DISCRETE SIR MODEL FOR SIMULATION OF VARIOUS COVID-19 SCENARIOS

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Abstract: This project features SIR model to model COVID 19 situation development as a function of various social environment conditions (government restrictions, social distancing, etc.). Such a simulation can help people to understand the strict should be to restrictions to manage the COVID 19 situation development in reasonable way. Simulation are created via Python programming language. The findings of this research shows, that the social distancing and similar concepts could influence the situation in a significant way.
Key words: SIR, COVID 19, Python, social distancing

1 Introduction

There have been a pandemic so called COVID-19 [1] virus since the beginning of 2020. Countries all around the world were decided to lock-down to stop spreading of the virus. In order to understand how behavior of societies affect the infection, we use SIR model to describe.

SIR model [2] is compartmental models simplify the mathematical modelling of infectious diseases. The population is assigned to compartments with labels - for example, susceptible, infective, or remove. People may progress between compartments.

2 SIR Model

The SIR model itself was origin in the early 20th century, with an important work being that of Kermack and McKendrick in 1927. The models are most often run with ordinary differential equations (which are deterministic), but can also be used with a stochastic (random) framework, which is more realistic but much more complicated to analyze. The discrete SIR model can be described by following the equations below. To find susceptibles rate in day t as follows

$$S_{t+1} - S_t = -bS_t I_t, \tag{1}$$

where b is the infection rate. The number of infectives can be obtained as follows

$$I_{t+1} - I_t = bS_t I_t - aI_t, \tag{2}$$

where the a is the recovery rate parameter. And the number of removed for every day is calculated as follows

$$R_{t+1} - R_t = aI_t. \tag{3}$$

2.1 Calculation example

Consider initial population: $S_t = 10000$, $I_t = 1,000$, $R_t = 0$; and model parameters: $a = 0.05$ and $b = 0.0001$. The first steps will look as follows:

t	S_t	I_t	R_t	bS_tI_t	aI_t	S_{t+1}	I_{t+1}	R_{t+1}
0	10,000	1,000	0	1,000	50	9,000	1950	1950
1	9,000	1,950	50	1,755	97.5	7,242	3,607.5	147.5
3	7,242	3,607.5	147.5	...	...	....	...	...

2.2 Python implementation

Python [3] is an interpreted, high-level, general-purpose programming language. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects.

In this work the Python is used to simulate the SIR model with various conditions. To simplify the calculations, the Numpy package [4] is used. The Matloplotlib package [5] was used for creation of graphs.

3 Results

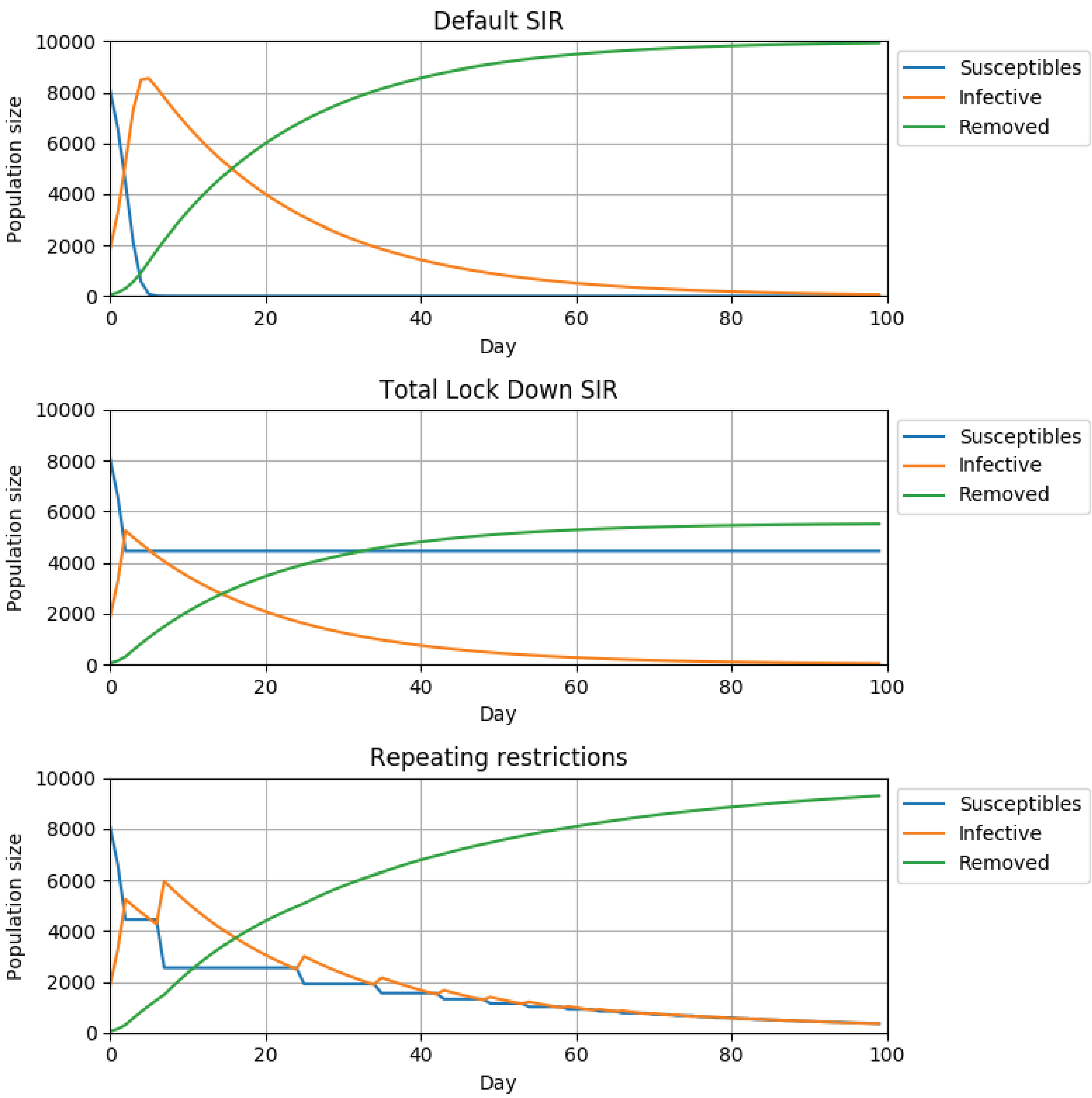

Fig. 1: Simulated development with various settings, from top: a) SIR model with no modification; b) SIR model with total lock-down at day 3; c) Mild restrictions triggered by situation worsening.

For all simulation we used the same following initial conditions: $S_t = 9,000$, $I_t = 1,000$, $R_t = 0$, $a = 0.05$,

$b = 0.0001$. Fig.1 shown results of all simulations. See from top: a) SIR model with no modification; b) SIR model with total lock-down at day 3 - the infection rate is reduced to 0; c) Mild restrictions triggered by situation worsening - if the number of infected increases the infection rate is reduced by factor of 90%.

Conclusion

SIR model was used to describe scenario of diseases infection by using mathematical modelling. While Python was used to simulate graph in different scenarios. By combining these together, it helps to clarify and understand more about how human behaviors trend of infection.

To conclude, It will take several days for this pandemics to decay especially high population countries. In meanwhile, thoughtfulness and awareness behaviors help this pandemic situation getting better such as lock-down, social distancing and wearing mask.

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