The Simulation of COVID-19

Introduction

2020 is a year of pandemic. COVID-19 infects more and more people across the whole world and causes a great loss to all humankind. COVID-19 has raged the world for more than a year, during the pandemic, the governments of different countries had applied many measures such as social distancing, wearing masks, quarantine, travel restriction,etc. to prevent the pandemic to cause more damage. In this case, we want to write a program to simulate the situations of different pandemics, then we can use this simulation to predict the following growth of the pandemics. We can simulate the situations of applying some preventive measures as well. We hope that this program can help us fight with pandemics.

Purpose

Since we can acquire the data of infection rate and other factors in the early state of pandemics, we are able to utilize these factors to simulate the development of the pandemic and know what to expect. Also, we can change the factors to estimate the results after applying some measures. We expect this simulation can help estimating and experimenting about the pandemics.

Numerical Analysis

- Basic Setups:

SIR Model:

1. The population is divided into 3 categories, those who are susceptible to the Covid-19, those who are infectious, and those who have recovered from the infection.
2. For every unit of time a susceptible person spends within an "infection radius" of someone with the Covid-19, they'll have some "probability of contracting it themself." So we use the physical proximity as a stand-in for things like shaking hands, touching the same surfaces, kissing, sneezing on each other, and so on.
3. For each infectious person, "after a given period of time, they'll recover from Covid-19" and no longer spread the disease.

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4. We introduce a "central spot" and think of this as a city.
5. In some cases, we have "a few communities" with transit between them. Each person has some probability of traveling to the center of different communities.
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Parameters:

1. Population: S (blue), I (red), R (gray)
   So "S" stands for susceptible, "I" stands for infectious, and "R" stands for removed (because some people die).
2. Infection radius: Preset value = ??
   If Doubling the radius, we might think of this as more total interactions between people or a more socially engaged society.

3. The probability of infection: Preset value = 0.2
   If cutting the number in half, you might think of this as better hand washing, cough protection, and less face touching.
4. Travel rate: Preset value = 0.2

- Identify, Isolate, and Therapeutics:

Assuming that we have good testing and responsiveness,

1. Once we hit some critical threshold of the cases, we'll start "sending people to a separate zone" 1 day after they get the Covid-19.
2. There is a chance of not getting quarantined because you show no symptoms and don't get tested.
3. Assuming there exist antiviral therapeutics, we can lower the infection duration. This method has the same effect as isolating cases.

Parameters:

1. Population: S (blue), I quarantined(red), I not isolated (yellow), R (gray)
2. The probability of not getting quarantined: Preset value = 0.2
3. Infection duration: preset value = 10 (days)

- Travel restrictions:

1. When we hit 100 cases, we cut down this travel rate by a factor of 4

Parameters:

1. Travel rate: After hitting a particular threshold of cases, the travel rate is 0.05.
2. Trigger number: Preset value = 70

- Social Distance Factor:

1. After they hit 50 cases, we apply social distance factor as a "repulsive force" between people and have glow yellow when they feel too close to their neighbor.
2. But some people may not conform to social distancing, so there are varied percentages of population executing social distancing in different places.

Parameters:

1. Social distancefactor: Preset value = 2.0 (it doesn't represent in meter, just a factor)
2. Percentage of social distancing population: Preset value = 0.7

● Quantify the rate of spread:
Consider one person with the disease and count how many people they infected while they have it. The average for this count across everyone who has been sick is known as the effective reproductive number, or R.
R_0, which is the value of R in a fully susceptible population, is the basic reproductive number.
When R>1, the infection is growing exponentially, and it represents an “epidemic.”
When R holds steady around 1, it is called “endemic.”
If R<1, it means it’s on a decline.

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● Central Hubs:
We are curious about the effects of some kinds of shared central location, like a market or a school. So we introduce a destination for our dots. And we compare a case with a lower probability of infection with a case with a normal probability of infection. Also, make a case where you will turned on the social distancing after a threshold is hit.

Predicted Problem

Array is too big:
The individual array would be a 100 by 100 array, so it will have large computation and need a large memory space. We don’t know whether our computer can do this computation.
Quarantine zone:
How to separate infected individuals to a quarantine zone where each individual doesn’t infect others.
Social distance factor:
How to produce a right repulsive force having each individual separate a proper distance as a function of x and y? It can not make all individuals separated. There are still some individual would be infected in an appropriate range.