Linxin Liu (NUID: 001565720)
Tianqi Zhang (NUID: 001056916)
Gan Li (NUID: 001063585)

INFO 6205

Program structure and algorithm

Spring 2021

Final Project Report

Introduction about this topic

COVID-19 is spreading to worldwide since 2020. It is causing the great harm of people, especially, the elderly and children. Comparing to elderly people, young people are less likely to get killed by corona virus. But they can still be infected and transmit the virus to others. With contact tracing, wearing masks and quarantining, a few countries have managed to control the spread of virus. Now that, vaccines have been developed and been used to stop the spread of virus.

Goal of our project

The main goal of our project is to simulate the spread of the COVID-19 virus and the spread of SARS-CoV-2, comparing the two viruses and then drawing our conclusion based on the observation. This project simulates the spreading of viruses by comparing the R factor and the K factor of COVID-19 and SARS. Our project also takes the population density, the usage and the effectiveness of masks, the prevalence of testing and contact tracing, the barriers of quarantine, and the vaccine into account, when we stimulate the spread of the COVID-19 and SARS.

Complete project details

We take the follow points into account:

- **The R and K factors of the disease:** We believe that R factor is the average number of people that a person with virus can infected. Thus, R is 3 for COVID-19 and 2 for SARS-CoV-2. The meaning of K factor is the percentage of population that caused others infected by viruses. Then, K is 0.1 for COVID-19 and 0.16 for SARS-CoV-2.
- **The Population density:** For our project, the total population of the city is 2000 plus 100 patients who carry viruses and enter the city. We set the safe distance between two people be 100 for both COVID-19 and SARS-CoV-2.
- **The usage and the effectiveness of masks:** Because not everyone wants to wear a mask, we set the usage rate of mask to be 0.2 for the entire population of the city. This means that before the spreading of the virus, people have already worn masks. We set the efficiency of the mask to be 0.9 for both COVID-19 and SARS.
- **The prevalence of testing and contact tracing:** Since not everyone wants to test or be able to afford the testing, we set the test rate for viruses be 0.2. We called those people, who are infected by viruses and tested positive, confirmed. Once, a person with viruses is tested positively, this person may or may not be contact tracing. If this person is contact

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traced, this person shall not move in the city. Since people want the freedom, we set rate of contact tracing be 0.5.

- **The barriers for quarantine:** For our project, the hospital is the place to quarantine confirmed patients and the capacity of the hospital is 200 patients.
- **The vaccine:** Because vaccine is not enough for everyone, the availability of the vaccine is 0.1 for the entire population of the city. The injection of the vaccine is already happened at the beginning stage of the spreading of viruses. The efficiency of the vaccine is 0.7 for both COVID-19 and SARS.
- **The death rate:** In our project, the death rates are 0.02 and 0.11 for COVID-19 and SARS, respectfully.
- **The cure:** In our project, the cure rate for COVID-19 is 0.05. If a person is infected by corona virus, this person will need 30 days to self-cure and this person has 0.7 chance to self-cure. The cure rate for SARS is 0.89. If a person is infected by SARS virus, this person will need 30 days to self-cure and this person has 0.9 chance to self-cure.
- **The recovered resistance:** Once an infected person is cured, this person will have resistance to viruses. In our project, the recovered resistance is 0.9 for both COVID-19 and SARS.
- **The sided effects:** Even though, an infected person can be cure, some infected people cannot be cured, and the chance for an infected person to be cured is determined, when this person is infected. In our project, we called those people, who have sided effects and cannot be cured, destroyed. The chance for an infected person to be destroyed is 1 - 0.95 ^ N by days for COVID-19 and SARS.

Invariants

In a day, the program will do one action to people who are in different statuses.

Entropy Source

The entropy source is from two aspects, one is the random move of citizens, and another is the infection rate, which determines by vaccines, masks, social distance, testing, contact tracing, and virus itself.

The entropy is $h=\lg(n!)-\Sigma(\lg(m_i!))$, where n is the total population and m_i is the numbers of people in each status per day. For corona virus, the number of infected people $m_i = -2.1396x^2 + 92.494x - 0.646$, where x is days. At the recovery phase, the number of infected people $m_i= 0.1933x^2 - 29.118x + 1026.2$. For SARS, the number of infected people $m_i=-1.1538x^2 + 77.108x + 14.132$, where x is days. At the recovery phase, the number of infected people $m_i=0.122x^2 - 20.442x + 818.16$.

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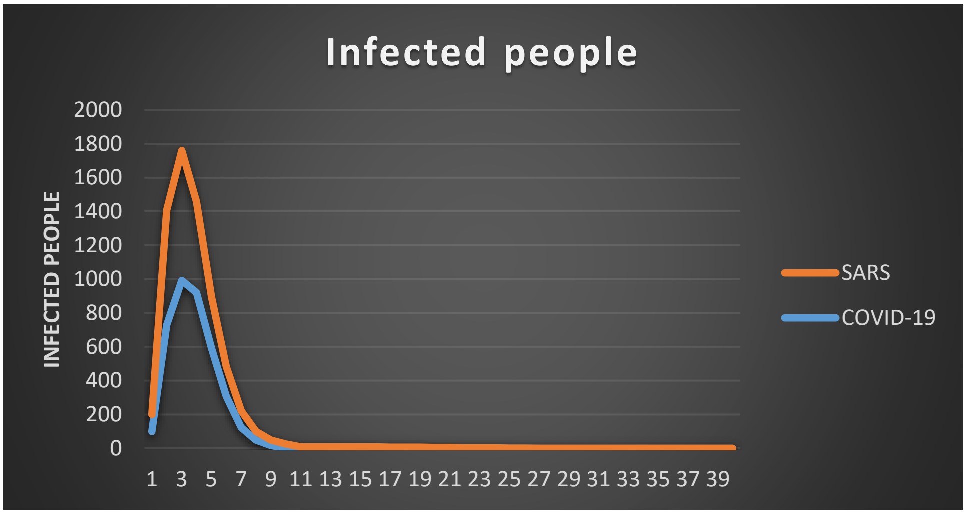
Implement-charts, algorithm.



Output

Day	COVID-19	SARS
0	100	100
1	190	174
2	270	232
3	321	289
4	389	364
5	455	430
6	518	477
7	595	562
8	656	616
9	730	679
10	781	739
11	821	800
12	851	825
13	884	836
14	906	828
15	927	826
16	944	803
17	955	795
18	982	784
19	992	768
20	991	746
21	1000	727
22	1004	699
23	997	692
24	986	663
25	982	639
26	965	597
27	959	586
28	953	568
29	920	537
30	904	518
31	875	494
32	831	474
33	793	448
34	761	412
35	725	385
36	688	359
37	653	342
38	615	318
39	592	302
40	564	280
41	528	263
42	507	258
43	466	251
44	445	232
45	411	228
46	373	213
47	353	199
48	327	186
49	308	176
50	285	171
51	263	160
52	247	147
53	227	141
54	210	139
55	190	129
56	174	114
57	157	109
58	137	100
59	122	98
60	110	91
61	103	86
62	95	76
63	89	74
64	79	69
65	74	65
66	69	62
67	60	61
68	55	58
69	48	52
70	41	51
71	34	47
72	29	43
73	27	40
74	21	40
75	21	38
76	20	38
77	19	35
78	17	33
79	16	32
80	14	30
81	12	32
82	11	33
83	8	32
84	6	28
85	5	27
86	3	27
87	2	24
88	2	23
89	2	24
90	2	22
91	2	19
92	2	17
93	2	14
94	2	11
95	1	10
96	0	9
97	0	9
98	0	9
99	0	8
100	0	8
101	0	8
102	0	8
103	0	8
104	0	8
105	0	8
106	0	6
107	0	6
108	0	6
109	0	5
110	0	5
111	0	3
112	0	3
113	0	2
114	0	1
115	0	1
116	0	0
117	0	0
118	0	0
119	0	0
120	0	0
121	0	0
122	0	0
123	0	0
124	0	0
125	0	0
126	0	0
127	0	0
128	0	0
129	0	0

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SARS COVID-19 screenshots

COVID-19

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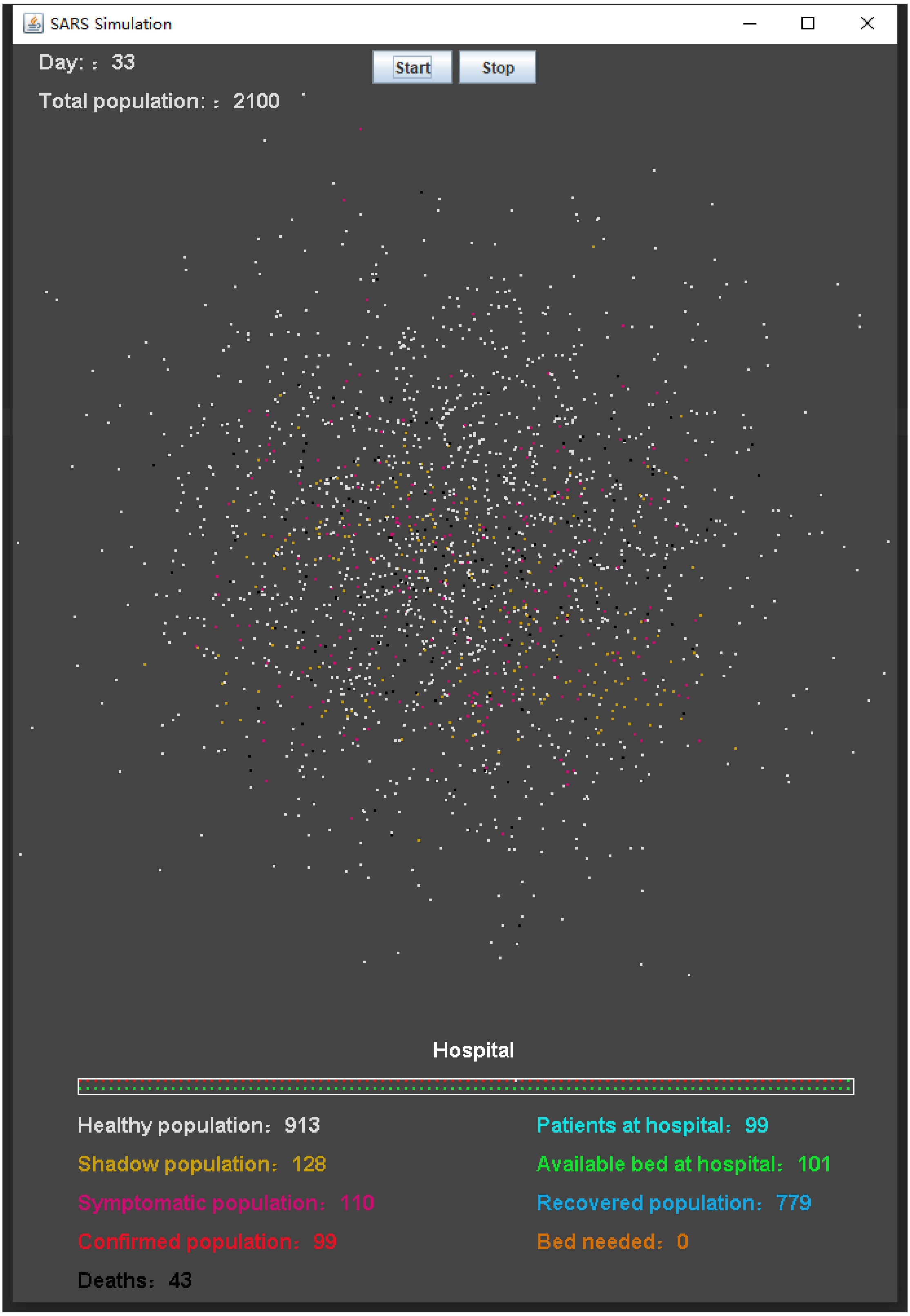
SARS



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Mathematical analysis

For COVID-19, we could see that the number of infected people grows by $y = -2.1396x^2 + 92.494x - 0.646$, where x is days, when the number of infected people is growing positively. The peaking point for the spreading of COVID-19 is at the 22nd day. In the recovery phase, the number of infected people grows by $y = 0.1933x^2 - 29.118x + 1026.2$, where x is days. For SARS, the number of infected people grows by $y = -1.1538x^2 + 77.108x + 14.132$, where x is days. The peaking point for SARS is also at 20th day. In the recovery phase, the number of infected people grows by $y = 0.122x^2 - 20.442x + 818.16$, where x is days.

To stimulate the spreading of viruses, we traverse the person pool to simulate different people's actions every day. The time complexity for this step is O(n). However, for each normal and recovered person, we need an extra traverse for the person pool to simulate the infections. So, the total time complexity is between O(n) and O(N^2), which determines by how many normal and recovered people in the person pool.

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```java
/**
 * @author Ethan Zhang
 * @description a person's action in one day, people with different states acts differently
 * @createTime  13/04/2021
 */
public void action() {
    // if this person is destroyed or dead, no need to handle him/her any more
    if (state == State.DEATH || state == State.DESTROYED) {
        return;
    }

    // quarantined people's action
    if (state == State.QUARANTINED) {
        PersonAction.quarantinedPersonAction( person1: this);
        return;
    }

    // confirmed people's action
    if (state == State.CONFIRMED) {
        PersonAction.confirmedPersonAction( person1: this);
        return;
    }

    // symtomatic people's action
    if (state == State.SYMPTOMATIC) {
        PersonAction.symptomaticPersonAction( person1: this);
        return;
    }

    // shadowed people's action
    if (state == State.SHADOW) {
        PersonAction.shadowPersonAction( person1: this);
        return;
    }

    // normal and recovered people's action
    if (state == State.NORMAL || state == State.RECOVERED) {
        PersonAction.normalAndRecoveredPersonAction( person1: this);
    }
}
```

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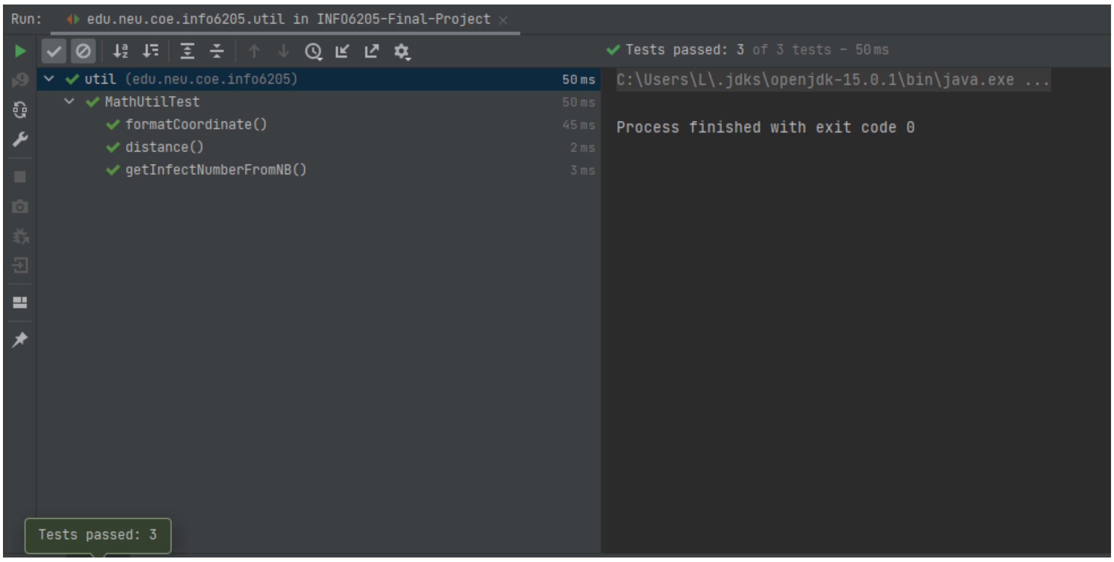
```java
/**
 * @author Ethan Zhang
 * @description normal and recovered peoples' action
 * @createTime  13/04/2021
 * @param person1 person with state of normal or recovered
 */
public static void normalAndRecoveredPersonAction(Person person1) {
    // check if there is an infection on this person
    List<Person> people = PersonPool.getInstance().personList;
    for (Person person2 : people) {
        if (infect(person1, person2)) {
            break;
        }
    }

    // normal and recovered person may move randomly in the city
    randomMove(person1);
}
```

Conclusion

After stimulating the spreading of COVID-19 and SARS, we can conclude that SARS can spread to more people than COVID-19 does. However, humans can control the spread of these two viruses by taking right actions. All infected people can stop the spread of virus by wearing a mask, stop contacting others physically and quarantining in one place. By wearing masks and the injection of the vaccine, the spreading of the viruses among healthy people can be slowly. To control the spreading of the COVID-19, we need people from the city to inject vaccine, wear masks, and we need people from outside the city do not enter the city.

Unit test

MathUtilTest



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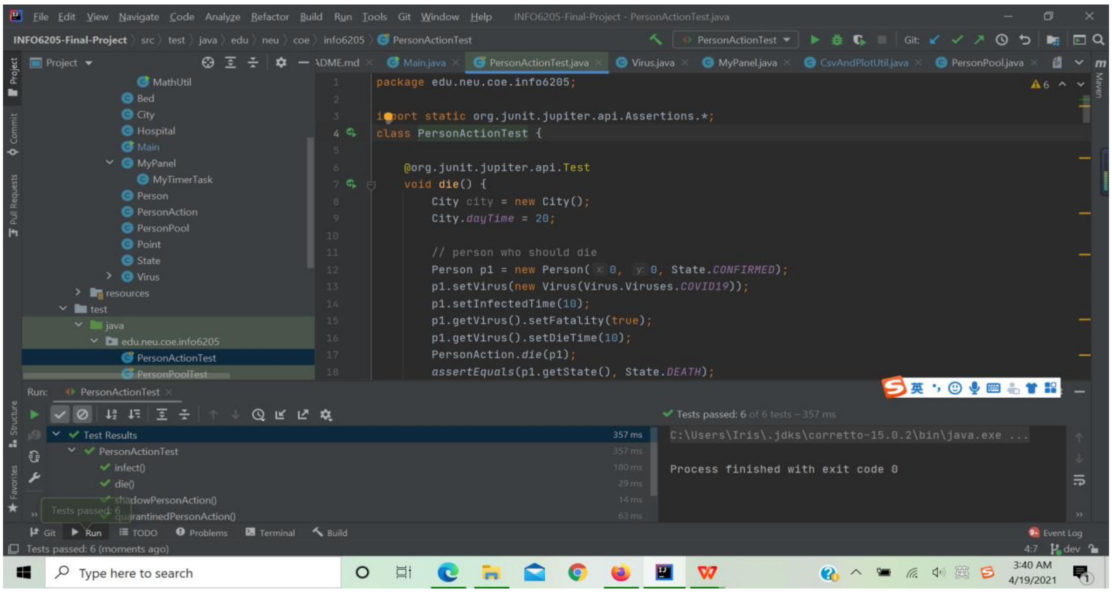
PersonActionTest



PersonPoolTest