable of becoming sick from an infection caused by the Novel Corona-virus. So, initially, the total exposed population will come under susceptible.

2.2 Infected, I(t)

When a certain amount of population becomes infected, that proportion leaves the susceptible category. Once many people get infected, then those people are not susceptible to get it a second time. You just get infected once, and that is the assumption as well! The ones who are now having the disease are going to transition at some point, hopefully into a recovered status.

2.3 Recovered R(t)

The number of the total population out of the infected category who does not have the disease anymore constitutes the recovered category.

3 MODEL PARAMETERS

$$\frac{dS(t)}{dt} = -\beta S(t)I(t)$$

$$\frac{dI(t)}{dt} = \beta S(t)I(t) - \alpha I(t)$$

$$\frac{dR(t)}{dt} = \alpha I(t)$$

3.1 Terminology

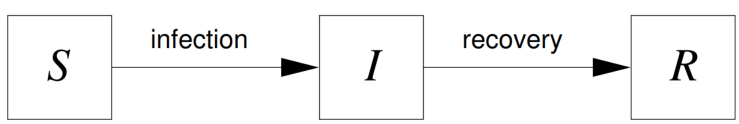
- $\frac{dS}{dt}$ explains how to number of susceptible is changing with time.
- $\frac{dI}{dt}$ explains how to number of Infected people is changing with time.
- $\frac{dR}{dt}$ explains how to number of recovered is changing with time.
- The terms β and α indicate the attack rate (number of susceptible persons get infected per day) and the recovery rate of the flu (inverse of the number of days a person remains infected), respectively.

- The R_0, known as the basic reproductive number, is defined as the expected number of people infected from a contagious person over the length of their contagiousness (in a fully susceptible population).
- $R_0 = \frac{\beta}{\alpha}$ which is the expected number of close contacts per day β multiplied by the average number of days contagious $\frac{1}{\gamma}$. If $R_0 > 1$ (or equivalently, $\beta > \gamma$, then we will likely have an epidemic on our hands as each infected person will infect more than one other on average, who will infect more than one other, and so on (i.e., exponential growth) until we reach herd immunity (but more on that later)
- For notation, we take S_t, I_t, R_t as the number of Susceptible, Infectious, and Removed people in the population on day t. The total population size N is assumed to stay constant over the observation period and is equal to the sum of all counts (i.e., $N = S_t + I + t + R_t$). This discrete time version of the SIR model specifies the equations:

$$S_{t+1} - S_t = -\frac{\beta I_t S_t}{N}$$

$$I_{t+1} - I_t = \frac{\beta I_t S_t}{N} - \gamma I_t$$

$$R_{t+1} - R_t = \gamma I_t$$



3.2 Data Used

We used the data collected on COVID19-India API (**https://data.covid19india.org/**). Below is a sample of data.

		A	B	C	D	E	F	G
		Date	State	Confirmed	Recovered	Deceased	Other	Tested
		Datetime	Categorical	Number	Number	Number	Number	Number
301	26-Dec-2020	26-Dec-2020	Delhi	622094	604746	10437	0	8275838
302	27-Dec-2020	27-Dec-2020	Delhi	622851	605685	10453	0	8351048
303	28-Dec-2020	28-Dec-2020	Delhi	623415	606644	10474	0	8408511
304	29-Dec-2020	29-Dec-2020	Delhi	624118	607494	10502	0	8493400
305	30-Dec-2020	30-Dec-2020	Delhi	624795	608434	10523	0	8578080
306	31-Dec-2020	31-Dec-2020	Delhi	625369	609322	10536	0	8659830
307	01-Jan-2021	01-Jan-2021	Delhi	625954	610039	10557	0	8740395
308	02-Jan-2021	02-Jan-2021	Delhi	626448	610535	10571	0	8807759
309	03-Jan-2021	03-Jan-2021	Delhi	626872	611243	10585	0	8876518
310	04-Jan-2021	04-Jan-2021	Delhi	627256	611970	10597	0	8926806
311	05-Jan-2021	05-Jan-2021	Delhi	627698	612527	10609	0	9006583
312	06-Jan-2021	06-Jan-2021	Delhi	628352	613246	10625	0	9082133
313	07-Jan-2021	07-Jan-2021	Delhi	628838	614026	10644	0	9158755
314	08-Jan-2021	08-Jan-2021	Delhi	629282	614849	10654	0	9234479
315	09-Jan-2021	09-Jan-2021	Delhi	629801	615452	10666	0	9314754

4 MODEL SOLVING : EULER METHOD

4.1 MATLAB code

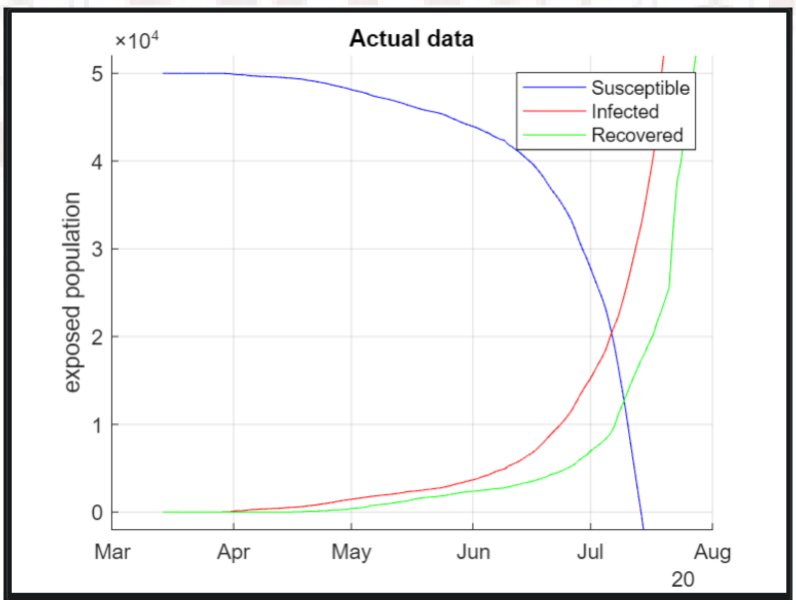
```
%Getting raw data from the website
url='http://api.covid19india.org/csv/latest/
   state_wise_daily.csv';
raw=webread(url);
2
%Creating confirmed and recovered arrays which
   will contain the infected
%and recovered cumulative data respectively
j=1;
%Initialising the AP column with the first row
   containing initial confirmed
%case
i=1;
%Initialising the AP column with second-row
   containing initial recovered
%case
k=2;
```

```
confirmed (j) =0;
recovered (j) =0;
while (i<length(raw.AP))
confirmed (j+1) =confirmed(j)+raw.AP(i);
recovered (j+1) =recovered(j)+raw.AP(k);
j=j+1;
i=i+3;
k=k+3;
end
3
%% Finding constants beta and Gamma from the
   data

%N is the assumed exposed population in Delhi
N=50000;
%"d" is the unique dates frm the raw data
d=unique(raw.Date);
%Creating infected and recovered arrays from "
   confirmed" and "recovered"
%arrays respectively
infected=confirmed(2:end)' ;
recovered=recovered(2:end)';
%Since N=suspectable+infected+recovered
susceptible=N-infected-recovered;
%The step size is one day
dt=1;

for i=1:(length(susceptible)-1)
b(i)=(susceptible(i)-susceptible(i+1))/(
   susceptible(i).*infected(i)*dt);
end

for i=1:(length(susceptible)-1)
g(i) =(recovered(i+1)-recovered(i))/( infected(i
   )*dt ) ;
end

%Take the final value of b and g arrays as beta
```

```
and gamma respectively
gamma=g(end);
beta=b(end);
4
%%
%Using the calculated "beta" and "gamma" we will generate future
%Susceptible, Infected and Recovered using SIR Model

%Initialising Sucseptable, Infected, and Recovered arrays with last date
%values in the raw data respectively
susc=[susceptible(end) inf];
infec=[infected(end) inf];
rec=[recovered(end) inf];
%The first date of prediction will be equal to last date of actual data
d1=d(end);
%Specify the last date of prediction
d2=datetime(0021,12,30);
d_interval=d1:d2;

%Finding Susceptible, Infected, and Recovered array elements starting from
%today to the specified date in "d2" variable using SIR Model
for i=1:length(d_interval)-1

susc(i+1)=(susc(i)-((beta)*susc(i).*infec(i)*dt));
infec(i+1)=(infec(i) +(((beta)*susc(i).*infec(i))-...
((gamma).*infec(i))) *dt);
rec(i+1) =(rec(i) +(((gamma).*infec(i))*dt));

end
%Rounding the values
```

```
calculated_susceptible=round(susc');
calculated_infected=round(infec');
calculated_recovered=round(rec');
5
%% Plot
%Plotting actual data
figure(1);
hold on;
plot(d,susceptible,'b');
plot(d,infected,'r');
plot(d,recovered,'g');
ylim([-2000 52000]);
title('Actual data');
ylabel('exposed population');
legend('Susceptible','Infected','Recovered');
grid on;
```

4.2 Output



Graph of actual data

5 CONCLUSION

We have used data untill 31st May 2020 for all these analysis. We have seen some approaches to modelling diseases such as COVID-19 through MATLAB. We have found essential characteristics within this process. We have done Data Analysis and Data Extraction and included a reliable source for the COVID-19 data. We have used preprocessing to extract a subset of the collected data and organise the data accurately. We have done Data Modelling with model construction, i.e. finding the best model that fits the COVID-19 pandemic. We have done the calculation of model parameters using real collected data and finally done the Data Visualisation. All these steps were essential, and luckily, MATLAB has so many functions and tool to use in the given scenario.