Epidemic Spread Simulation and Dashboard

Suhas Cholleti, B.E.

Advisor: Thomas B. Kinsman, Ph.D.

Computer Science @ RIT
B.Thomas Golisano College of Computing & Information Sciences

Introduction

COVID-19 has had a devastating impact in our lives since the beginning of 2020. It is important to understand the attributes which drive spread of COVID-19. With this project, we want to create a simulation that allows individual behaviors to be switched on and off, allowing us to understand which human behavior has the most impact on viral spreading. Running simulation on a console is a barrier to most people. Here we increase the performance of the existing interaction model[1], and incorporate an interactive user interface with data visualization to make the computations more available. This work enables increased population size, reduced runtime, interactive control, visual feedback to the user.

Data Simulation

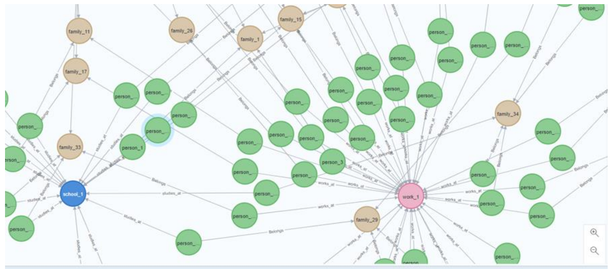

Fig 1. One Graphical Representation of the Population, in Noe4j. Green Nodes represent people, Brown nodes represent families.

In this experiment, population of the community is simulated. The user can select the size of the population and create the population using the Create Population Button on the Dashboard.

- Initially Nodes for each of the activities/ places are created. There are multiple Schools, workplaces, dog walking parks, malls, gas stations etc. Each of these places are denoted as a node in a Neo4j graph database.
- The program creates family structures. Each family has a size, and attributes such as masking propensity, pet ownership, and other sub-communities.
- Finally, the people in the family are created. Each person belongs to a family. Each of the people are also assigned different attributes such as age, Date of Birth, Work / School, volunteer activities, community sports, and religious affiliation.
- Each person node is connected to other people nodes through their activities and affiliations.
- People are assigned different actions depending on the attributes and the day of the week. These values are then used in simulating different scenarios.

Epidemic Smulation Experimentation

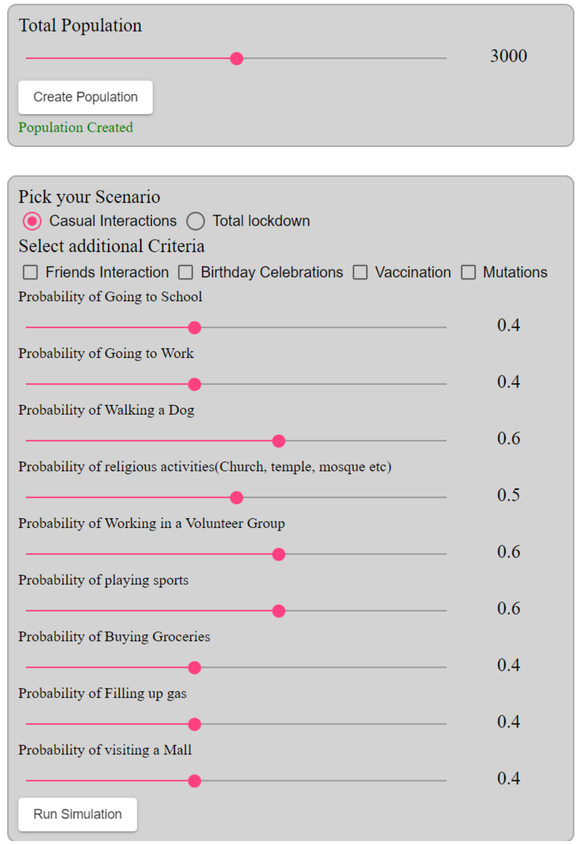

Fig 2. View of the scenario, criteria and probability selection of the Epidemic Simulation Dashboard

Before running the simulation, there are couple Transmission scenario that we were designed:

1. General Scenario: In this scenario, the population takes part in all the activities. The population behaves with no regard to the ongoing pandemic.
2. Total Lockdown Scenario: In this scenario, the population takes part in only a limited number of activities that are completely essential.

Users can also select zero or more additional criteria, along with the scenario:

1. Family group Interaction: Groups of family's are created. These groups meet every week. Can only be used in the General Scenario.

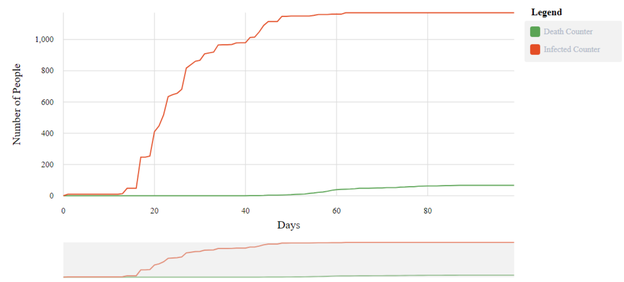

Fig 3. View of the Results on the Epidemic Simulation Dashboard

2. Birthday Celebrations Allows children between the age of 4-18 to celebrate birthdays. Can only be used in the General Scenario.
3. Vaccination: Vaccinates 70% of the population, which removes them from the set of people that can be infected.
4. Mutations: Allows mutations to occur, every 10 - 14 days which increase the spreading rate and decrease the incubation period.

All of these scenarios, additional criteria and probability sliders are to the left on the dashboard. Once all the simulation criteria and the probabilities are selected, the simulation is initialized and run for 100 days.

The system is initialized by selecting ten people at random who are added a queue of infected people. The attributes of infected people are compared with those of the healthy people on that day. If the conditions are met, the newly infected are derived and they are added back to the queue. The people who are in the infected set will not be infected again. This process is done for each day of the simulation period. The results are returned and are displayed on the right side of the dashboard.

Results

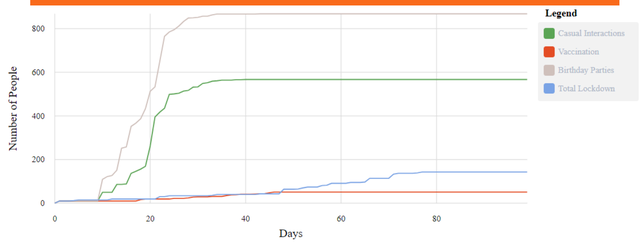

Fig 4. Snapshot of epidemic simulation graph. Only Base scenarios with no additional criteria were used. Casual Interactions Increase the number of cases dramatically compared to Lockdown Scenario.

Figure 4 shows that we can create a population of up to size 5000. It also shows the various options that can be used to run a simulation. Different scenarios and criteria can be used either independently or in tandem to generate an epidemic and view the results.

In the lockdown scenario, the total number of infected people is less compared to Casual Interactions . This is due to the fact that the people do not come in contact with each other except for a few essential activities.

Conclusion

- We have studied the impact of different scenarios (General and Lockdown) and different behaviors (Like Vaccination, Birthday Celebrations) in a small-world community.
- The experiment show that lockdown with only essential activities reduces the rate of viral spread.
- The research showed that vaccinating 70% of the families helps in reducing the virus' spread.
- The User Interface has options to pick and choose which scenarios and criteria to select. It also has the capabilities to adjust the Probabilities of various activities to occur.
- The User Interface provides an amazing Visual Feedback, which helps in understanding the affects of the behavior.

Future Work

- Future work could focus on improving the performance and throughput of the system, and simulate multiple viral variants.
- The number of schools, park and the other nodes representing the nodes are fixed irrespective of the population. This needs to be changed to vary with the population size.
- Immunity/Vaccine to one strain of a virus need not be helpful with other mutations of the virus. This can be implemented to be more realistic.
- A scenario that introduces Social Distancing norms, and Hygiene would be helpful.

References

1. Ravikiran Jois Yedur Prabhakar. Simulating the Spread of an Infectious Disease in a Small Community (2021)
2. Gang Xie. 2020. A novel Monte Carlo simulation procedure for modelling COVID-19 spread over time. Scientific reports 10, 1 (2020), 1–9
3. Ahmad B Hassanat, Sami Mnasri, Mohammed Aseeri, Khaled Alhazmi, Omar Cheikhrouhou, Ghada Altarawneh, Malek Alrashidi, Ahmad S Tarawneh,Khalid Almohammadi, and Hani Almoamari. 2021. A Simulation Model for Forecasting COVID-19 Pandemic Spread: Analytical Results Based on the Current Saudi COVID-19 Data. Sustainability 13, 9 (2021), 4888.