CSC-207

FINAL PROJECT
VIRUS SPREAD SIMULATOR

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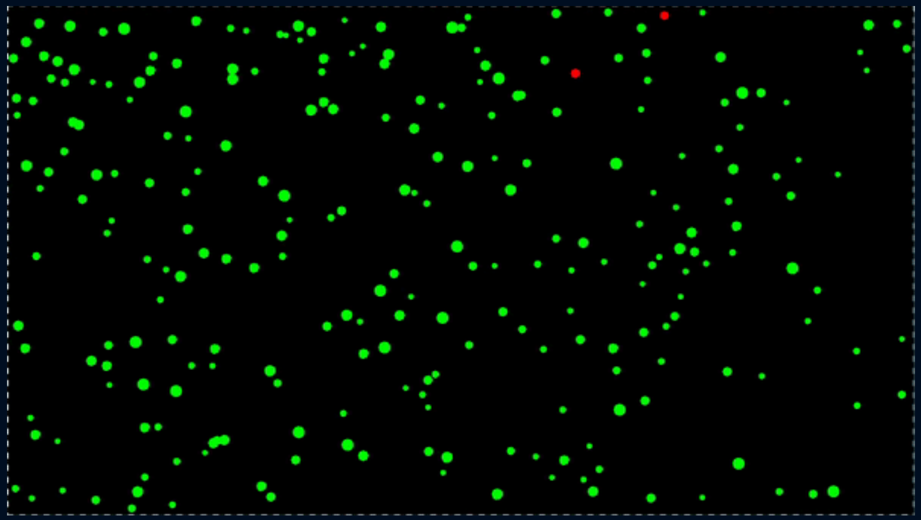
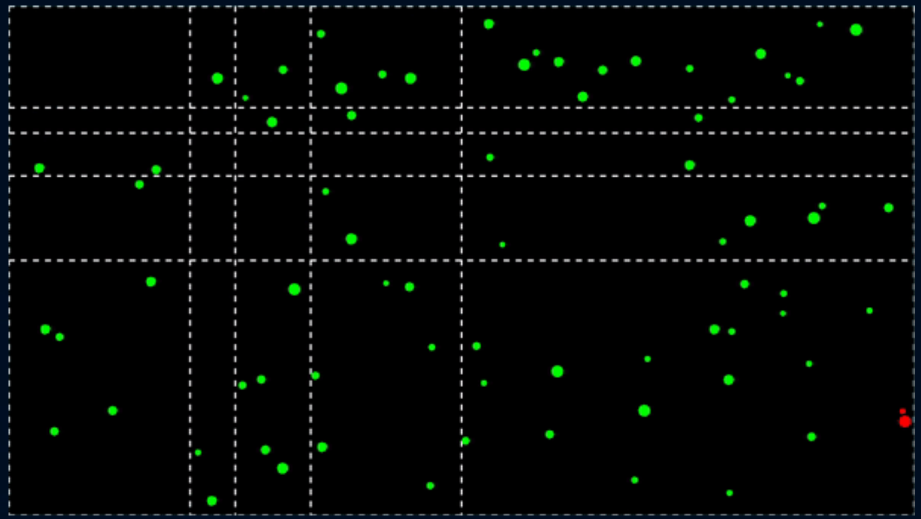
Abstract

- Our group is planning on creating a java program that simulates the spread of COVID-19 and, potentially, other kinds of virus.
- This project is very relevant right now since the COVID-19 has become a global pandemic. Research done by scientists show that social distancing is an important measure to slow the spread of the virus.
- Our project intended to show how different size of population and hospital capacity would affect the growth rate of virus and the importance of social distancing, in order to mitigate the spread of COVID-19.

Build-in Packages

- Our project is based on previous work by Zayed, which is a basic collision-infection based simple simulator. The original version randomly put fix amount of people (dots) in a city (a specific window) and define the collision as the way for the virus to spread out.





- Reference: https://github.com/AzizZayed/Virus-Spread-Simulation

Problems and Limitations

- The original version assume that the entire population is identical, which ignore the fact that age would affect the infection, recover, and death rate.
- Whenever the user want to change the setup, they need to go back to the code to modify.
- It is hard to know the exact number of infections, death and the day-time.
- In real life, when a person is diagnosed, hospital is available, which might decrease the death rate and increase the recovery time.

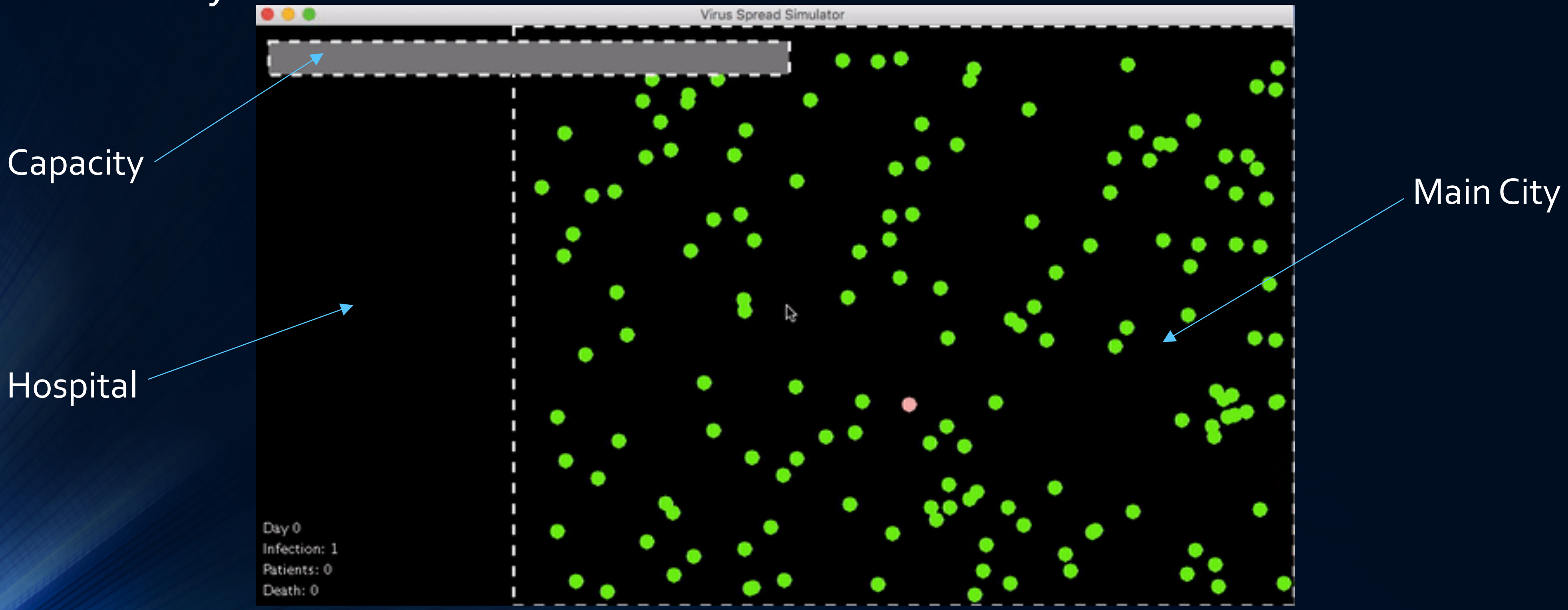
Solutions and Extensions

In order to solve the previous limitations

our group did the following upgrades

Hospital

- We introduce a hospital with a specific capacity to hold most of the patient that diagnosed as infected. The recovery time here is different from that in the main city.



Different State of a Person

- Unlike the original version, which only has healthy(green) and infected(red) people, we introduce more detailed state of each person

Healthy

Recovered

Sick (No Symptom)

Dead

Hospitalized

```
public enum State {
    HEALTHY, // green
    RECOVERED, // blue
    SICK,//No Sympotom(Not HOSPITALIZE) pink
    DEATH, // white
    HOSPITALIZE //red
}
```

More information about a Person

- The original version simply defined an infection rate as "0.9/1.0 change to get infected" when collide with other dots.
- We introduced more detailed information about a person such as age, which would in turn affect the infection, recovery, and death rate.

```
//0.4s represents one day
//Recovery takes 14 days to 42 days
//Death rate varies from 0·00161% to 7.8%

    private float probSick; // probability of getting sick after a collision with a sick person
    private float recoveryTime; // time in milliseconds to recover from first sick
    private float deathProb;
    private float SympotomTime = 5600.0f; // time in milliseconds to recover from first sick
    private long sickTime = -1l; // store the time the person has been sick
    private long HospitalTime = -1l; // store the time the person has been sent to Hospital
```

Data and Calculation

- Every 0.4 second represents a day.
- Population Age Distribution: Age is uniformly distributed between 0 and 90.
- Speed: Each person's speed is negatively correlated to their age.
- Every person has 50%-90% chance of getting infected, positively corrected to the age. Sick state will last for 14 days after infected for everyone, then turn into Hospitalize State.
- After turning into Hospitalize State, this patient will recover after 14 to 42 days, positively correlated to the age except the patient dies. Note the getting into hospital can halve the recovery time.
- Rate of infection = Duration * Opportunity * Transmission probability * Susceptibility.

- Death rate for different ages

0-10: 0.0000161

10-20:0.0000695

20-30: 0.000309

30-40: 0.0844

40-50: 0.0016

50-60: 0.00595

60-70: 0.0193

70-80: 0.0428

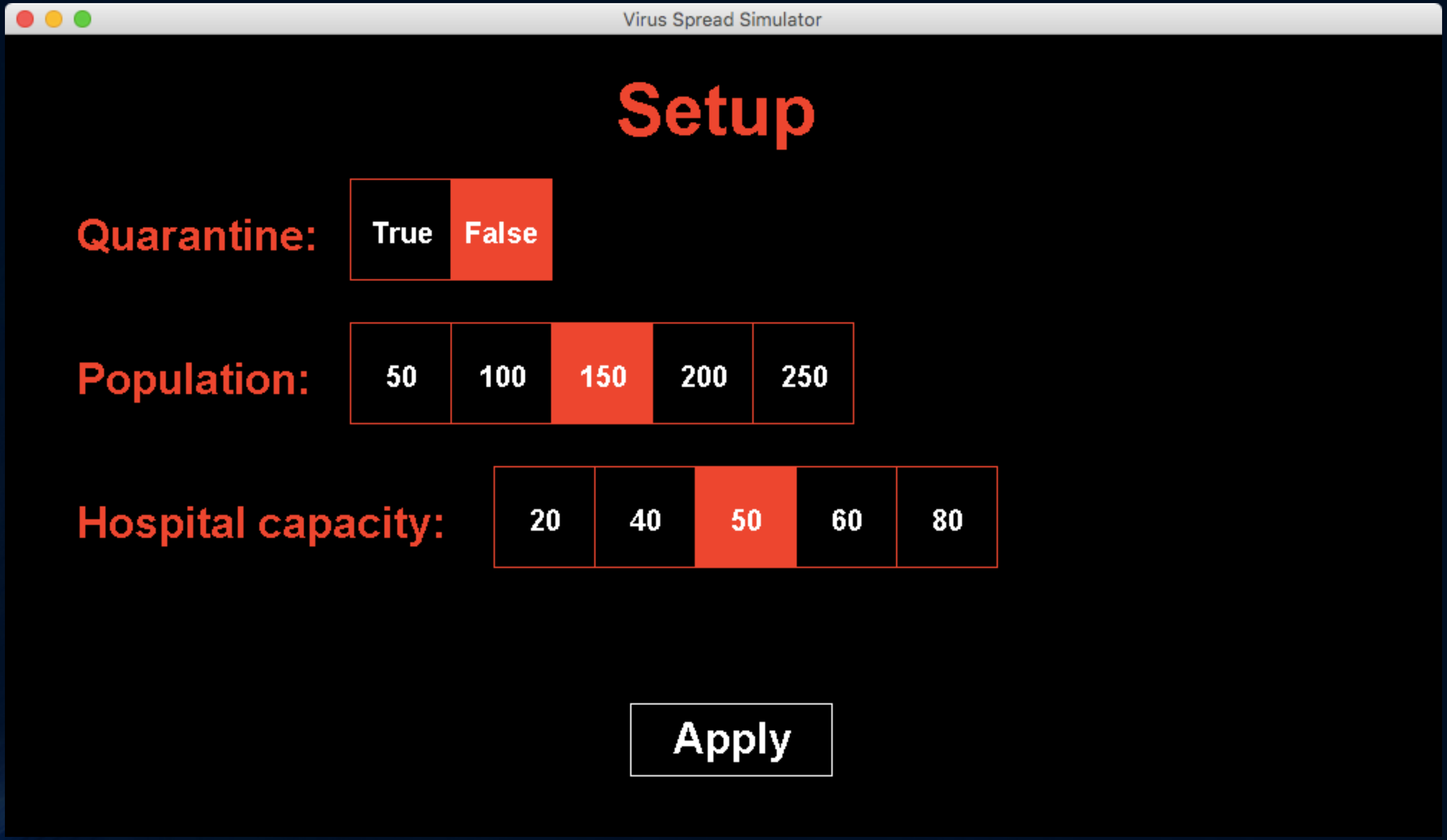
80-: 0.078

- Reference: https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30243-7/fulltext

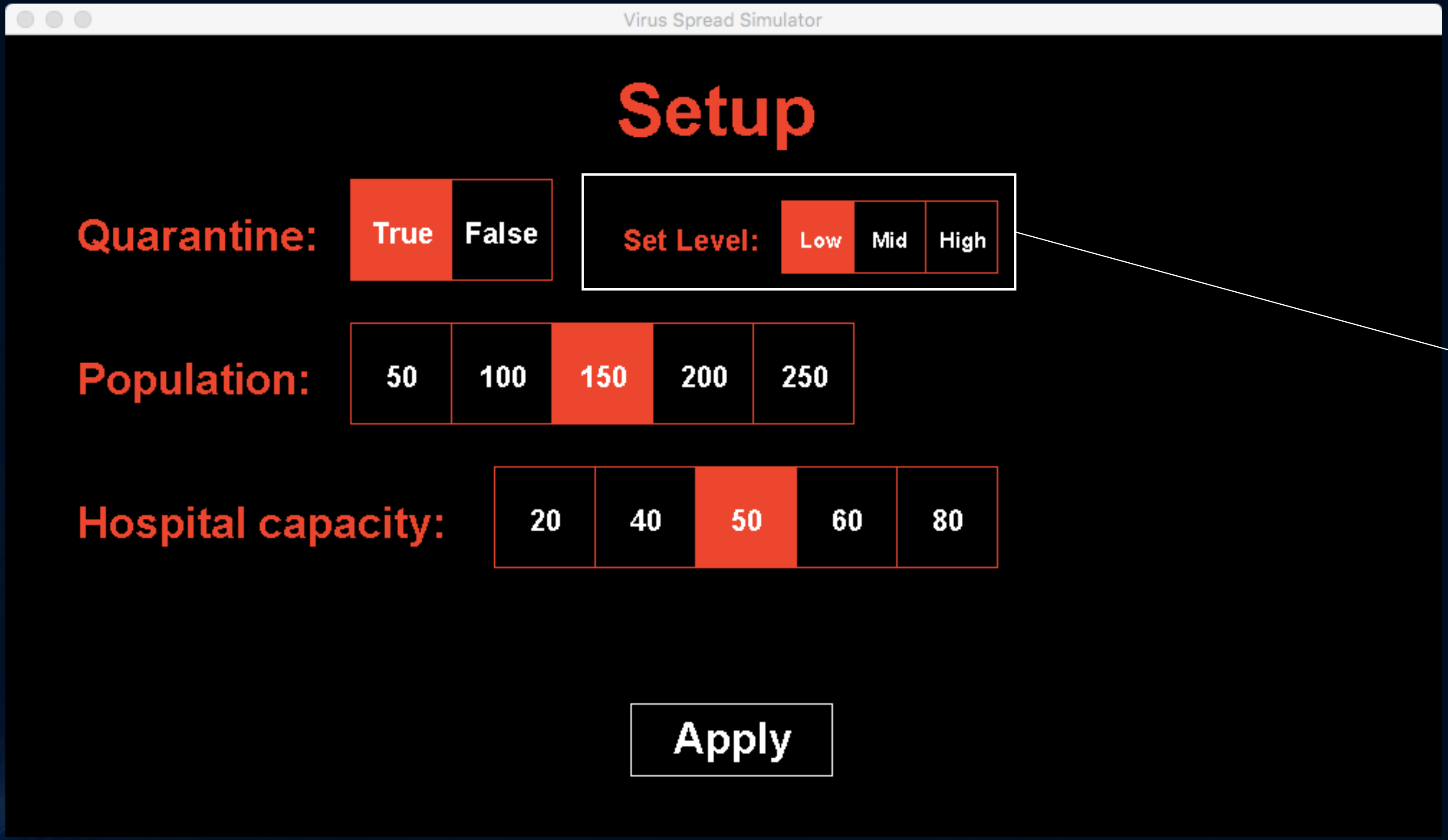
GUI (Graphical User Interface)

- As we mentioned before, the original version lack the ability to let the user to setup the environment.
- In order to solve this problem, we develop a GUI-like Canvas interactive panel that allows the user to setup the environment while the program is running.
- The user is now able to set:
  - Quarantine Mode: True or False
  - Population: 50, 100, 150, 200, 250
  - Hospital Capacity: 20, 40, 50, 60, 80

Menu


Virus Spread Simulator
Setup
Quarantine:
True
False
Population:
50
100
150
200
250
Hospital capacity:
20
40
50
60
80
Apply

Menu



Quarantine Level

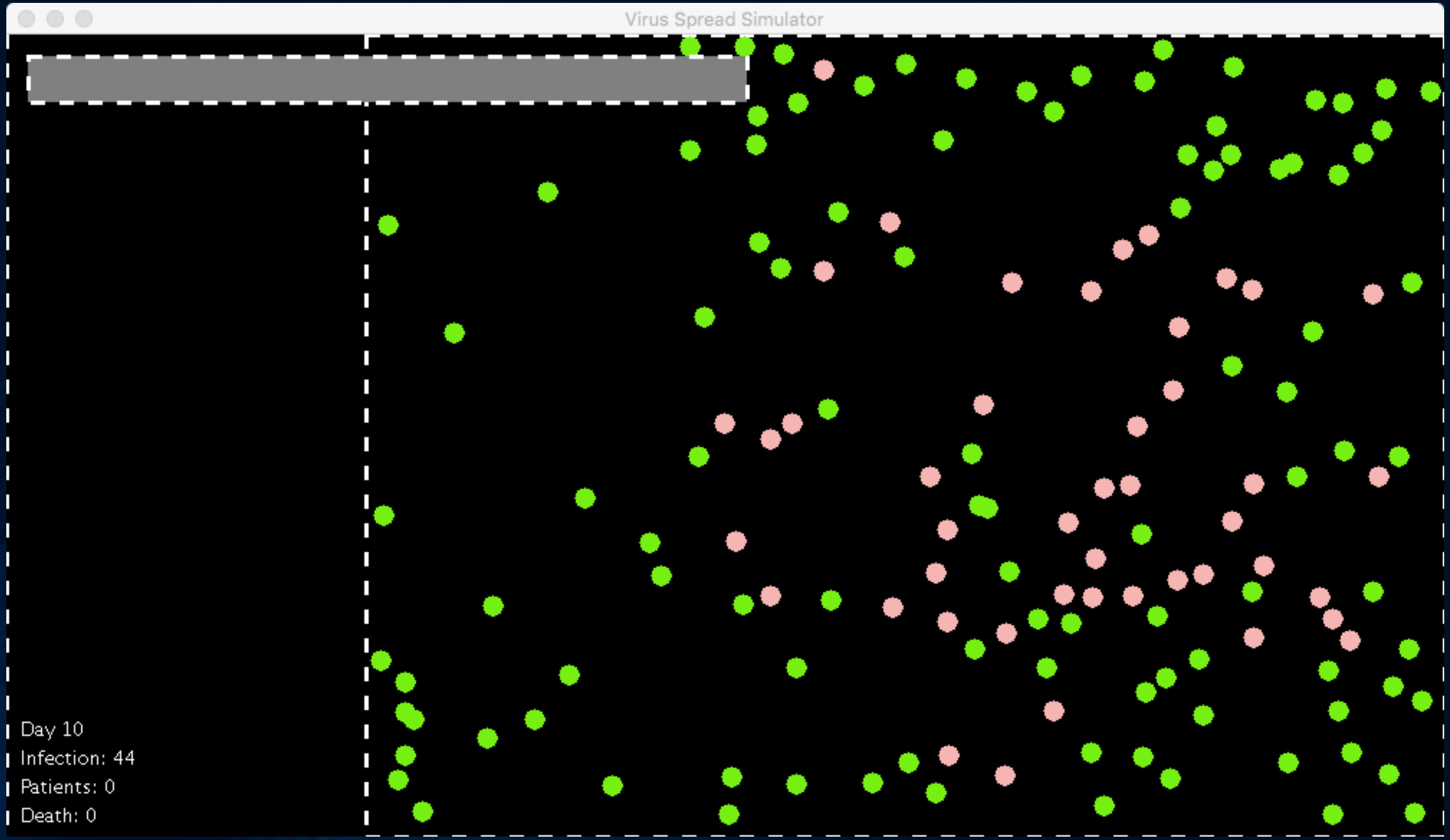
Example 1

Quarantine: False

Level: None

Population: 150

Hospital Capacity: 50



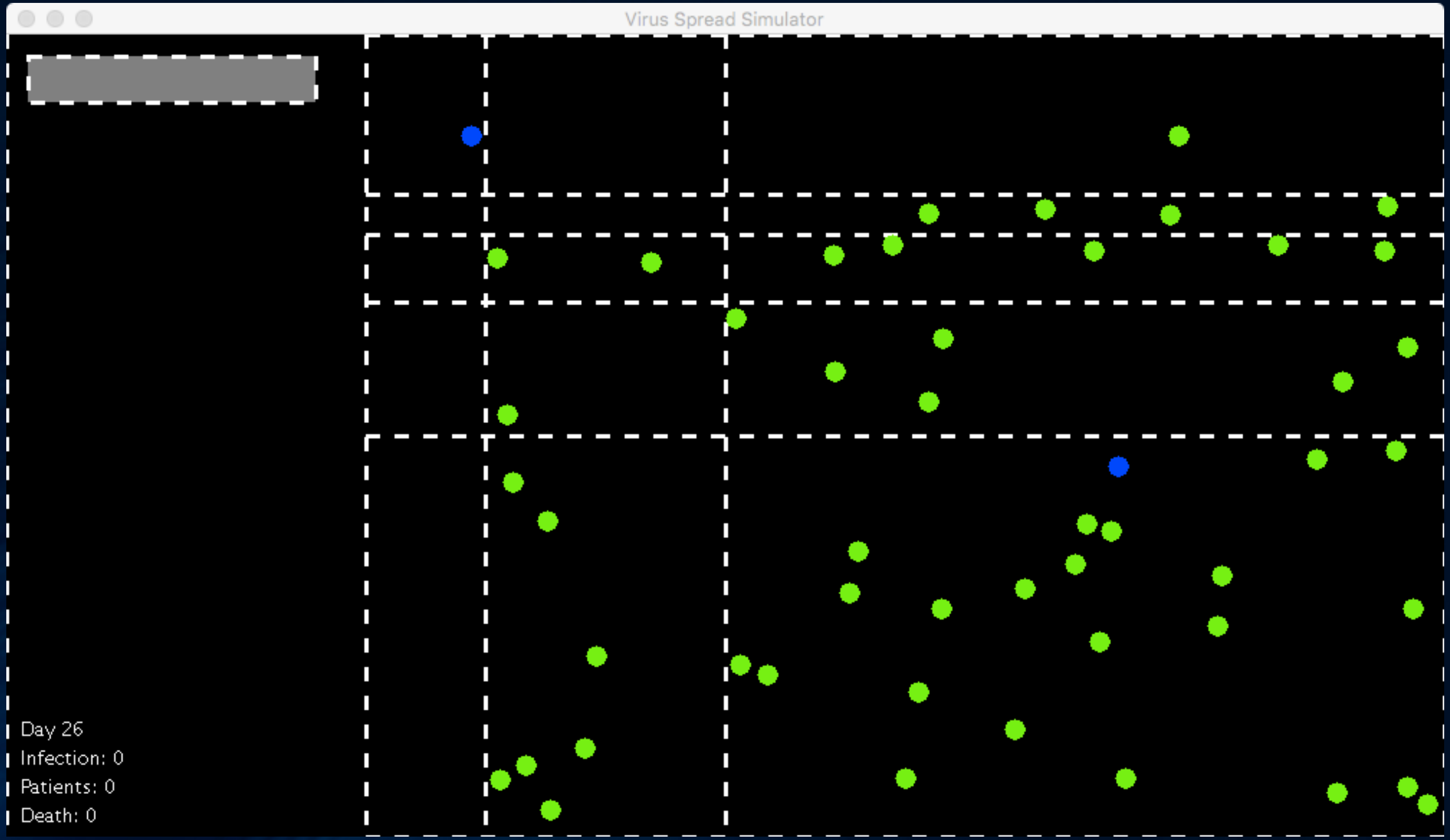
Example 2

Quarantine: True

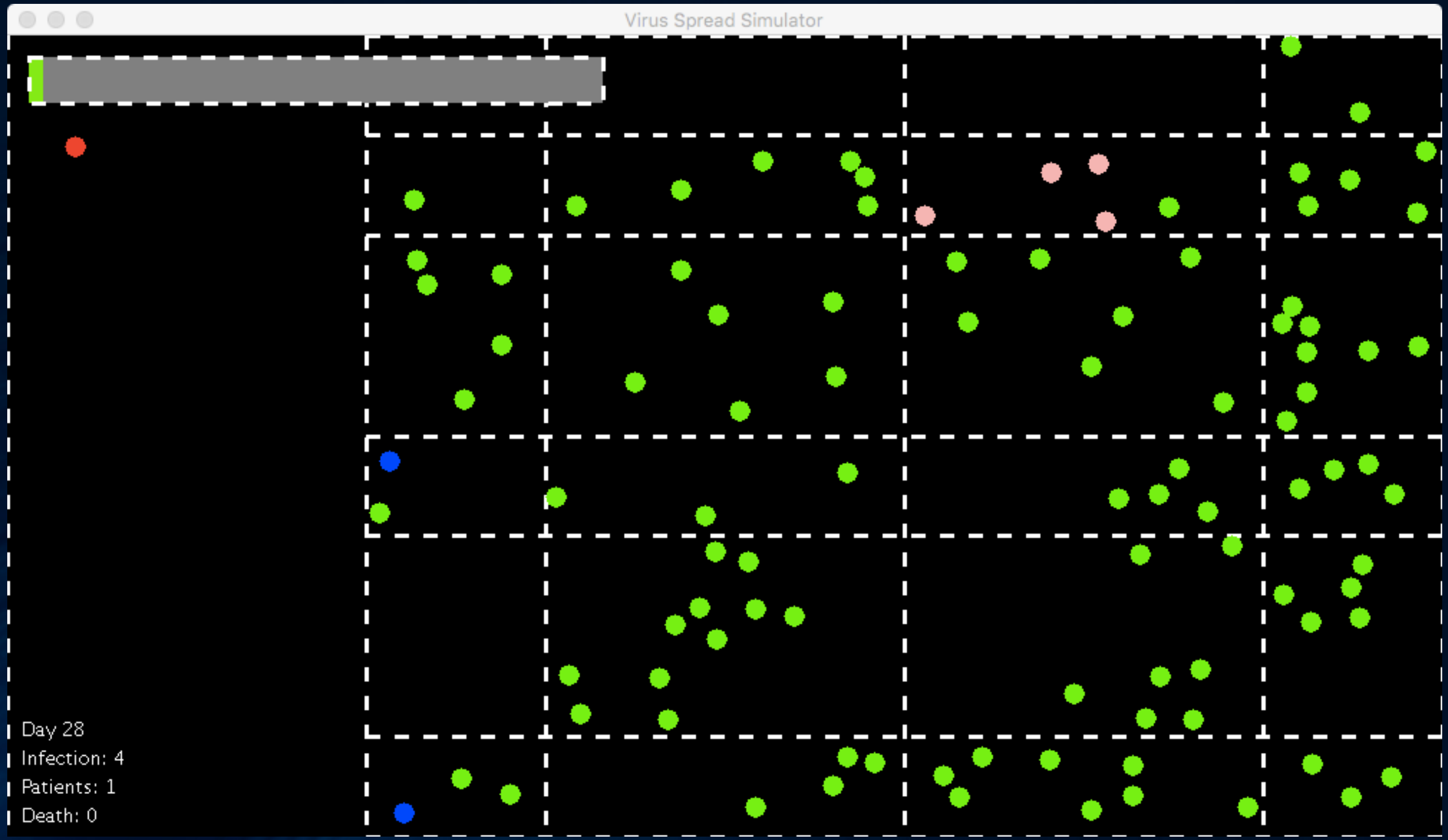
Level: Low

Population: 50

Hospital Capacity: 20



Example 3



Quarantine: True

Level: Medium

Population: 100

Hospital Capacity: 40

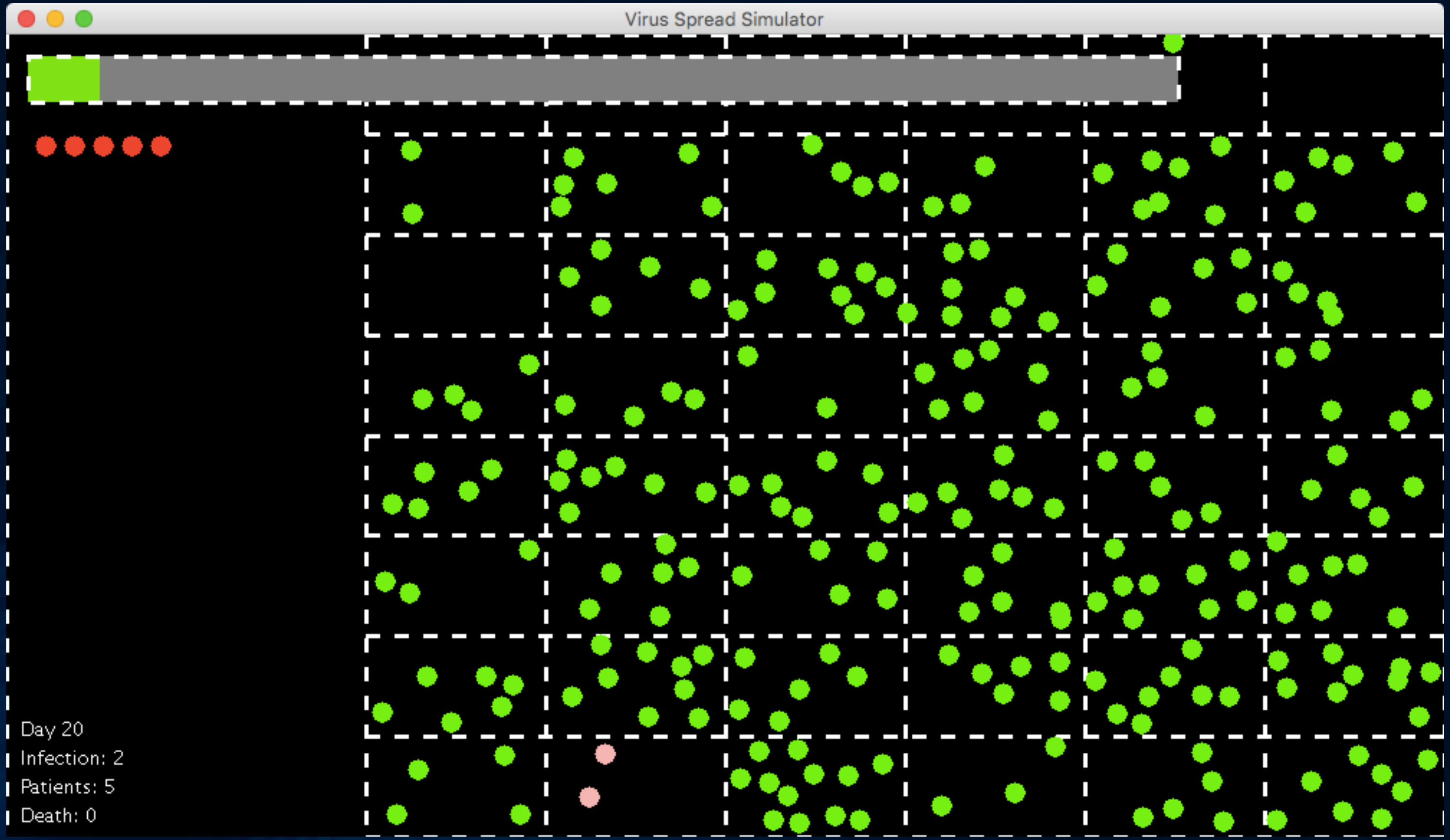
Example 4

Quarantine: True

Level: High

Population: 250

Hospital Capacity: 80

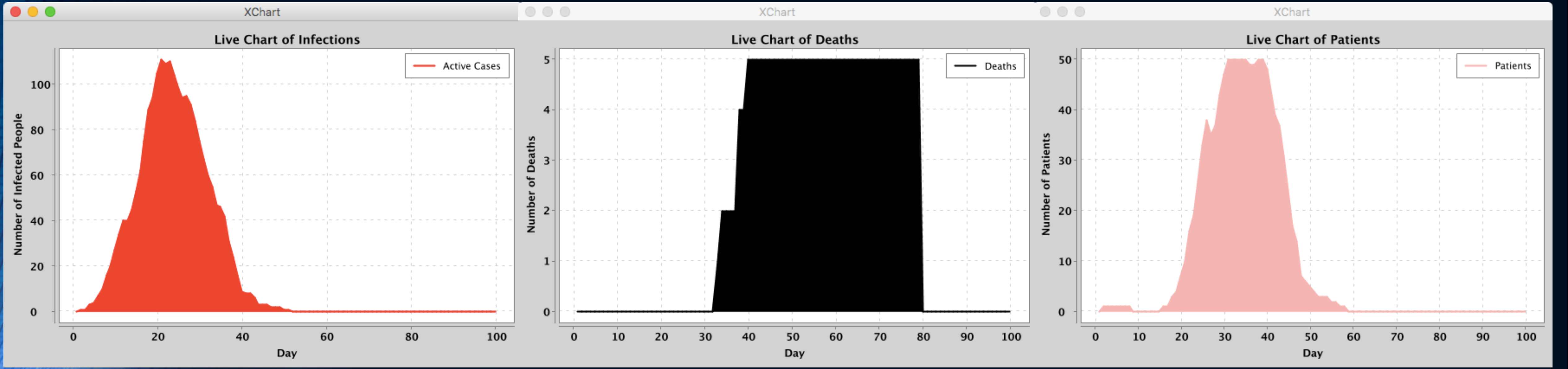


Live Chart

- One new aspect we added to the program is a couple of live-charts that shows the curves for infection, patients, and death. These graphs is lively related to the simulator, which makes the outcome clear for the users to understand and analyze.

Deficiency:

Since we used the external jars from X-chart, which is a one-time pop-up window live chart system, it is currently not possible to refresh the charts when the users reset the city environment. Right now, the users must restart the program to see different graphs under different condition. If we have more time, our next step is to let these live charts be refreshable and optional for the user.



Data Analysis

- It is commonly known that such a visualization can only gives the user a general idea of how virus would spread out across the entire community. It would be more useful if we can record all the data we get from the simulator and people can use these data to do some further analysis.
- Therefore, we decided to make the program able to write all the data (including infections, patients, death, quarantine, etc.) into a csv file for the convenience of further analysis.

- The report on the right is a screenshot of a csv file written by our program. It simply shows the shift from NO quarantine to a low-level quarantine mode.

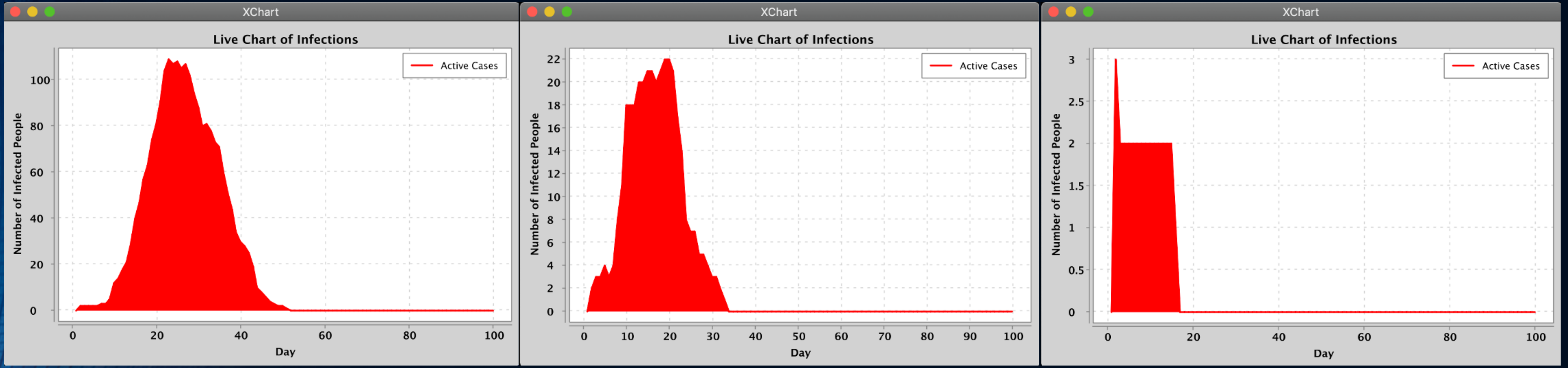
Report

Day	Population	Hospital Capacity	Infections	Patients	Deaths	Under Quarantine	Quarantine Level
1	150	50	1	0	0	FALSE	N/A
2	150	50	2	0	0	FALSE	N/A
3	150	50	2	1	0	FALSE	N/A
4	150	50	1	1	0	FALSE	N/A
5	150	50	1	1	0	FALSE	N/A
6	150	50	2	1	0	FALSE	N/A
7	150	50	2	1	0	FALSE	N/A
8	150	50	2	1	0	FALSE	N/A
9	150	50	3	1	0	FALSE	N/A
10	150	50	4	1	0	TRUE	low
11	150	50	4	1	0	TRUE	low
12	150	50	8	0	0	TRUE	low
13	150	50	10	0	0	TRUE	low
14	150	50	12	0	0	TRUE	low
15	150	50	17	0	0	TRUE	low
16	150	50	52	1	0	TRUE	low
17	150	50	57	1	0	TRUE	low
18	150	50	62	1	0	TRUE	low
19	150	50	67	1	0	TRUE	low
20	150	50	75	2	0	TRUE	low
21	150	50	80	2	0	TRUE	low
22	150	50	79	6	0	TRUE	low
23	150	50	79	8	0	TRUE	low
24	150	50	79	10	0	TRUE	low

- The following few slides are full of graphs and words extract from our analysis file. It would not be a part of our presentation. However, in order to fully explain our conclusion, we hope that the detailed explanation won ‘t bother you for the redundancy.

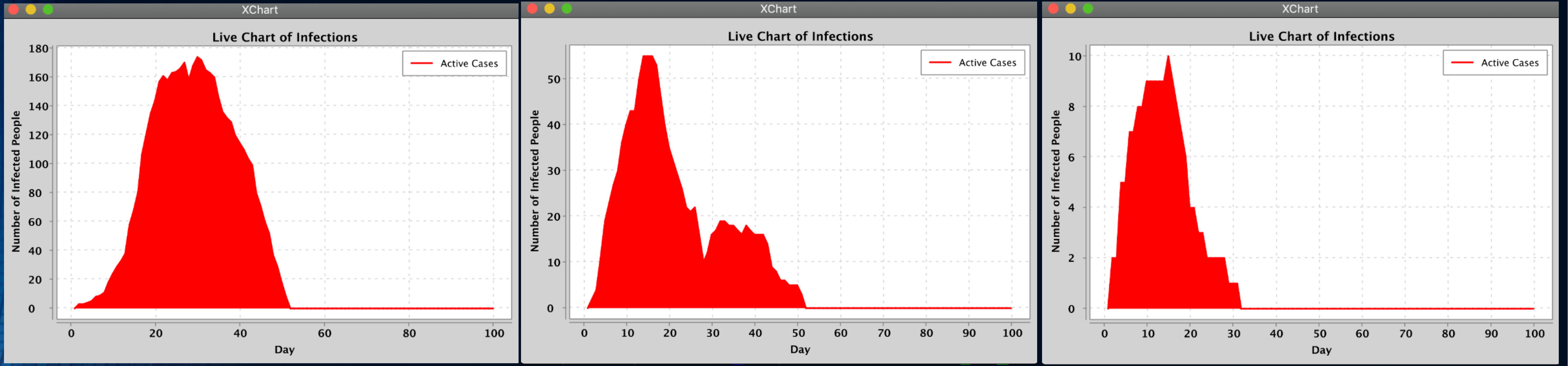
Final Report

The Effect of Quarantine



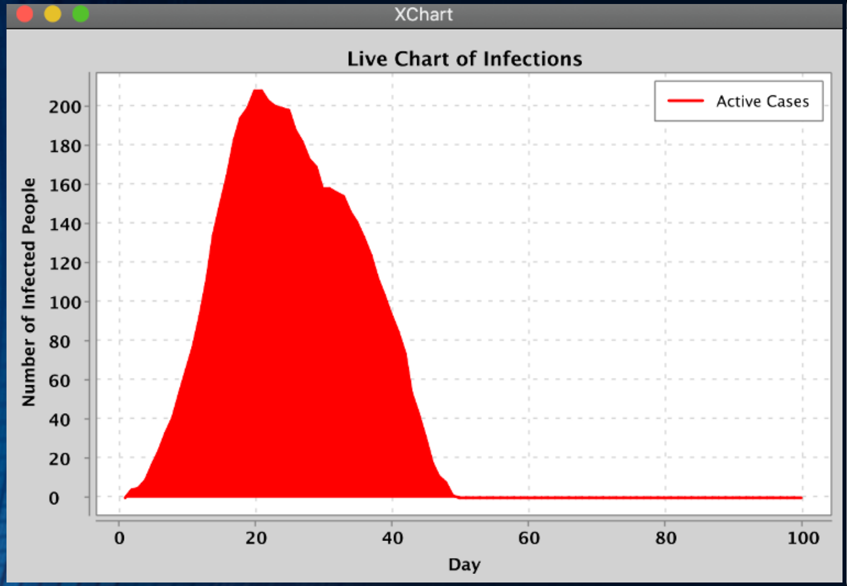
The three graphs above depicts a simulation of the spreading of COVID-19 in a city of 150 people with a hospital capacity of 50 people. Figure 1a is without quarantine and figure 1b and 1c are cities with a low and high level of quarantine, respectively. As sees in figure 1a, there are about 110 infected people at the peak of the virus; in figure 1b, there is a big decrease in the number of people infected (only 22); finally, in figure 1c, there is merely 3 people infected with the virus. This stark difference shows the effectiveness of quarantining (social distancing) in order to slow the spread of the COVID-19. Hence, our project confirms that social distancing works and that it is an important measure in order to mitigate the spread of the contagious virus.

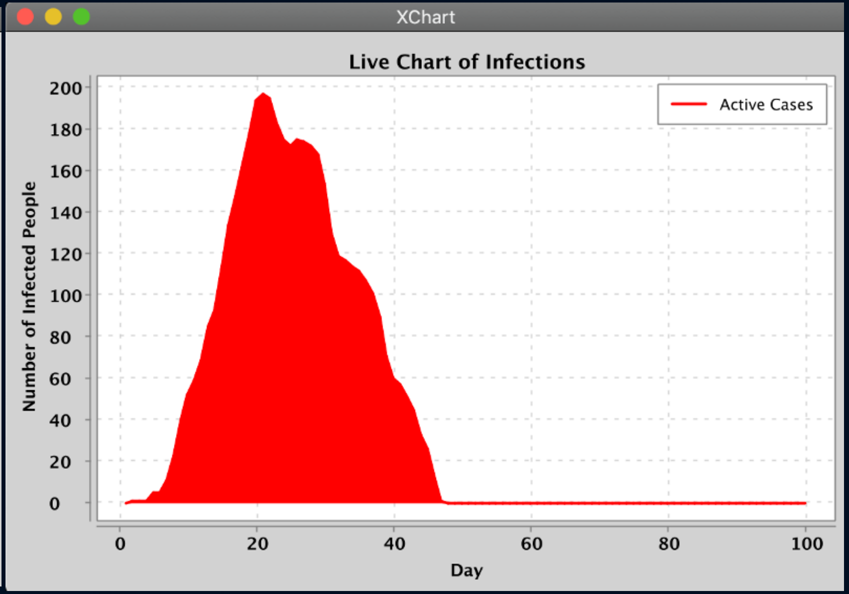
The Effect of Population Size

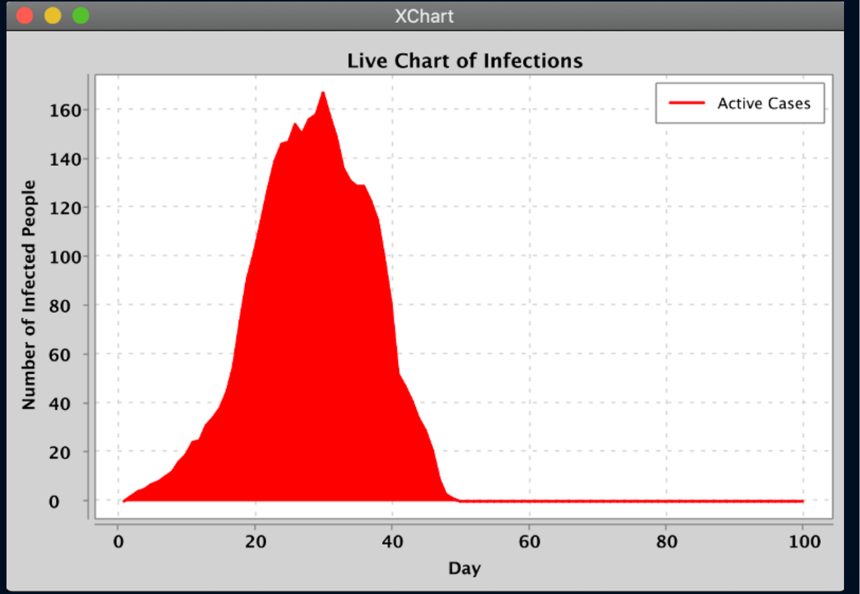


The three graphs above depicts a simulation of the spreading of COVID-19 in a city of 250 people with a hospital capacity of 50 people. The three graphs are similar to the graphs in the first comparison; meaning, the first graph has the most infection (no quarantine), followed by the second (low quarantine) and third (high quarantine) graphs. One main difference is the number of infected people at the peak of the virus. With the same hospital capacity of 50 people but with a population that is much bigger (250 people), we can see that the number of infected people at the peak are higher for graphs in figure 2a, b, and c, compared to the graphs in the 1a, b, and c. This shows the importance relationship between population size and the spread of the virus. People living in cities with a higher population is inherently at a higher risk of getting infected with the virus compared to someone living at a city with a lower population.

The Effect of Hospital Capacity







The three graphs above depicts a simulation of the spreading of COVID-19 in a city of 250 people with no quarantine in three of them. Figure 3a is a city with a hospital capacity of 40, figure 3b has a hospital capacity of 60, and figure 3c is a city with a hospital capacity of 80. At first sight, the three graphs appear to all be very similar. However, notice that the number of infected people at the peak of the virus in figure 3a is around 210, while that number is 185 and 170 for figures 3b and 3c, respectively. There is a clear relationship between the capacity of a hospital and the number of infected people with the virus—as the capacity of the hospital increases, the number of infected people decreases. This relationship perfectly aligns with our own knowledge of a hospital and its effect on the number of infected people with the virus. Hence, we show that a larger hospital capacity leads to a lower infection rate of COVID-19.

General Conclusion

- Overall, our simulator shows that social quarantine has a positive effect in mitigating the spread of virus, and the level of quarantine would also affect the peak value of infection and death.
- The population size and hospital capacity is also essential for controlling the spread of virus since different city and community have different reaction to such a spread out.

Next Step

- Unfortunately, we do not have enough time to advance our program to make it more advanced and perfect. Problems such as having a more user-friendly menu/setup panel, options for refresh the live charts, and having more detailed and professional calculation of infection/death/recovery rate are waiting for us to solve in the future.
- Our next plan, is to student more professional researches on virus-spreading and therefore have more exposure to the scientific calculation of the simulator. Additionally, as Professor Hamid suggested before, it would be better if we can set the death rate, for which the simulator can be applied to different kind of virus. Also, the GUI part needs to be improved since right now we did not spend most of our effort on that part.
- Finally, we are expecting people to use our simulator with different setups to find more and more interesting and useful conclusions that might help the control of virus.

Acknowledgment

- We want to express our greatest thanks to Professor Hamid for her generous help and support to our project.
- We also thanks all the people who is currently fight against the COVID-19 virus. We hope the day for controlling and eliminating this virus is coming, and our small effort can help.

GitHub Link

- https://github.com/HuandongChang/COVID-19Simulator

References

- https://github.com/AzizZayed/Virus-Spread-Simulation
- https://www.nytimes.com/2020/03/05/health/coronavirus-deaths-rates.html?referringSource=articleShare
- https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30243-7/fulltext

Thank You