Lab L7: Epidemic processes

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I. Introduction

SIR models are a useful simplest compartmental models, which are used in to study the spread of infectious diseases in a population. There are three different class for individuals in the simulation, Susceptible(S(t)), Infected(I(t)) and Recovered(R(t)). It is a dynamic simulation over time. The SIR model is based on a set of differential equations that describe how the number of individuals in each compartment changes over time. In this experiment, I am going to control an epidemic (SIR) process through non pharmaceutical interventions.

If there is no medicine or vaccination available, it is only possible to reduce the infection rate by appropriate measures. There are some Non-pharmaceutical interventions such as hand washing, social distancing, isolation and disinfection. A mitigation strategy that attempts to lessen the effects of the virus on society as much as possible, but still tolerates low levels of transmission within the community.

II. The simulation model

A. Stochastic Elements.

Basic Reproduction Ratio. The basic reproduction number, often denoted as R0, is a key epidemiological parameter that represents the average number of secondary infections produced by a single infected individual in a completely susceptible population. It can be defined as:

$$R_0 = \frac{\beta}{\gamma}$$

In the simulation, the initial reproduction number is 4, which means that one individual can infect an average of 4 individuals.

Susceptible Individuals S(t). The class 'Susceptible Individuals' represents all individuals who are susceptible to an infectious disease but are not yet infected. The initial number of susceptible individuals is almost the number of populations d in the simulation.

Infected Individuals I(t). The 'Infected Individuals' class represents all individuals in the block that are infected and can transmit the disease to susceptible individuals. The initial number of ”infected individuals” is 1.

Recovered Individuals R(t). The class 'Recovered Individuals' represents all individuals who have recovered from the infection and are assumed to be immune, at least for a certain period. The initial number of ”Recovered Individuals” is 0.

Hospital Individuals H(t). The class 'Hospital Individuals' represents all Infected Individuals who needs to be Hospitalized. In the simulation, the 10% of Infected Individuals need to be Hospitalized.

Intensive Treatments Individuals IT(t). The class 'Intensive Treatments Individuals' represents all Infected Individuals who needs Intensive Treatments in hospitals. In the simulation, the 6% of Infected Individuals need to be Intensive Treatments.

B. Non Pharmaceutical Intervention Strategy

In my non-pharmacological intervention strategy, recovery and mortality rates are fixed, We can only change transmission rates and effective exposure rates. Transmission rates are related to the number of reproductions. If I can limit people's mobility, I can quickly reduce the number of reproductions. Eventually, I devised a function to assist me in updating the transmission rate. The physical meaning is I can use some quarantine measures when infected people exceed the capacity of hospitals and intensive treatment.

C. Ordinary Differential Equations

Ordinary differential equations are a type of differential equation that involves functions of a single variable and their derivatives. These equations describe how the function varies with the independent variable. There are five equations: dSdt, dIdt, dRdt, dHdt, dITdt, and dDdt, representing susceptible individuals, infected individuals, recovered individuals, hospitalised individuals, and intensively treated individuals, respectively, over time.

III. RESULTS

A. The SIR Epidemic Trajectory

In the SIR epidemic, the experiment simulate the whole process of epidemic for susceptible individuals, infected individuals and recovered individuals over time. As shown in the Fig.1, the amount of susceptible individuals is almost the sum of all populations at the beginning and 0 at the end of the epidemic. the amount of recovered individuals sta from 1 and will be close to the amount of all populations the end of the epidemic. The amount of infected individu first maintains a rapid increase and then declines rapidly a reaching the peak.

In the whole process, I can only change the convers rate if only non-pharmacological intervention strategies considered. However, the transition rate will always hav direct impact on the infected individuals, which can lead significant changes in the susceptible, the recovered and fatalities. When the rate of reversion increases, the peak infection is also advanced. Conversely peak advancemen delayed.

B. Individuals Based On SIR Epidemiological Trajectorie

In the simulation, I need to fulfil the requirement limiting cumulative mortality. I also need to monitor whet hospitals have excess capacity to admit susceptible infected patients. The Fig.2 show the Individuals Based SIR Epidemiological Trajectories.

C. Individuals Based On Non Pharmaceutical Intervent Strategy

I designed a non-pharmacological intervention strategy to limit mortality. The system maintains the original transmission rate in all populations until the limit of hospitalisations is reached. This indicates that a dangerous virus has emerged in the population and we need to take steps to control its spre Measures should be taken to limit the rate of transmissi such as quarantine.

I simulated the SIR model 100 times for different propa tion rates to find the propagation rate for the mortality lin After hospitalisation exceeded limits, the model can redu transmission rate to a specific value. The final results shown in Fig.3, where all indicators were met.

IV. Conclusion

This simulation models the course of an SIR epider with a non-pharmacological intervention strategy. When dreaded virus spreads, it is necessary to find an effective w to reduce the rate of transmission, such as quarantine. In t experiment, the cumulative number of deaths would reac staggering 137,00923 without any intervention. In terms non-pharmacological intervention strategies, the transmiss rate decreased to a tolerable value. Cumulative number deaths in a year is below 100,000 and all hospitals av overload.

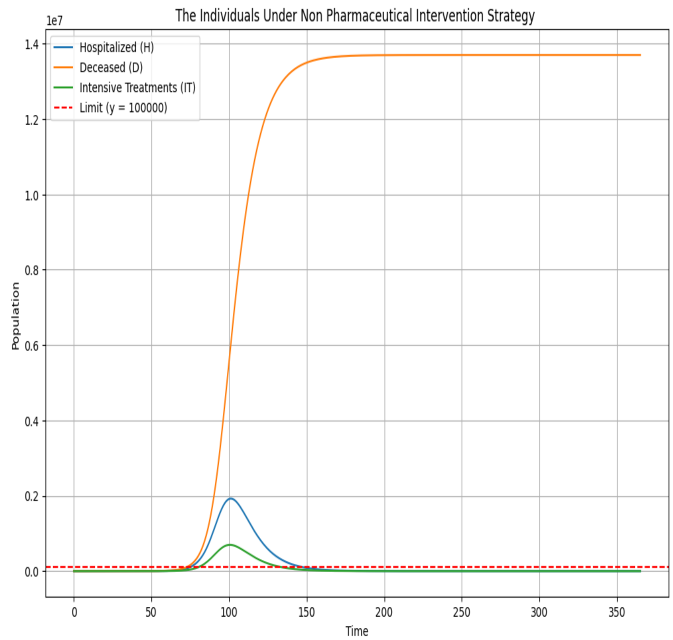

Fig. 1. Individuals based on the general SIR epidemiological process

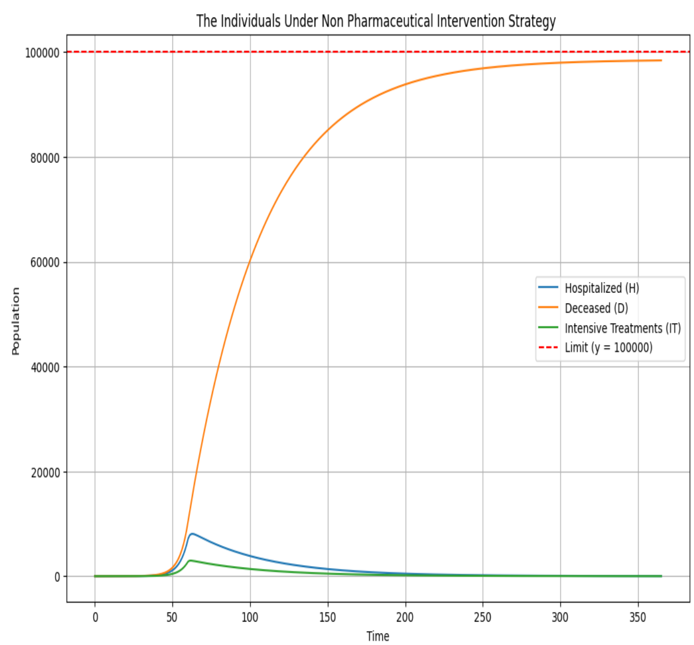

Fig. 2. Individuals based on non-pharmacological intervention strategies

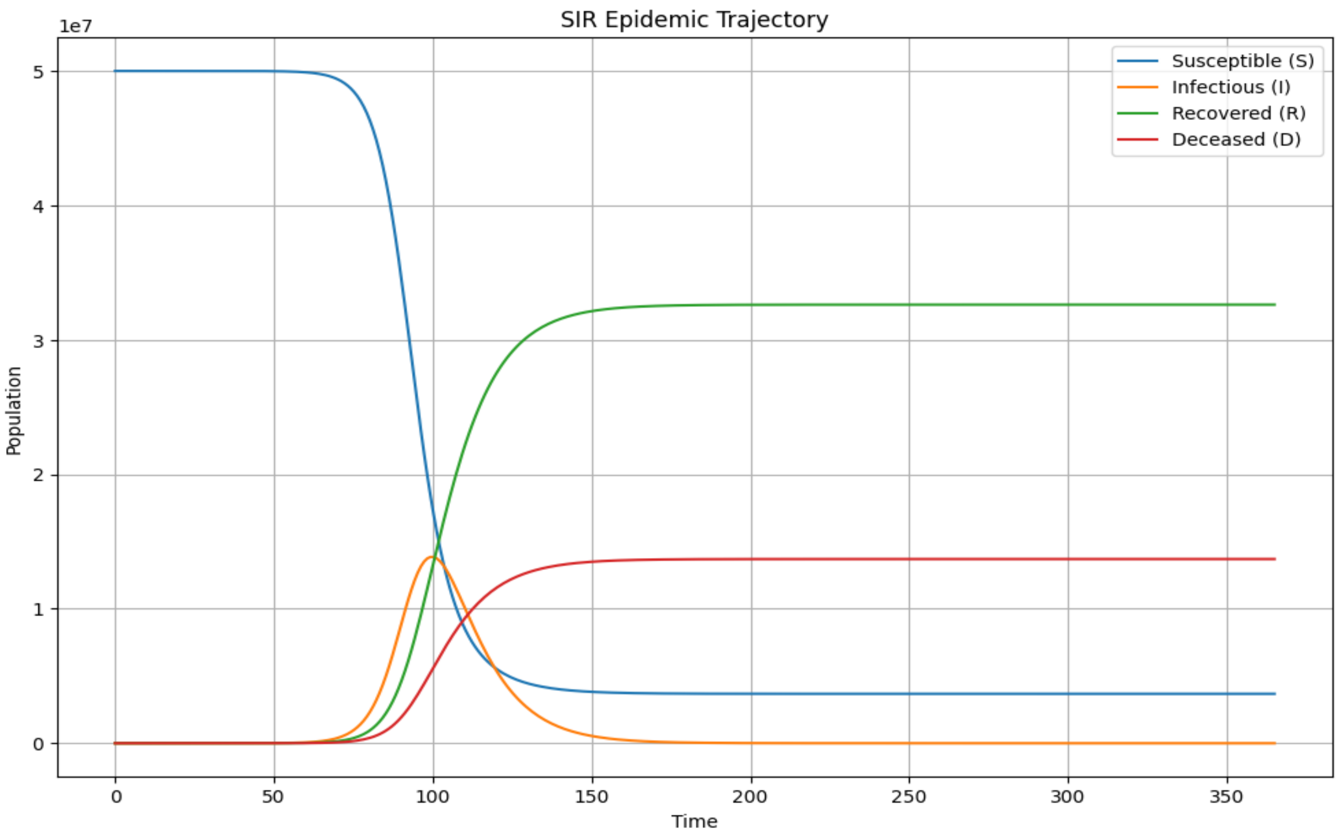

Fig. 3. The process of SIR Epidemic Trajectory