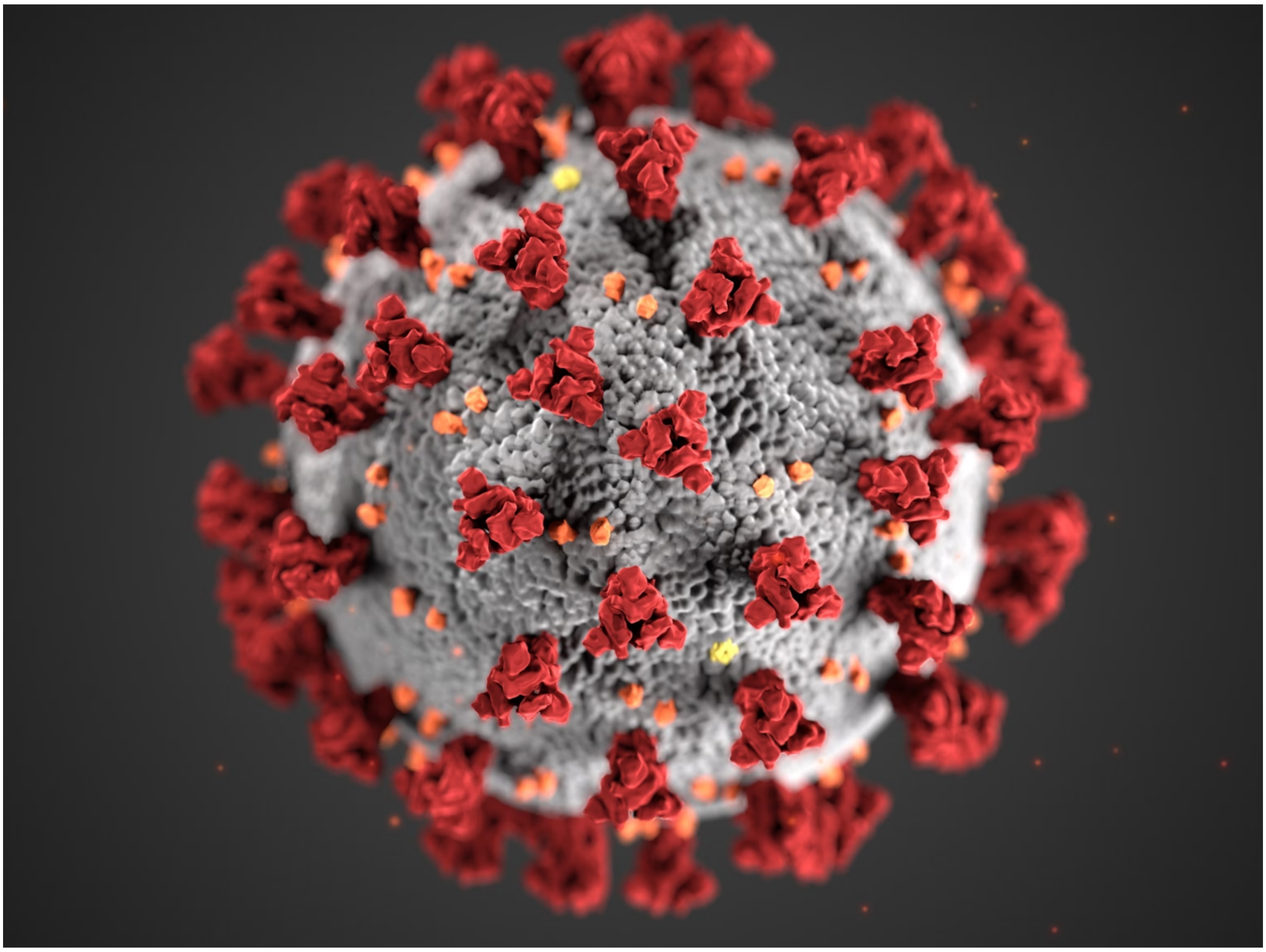

Covid-19 Simulations and Analysis

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Overview

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Complex simulation
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Introduction

COVID-19 also known as Coronavirus or Covid is an infectious disease caused by the SARS-CoV2 virus (WHO, n.d.). The virus caused a pandemic after it spread from China to the rest of the world. The COVID-19 pandemic was the 5th deadliest in human history (*COVID-19 Pandemic*, n.d.), COVID-19 infected approx. 771,548,954 people and killed some 6,974,460 people. A few facts about the COVID-19 pandemic, The United States of America had the most deaths at 1.07m (Elflein, 2022).

The aim of the simulation presented in this report is to predict what might happen if COVID-19 was let out of control and to analyse the possible deaths, added immunity and the possible number of total infections.

Simple simulation

Estimating α

One of the requirements of the task is to find a value for α. As this requires what is essentially finding the interest rate of the balance of the initial population over the time period of 29 days that compounds to lead to the final amount, an easy choice for finding the α value is to use mathematica. To estimate the value of α the formula for compound interest is needed:

$A = P(1+r/n)^{(nt)}$
Where in this case:
$A = 12{,}741{,}386$
$P = 7{,}769{,}783$
α is the unknown
$n = 1$
$t = 29$
Then using mathematica to solve for r: (x has been substituted for α in this equation)

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principal_amount = 7769783;
final_amount = 12741386;
Solve[final_amount == principal_amount * (1 + x)^29, x, Reals]
```

This then gives us:
α -> 0.0172019

The Data

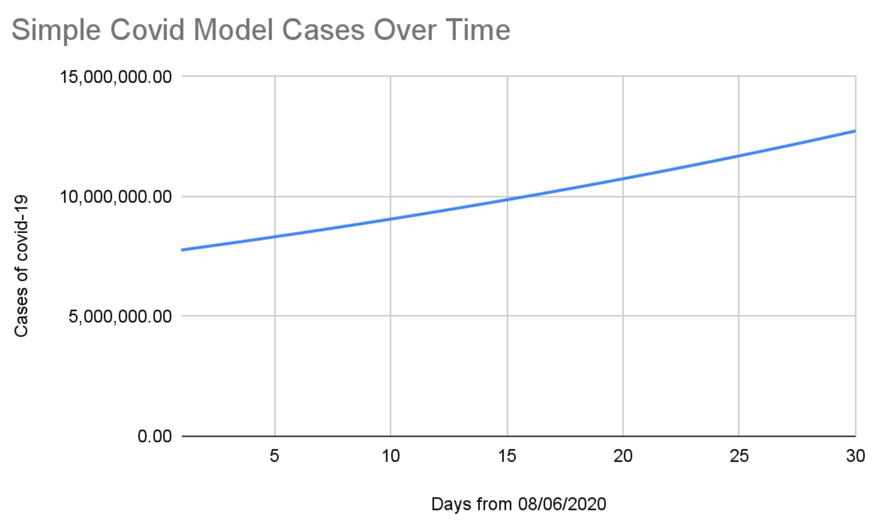

Figure. 1: The simple covid model. Number of predicted covid cases from 8/6/2020 to 6/7/2020

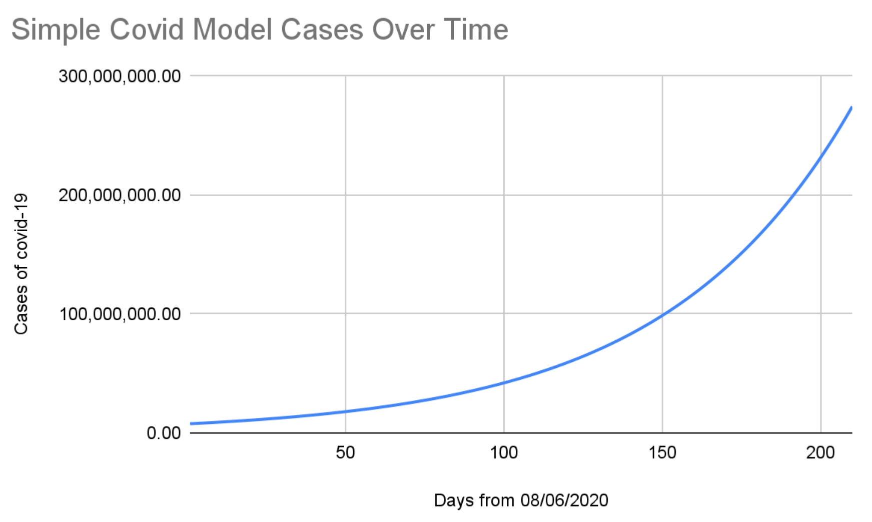

Figure. 2: The simple covid model. Number of predicted covid cases from 8/6/2020 to 31/12/2020

Link to spreadsheet:
AT4 - Covid Simple

Discussion

What does the data mean?

The simulations presented predictable results. Figure. 1 represents the number of covid cases compounding over time for 29 days from 8/6/2020. This graph doesn't show much in terms of the trends of the virus, instead it indicates that the simple model used to calculate the value on the graph is reasonable as on the 29th day, or 6/7/2020, the number of cases is 12,741,384. This is within 3 cases away from the real value (Means the α value is correct). Figure. 2 on the other hand neatly presents the exponential nature of the COVID-19 virus's spread. The gradient of the graph increases dramatically from the 50 to 100 days range to the 150 to 200+ days range. Figure. 2 illustrates what could happen if the COVID-19 pandemic was treated as trivial and not dealt with in any fashion. The total number of cases of COVID-19 after the 209 day period from 8/6/2020 to 31/12/2020 was 274,476,960. This is a dramatic difference from the total number of cases recorded from 81.68 million people who contracted the virus (OWID, 2023). This difference indicates that however correct the model was for the 8/6/2020 to 6/7/2020 range, on larger scales the simplicity of the simulation is detrimental to the results.

Errors / Interesting points

Both Figures 1 and 2 don't manifest errors as they represent a simple model of COVID-19. This does mean that the model, being simple, is not accurate to the real fluctuations of cases and is only good as an approximation / projection of the total number of infections. An interesting point is the surprising number of new cases there were over such a short period of time, ~5m cases in 29 days (Figure. 1) is rather daunting.

Possible Improvements

There are many improvements over this simple model. The COVID-19 pandemic was a complex situation with many hard to predict factors and influences that increased / decreased the spread of COVID-19. A list of possible improvements to the model that may increase the realism of its predictions is:

- Add patient recoveries from COVID-19
- Add patient deaths from COVID-19
- Make the R / α value fluctuate and change over time (This happens in reality)
- Collect more statistics about the situation

The above suggestions were all implemented below.

Any further improvements will be mentioned in the improvements for the new model.

Complex simulation

The problem

Simulating the infection, deaths and recoveries of COVID-19 is a very complex problem that requires many parameters and has a meaningful connection to real life. Making a simulation of COVID-19 is a good exercise in problem solving, data analysis and programming as it has many layers that can be unpacked and built into systems and models that most people may not have thought of. It can also help provide insights into future virus's spread and behaviour and might help prevent another pandemic.

The Data

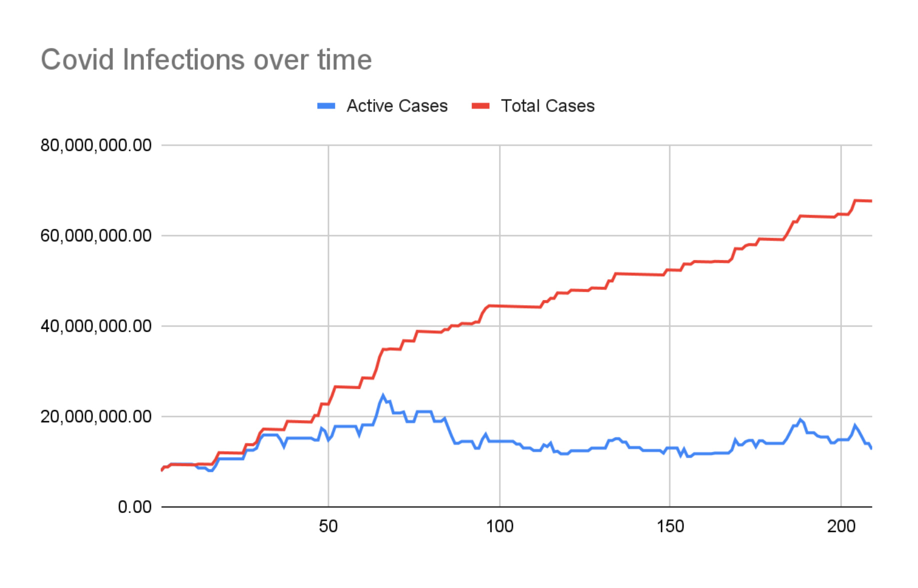

Figure. 3: Advanced covid simulation. Active cases and Total cases over 209 days.

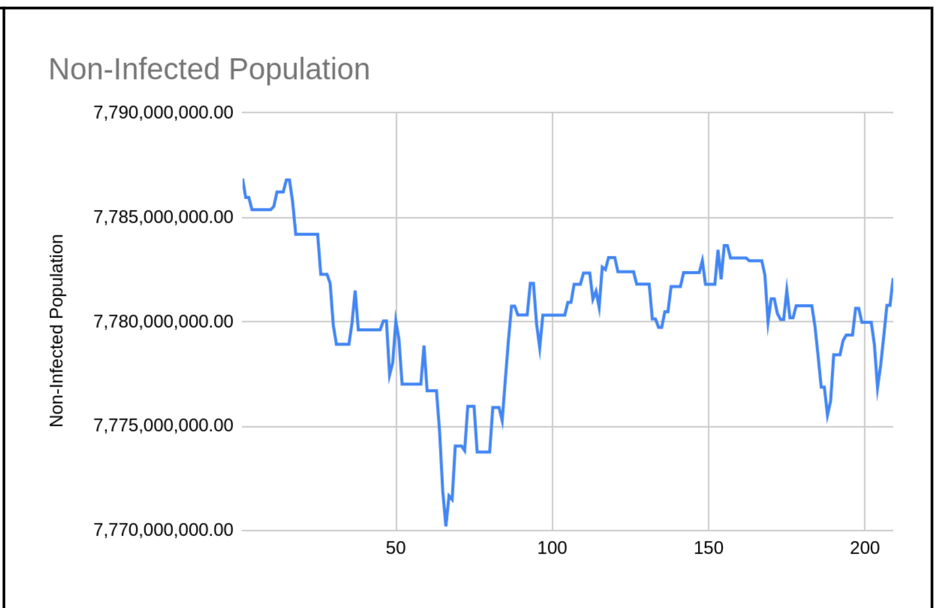

Figure. 4: The total non-infected population from the advanced covid simulation.

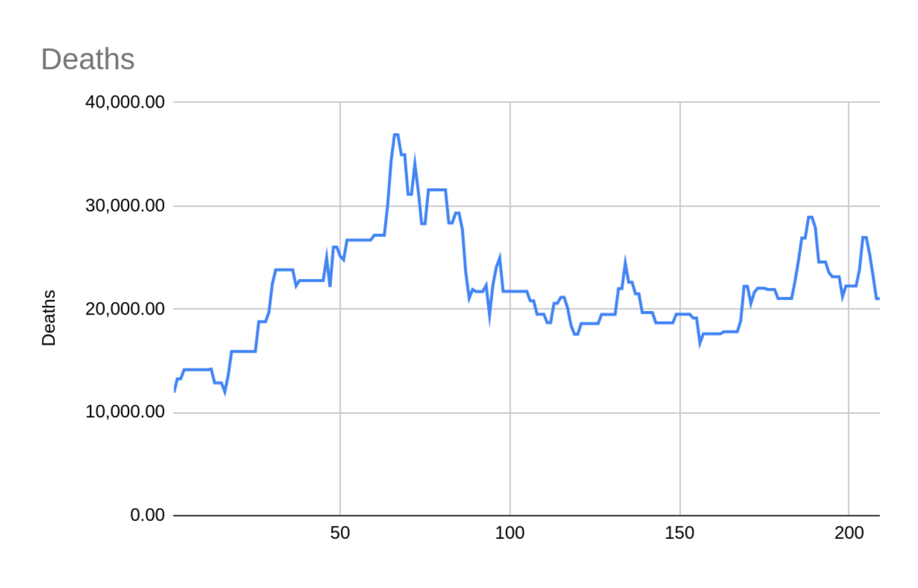

Figure. 5: Advanced covid simulation. Deaths over 209 days.

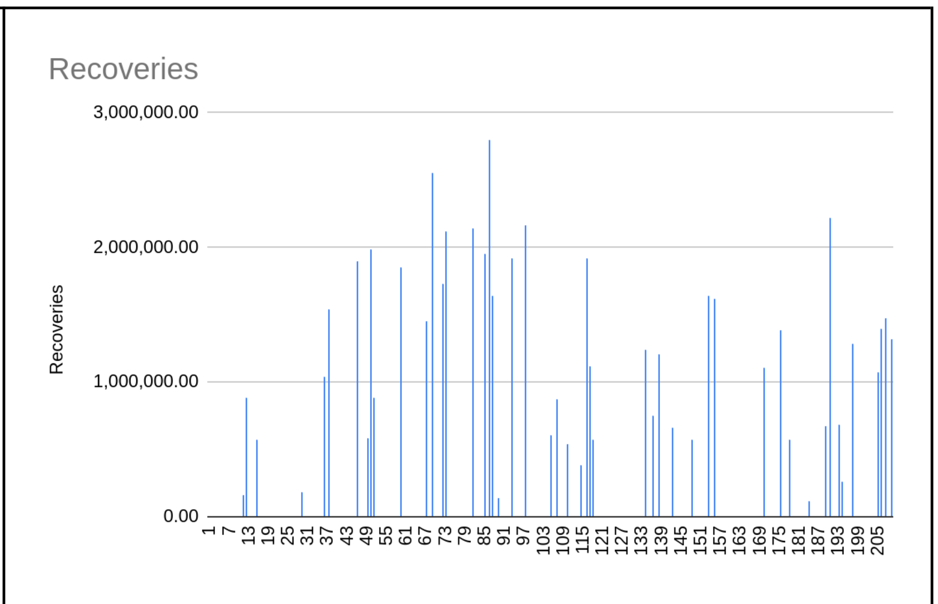

Figure. 6: Advanced covid simulation. Recoveries over 209 days.

Link to spreadsheet:

AT4 - Covid Advanced

Discussion

What does the data mean?

The complexity of the simulation is clearly reflected in all 4 of the graphs produced, Figures 3, 4, 5 and 6. Figure. 3 spotlights the unpredictability of the COVID-19 virus through the fluctuations in the number of active cases, especially in the 60 day range where there is a spike in cases to 24m concurrently infected patients and then a subsequent dip in cases as patients die and recover. Both of these aspects are visible in Figures 5 and 6. Figure. 5 outlines the connection between an increase in cases and an increase in deaths by COVID-19. The connection is most easily seen in the 60 day range where the spike in cases in Figure. 3 directly correlates to a spike in deaths in Figure. 5. Furthermore, Figure. 6 underlines the recovery process of COVID-19 with a 10 - 21 day period from infection to recovery. The spikes and dips in Figures 3 through 6 all share the same features in different ways, which are from the way the model handles all of these features as in they are heavily interconnected and work off of each other. Moreover, Figure. 3 illustrates the effectiveness of the model, especially averaged over the year as it finishes with 67.88m total cases on 31/12/2020 and in reality the total cases on 30/12/2020 was 81.68 million people (OWID, 2023). While the disparity is 14 million cases, with some tuning of values, the still rather simple model could accurately predict the early stages of the COVID-19 pandemic.

Errors / Interesting points

Figure. 6 accentuates the limitations of the model. The graph represents the number of recoveries each day from COVID-19. The gaps in the graph are from the way recoveries are being calculated, randomly choosing the number of days from infection the patient will recover. This being the same for all patients on the same day creates patches of no recoveries, where in reality the recoveries would be spread out over that 10 - 21 day period.

An interesting observation is that the peak in active COVID-19 cases at ~60 days from 8/6/2020 in Figure. 3 is in line with the spike in COVID-19 cases in Australia, around the same time (Source - Australian Govt).

Possible Improvements

Even after improving on the initial model, the new model is still relatively simple and doesn't take into account a wide number of factors that are present in real life. A number of these being:

- Social interactions and sociality
- Restrictions / precautions
- Immunity
- Spreading time / developing time
- Isolation
- Super spreaders
- And the list goes on.

A better way to simulate the spread of COVID-19, while being nearly infinitely more computationally expensive, is to simulate the population as a set of regions with a number of agents in each region. Each region would then have their own regulations and modifiers on the spread of COVID-19 and Agents would then be able to move from region to region. Each actor would have their own immunity, infection rate, recovery time, etc, and would more accurately represent the spread of COVID-19 outside of the vacuum of a computer simulation.
Note: This was my initial plan but I reconsidered after thinking it would take too much time to both simulate and create the simulation.

Reflection

What you did and the results:
I created a program to simulate covid-19 infection and spread. Within that I initially wanted, as stated above, to do a more complex simulation with agents and cities / regions but as I mentioned earlier I decided against that because of the extra work it would require. When I created the simple simulation, I somewhat struggled to think of ways to extend it, however after some research and just looking at some real covid data I settled upon simulating some of the aspects of a real covid patient, the infection rate (the R value) changing, the recovery time being different and the death rate of patients. I initially failed to get reasonable results from my model but after changing values and introducing more features into the simulation, recovery time and such, I managed to get a relatively accurate model. The model itself was accurate overall, but I doubt it was accurate for the daily breakdowns and some of the features got exaggerated, deaths for example, in the simulation were ⅔ of the total deaths over the entire COVID-19 pandemic, in just over half of the 2020 year.

The challenges you faced along with how you resolved them:
I faced a number of challenges throughout the creation of the models and the report. Firstly, I had a limited understanding of the topic to begin with and needed to do quite a bit of research to fully understand it. Once I understood the topic I then broke it down into a few sections and worked bit by bit taking inspiration from real life and how COVID-19 spreads usually. Additionally, I had to work this around my ludicrous amount of assessments (for being so close to exams) and revision for exams. This was fixed with a study schedule and putting off this project longer than I should have.

Your thoughts on this assessment and this unit of work (Simulations):
The simulations topic was certainly interesting and insightful into some interesting models and problems, however, there wasn't much for me to extend for the most part of the unit. The theory was interesting to learn but the application of the theory got a little bit tedious after some time. The assessment (this one) had a good range of simulations to select and provided a number of opportunities for extension.

Some feedback for this assignment:
Can you make the fact that we need to discuss both the simple version and the extended version clear from the start (if that didn't happen when I was absent).
Maybe make the code for the simple version a pass/fail as it was kind of difficult to actually extend.
Move the assignment back a bit, away from exams (if possible) preferably as I was more focused with finishing this assignment rather than studying for exams.

References

COVID-19 pandemic. (n.d.). Wikipedia. Retrieved October 31, 2023, from https://en.wikipedia.org/wiki/COVID-19_pandemic

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