VG 101 Final Project

SIR Modelling for COVID-19 Pandemic Using MATLAB

Assigned: April 15 2020

Due: April 29 2020

Introduction

In this project you are asked to build Susceptible-Infectious-Recovered (SIR) models using the actual confirmed case data for one specific area.

The SIR model can be represented by:

$$\frac{dS}{dt} = -\frac{\beta}{N}SI \tag{1}$$

$$\frac{dI}{dt} = \frac{\beta}{N}SI - \gamma I \tag{2}$$

$$\frac{dR}{dt} = \gamma I \tag{3}$$

where β is the contact rate by an infected people at a point in time and γ is the recovery rate. $\frac{1}{\gamma}$ is the average infectious period. t is time, $S = S(t)$ is the number of susceptible persons at time t, $I = I(t)$ is the number of infected persons at time t, $R(t)$ is the number of recovered persons in time t. $R_0 = \frac{\beta}{\gamma}$ is the basic reproduction number. From (1), (2), (3), the population size N can be calculated as:

$$N = S + I + R = const \tag{4}$$

The initial conditions are $S(0) = S_0$, $I(0) = I_0$, $R(0) = R_0$

In order to use the model, we must estimate the model parameters β, γ and initial values of S_0 and I_0 from available data. Note that, for the initial time, we can reasonably set $R_0 = 0$ and $I_0 = C_1$. When S_0 can be estimated, the entire population N can be obtained.

The available data for a city, a province or a state are the confirmed case number which is:

$$C = I + R \tag{5}$$

We can estimate the parameters and initial values by minimize the difference between the actual and predicted number cases. The following objective function needs to be minimized to achieve the estimate of each parameter: α, β, γ.

$$\text{Min} \left\| C_t - \hat{C}_t(\beta, \gamma, S_0) \right\|^2 \tag{6}$$

where $C_t = (C_1, C_2, \dots, C_n)$ are given number of cases in times $t_1, t_2, \dots, t_n$ and $\hat{C}_t = (\hat{C}_1, \hat{C}_2, \hat{C}_3, \dots, \hat{C}_n)$ are the corresponding estimates calculated by the model. The

estimated parameters need to be optimized to reach the minimum value of (6).

In MATLAB/OCTAVE, you can use the build-in function `fminsearch` to find the estimated parameters. To solve the integration of the model equation, you can use MATLAB's function `ode45`.

Here are the tasks.

1. Model a SIR model, with a time span of 200 days, using the following parameters: $\beta = 0.2; \gamma = 0.083; N = 1000000; I_0 = 1; R_0 = 0;$ demonstrate the predicted case number over time, i.e. the numbers of infected cases, recovered cases and susceptible cases over number of days as seen in the appendix.
2. Use the real confirmed case number from one area, to estimate the relevant parameter using the available data. You should finally demonstrate the predicted case number curve using the SIR model for at least twice of the time span of 厅 the available data. For example, if you have available data for a time span of 50 days, your predicted case number curve should last for at least 100 days. In addition, you need to include the actual case number data for each day in your figure for comparison.
3. New York State data in the appendix can be used and you are encouraged to use different data set from different city and area.
4. Provide your **source code with comments** and **a report** with results figures and necessary analysis and discussion. Further details are provided in the Section Report Specification.

Report Specification

Your report should include:

1. **Introduction**: A detailed description of the objectives and requirements of the project, and a brief description of the methodology.
2. **Methodology**: It contains

   - The flow of execution of each function. It is good to include a flow chart to illustrate it.
   - What technical problems you encounter, and how you tackle the problems
   - Testing of your program, which shows how you validate your program, i.e. confirm that the solution is correct.

3. **Results**

   Include the results using the plotting functions in MATLAB.

4. **Conclusion and future development**

   - Summarize the experience gained in the project
   - Indicate how your program can be extended and improved if more time is allowed.

5. **Appendix**

A User Manual of your program should be attached to the report as an Appendix to illustrate the usage of your program.

The report should be in PDF format. It is NOT required to include the complete source code in the report. Rather, you should copy the folder(s) containing all your project file(s), which also stores the report file.

Important Notes

1. After finishing the project, you should upload one ZIP/RAR file that contains the following:
2. The soft copy of the report (including the Appendix of User Manual)

- All folder(s) and files of your project
- A readme file (readme.txt) that tells us how to run the code and, if any, other important (IT) requirements for running the program. Note this is not a replacement of the User Manual which offers more comprehensive description about your project.

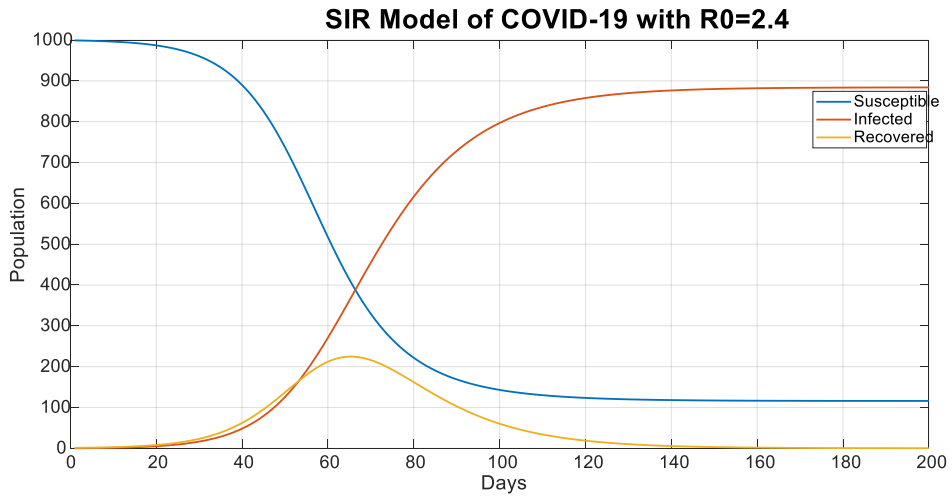
3. The documentation for your final project is a very important part. The ability of writing good comments will also be an important factor to the final assessment of your final project.

4. It is compulsory to use a word processing tool to write your report. The font size must be no bigger than 12 and no smaller than 10. Use 1.5 line spacing. Includes all diagrams and tables. The length of the main report should not be longer than 15 pages. You can use appendix to include other supporting information.

5. To be qualified for extra credits, you can use different model such as SEIR(Susceptible-Exposed-Infectious-Recovered) model other than SIR model and offer a comparison study.

Appendix

Epidemic development curve using simple a SIR model.



New York State Confirmed Case Number until April 6:

Date	Case Num.	Date	Case Num	Date	Case Num
2020/3/1	1	**2020/3/14**	613	**2020/3/27**	44635
2020/3/2	1	**2020/3/15**	729	**2020/3/28**	52318
2020/3/3	2	**2020/3/16**	950	**2020/3/29**	59513
2020/3/4	11	**2020/3/17**	1374	**2020/3/30**	68369
2020/3/5	22	**2020/3/18**	2481	**2020/3/31**	75795
2020/3/6	44	**2020/3/19**	4597	**2020/4/1**	83738
2020/3/7	89	**2020/3/20**	7245	**2020/4/2**	92472
2020/3/8	106	**2020/3/21**	10356	**2020/4/3**	102863
2020/3/9	142	**2020/3/22**	15168	**2020/4/4**	113704
2020/3/10	173	**2020/3/23**	20875	**2020/4/5**	122031
2020/3/11	216	**2020/3/24**	25665	**2020/4/6**	130689
2020/3/12	328	**2020/3/25**	30811		
2020/3/13	421	**2020/3/26**	37258		