ZÁPADOČESKÁ UNIVERZITA V PLZNI

KIV/VSS

Coronavirus Outbreak Simulator

Jakub Šilhavý
A21N0072P
silhavyj@students.zcu.cz

08. 11. 2022

Contents

1 Introduction **1**

1.1 Chosen topic 1

1.2 Outcomes 1

2 Existing simulators **2**

3 Model description **3**

3.1 Map layout 3

3.2 Mobility 3

3.2.1 Self-isolating 4

3.3 Infection spread 4

3.4 Limitations 5

4 Technology **6**

5 Conclusion **7**

1 Introduction

Coronavirus has been the subject of great debate over the last couple of years. The rapid speed of its initial spread resulted in hospital saturation, which were vital for those who needed intensive care. A worldwide approach to mitigate the virus spread imposed actions such as school closures, social distancing, flight cancellations, and wearing face masks, which not everyone has agreed upon. Since the very beginning, scientists have been trying to develop an effective vaccine to increase people's immunity to the disease.

There are online interactive articles that address the Coronavirus outbreak. In particular, why the number of infected people grew exponentially and what impact it has had on the population. Using simulations, they also test out different ways to "flatten the curve", which is an attempt to have as few people infected at once as possible. A spike in the number of currently infected people may saturate hospital capacities, which may result in a higher fatality rate as people will not be able to receive the treatment they need.

1.1 Chosen topic

As for the topic of my semester project, I plan to create a configurable COVID-19 simulator to visualize how the virus spreads and develops overtime since its initial outbreak. The simulation will be based off of the models mentioned in the following articles: [1], [2].

1.2 Outcomes

As one of the outcomes, I would like to find out how a frequent visit of popular places, such as a central market, restaurant, or church, affects the spread of the disease, which neither article accounts for. They both simplify people's mobility down to complete randomization. However, in my model, people would be moving around in a way that reflects how we all travel in real life more accurately. Another goal of the simulation is to compare the results discovered in both articles. For example, how many percent of people not obeying the rules it takes for the situation to get out of control.

2 Existing simulators

There are several already existing online simulators of a similar nature.

For example *CoSim* [5], which is a online COVID-19 simulation tool that helps explore the current COVID-19 situation in Germany. Another COVID-19 mobility model comes from the Stanford University, CA [4]. It dynamically models the spread of the virus within 10 of the largest metropolitan statistical areas in the US. The *Covid19Sim* website [6] offers a collection of tools to help make decisions regarding policy and strategy related to the coronavirus pandemic in the US. For instance, their COVID-19 outbreak detection tool, detects recent COVID-19 outbreaks in U.S. counties.

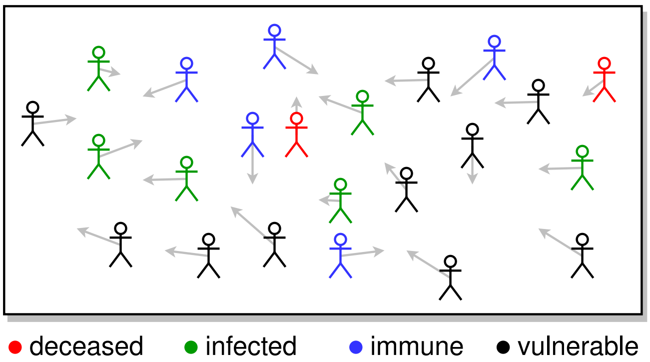
A list of other COVID-19 simulations can be found, for example, over at `https://en.wikipedia.org/wiki/List_of_COVID-19_simulation_models#Models_with_the_most_scientific_backing`.

3 Model description

It is important to highlight that the vast majority of the following parameters of the model will be adjustable through a graphical user interface (`GUI`), so the user can set them to whatever they think reflects the reality the best.

3.1 Map layout

The model will consist of a population made up of a thousand people systematically moving around on a 5 km by 5 km grid, which could be a representation of a small town. In my opinion, people do not move around randomly. They tend to go places. Therefore, there will be a couple of places located in the downtown area which each person frequently visits.



3.2 Mobility

The simulation starts with each person being at home, which is a randomly chosen position on the map. They are allowed to stay at any particular location for up to 8 hours. When the counter hits zero, they will have three options as to how to pick their next location. The person stays at home (40%), the person travels to one of the popular locations (50%), or the person travels to an arbitrary location (10%). All these probabilities must add up to a hundred percent. With every update of the simulation, they will move toward their final destination by a certain distance, which will vary with every person and could be interpreted as the person's speed. After they have arrived at their designated destination, they will stay there for a certain amount of time. When the time is up, the same process starts all over again.

3.2.1 Self-isolating

Additionally, some people will be social distancing and will therefore have different probabilities of how they move around. If a person is self-isolating, their chance of staying home will be 99.8%, and the remaining 0.2% will be split equally between the option of going to one of the popular locations and traveling to an arbitrary location. The number of people staying at home can be tweaked via the `GUI`. Initially, it will be set to 50%, meaning that half of the people will be staying at home most of the time while the other half will be free to move around as they want.

3.3 Infection spread

Each person in the population will be initially susceptible to the virus, except for a few unfortunate individuals who will start off as infected. When a vulnerable person happens to be within a 5m distance of an infected person, they will have a 50% $\pm$15% [1] chance of contracting the virus themselves. In addition to the transmission distance, they both must be either at home or on their way to their corresponding destinations. If one of them is at home and the other one is passing by, there will be a 0% chance of the virus being transmitted as they would be separated by a wall.

After the exposure, the person may or may not feel sick. If they do feel sick, they will most likely head back home and self-isolate until they either recover or die. If they do not develop any symptoms, they will continue to move around unaware of the fact that they have been infected with the virus. In other words, if a person catches the virus, there will be a 40% probability of them going back home to follow the same rules as if they had been practicing social distancing since the very beginning of the simulation. If this probability was set to 100%, it would mean that every infected person would be immediately isolated from the rest of the population. However, they could still infect other people on their way home.

The virus will last for approximately 14 days, after which the person dies, with a probability of 0.6% [2], or develops immunity, which will last for up to 2 months. If more than 20% of all people are sick at once, the healthcare system becomes saturated, and the fatality rate doubles.

[1] Infection probabilities may vary depending on the type of contact, such as shaking hands, having sex, sharing drinks etc.

[2] Mortality rates for individual countries can be found at [3]

3.4 Limitations

As with any other simulations, there will be some limitations and simplifications to this simulation as well.

For example, the simulation will not be able to capture scenarios such as public transpiration, where people are headed to the same destination while being within a close distance of each other along the way. Since the outbreak will be implemented as a discrete simulation, the program will only be able to update the state of the simulation at discrete time stamps, not in between them, which introduces an error to continual events such as walking next to another person. Another simplification is that there will be no feedback from the community itself, meaning they will not impose any measures to mitigate the spread of the virus as it kicks off. All people will follow the same rules throughout the simulation regardless of how many people are currently infected, which differs from how it has been over the past few years.

These are not the only flaws this simulation will have. I just wanted to list a few of them to give the reader a picture of some simplifications I will make.

4 Technology

The entire background of the simulation will be written as a `C++ CMake` project. As for the visualization, I have decided to use the `ImGUI` library [7], which is an open-source immediate mode library for creating `GUIs`. In order to plot out different charts and statistics, I have chosen to use the `ImPlot` library [8], which is based around `ImGUI`. Both libraries are cross-platorm, so the sumulation will run on both Windows and Linux.

5 Conclusion

The goal of the simulation is not to make any definitive conclusions. After all, I am not an epidemiologist. It is more of an experiment to find out whether my simulation will produce similar results to other simulations. The `GUI` will allow the user to tweak different parameters of the simulation, so they can set the values as they wish.

Bibliography

[1] Harry Stevens (March 14, 2020), Why outbreaks like coronavirus spread exponentially, and how to "flatten the curve", https://www.washingtonpost.com/graphics/2020/world/corona-simulator/

[2] Kevin Simler (March 16, 2020), Outbreak, https://meltingasphalt.com/interactive/outbreak/

[3] Johns Hopkins Coronavirus Resource Center, Mortality Analyses, https://coronavirus.jhu.edu/data/mortality

[4] Stanford University, COVID-19 MOBILITY MODELING https://covid-mobility.stanford.edu/

[5] Prof. Dr. Thorsten Lehr, COVID-19 Simulator, https://shiny.covid-simulator.com/covidsim/

[6] https://covid19sim.org/

[7] ImGUI GitHub repository https://github.com/ocornut/imgui

[8] ImPlot GitHub repository https://github.com/epezent/implot