Smallpox Outbreak Modeling in Python

Joe Fetsch

Computer Systems Lab 2009-2010

Abstract

This project is intended to model a martyr-type scenario in which a small terrorist groups infiltrate a city after infecting themselves with Variola Major; they attack hospitals first, passing as flu sufferers until the virus becomes contagious. After panic begins to spread, as the population realizes that they would have to avoid medical facilities even if they become infected, the remaining faction infiltrates the city, possibly in health control uniforms, fostering distrust of the government, spreading the virus further. With the mass panic and disease spreading, the city shuts down. Nobody is allowed in or out, effectively quarantining the city. Residents panic and remain at home in fear of infection, at which point the city stops functioning completely, and chaos runs free as infections spread and disease control units are helpless to intervene due to the quarantine and the population's general panic and instilled fear of health officials, causing them to refuse to cooperate.

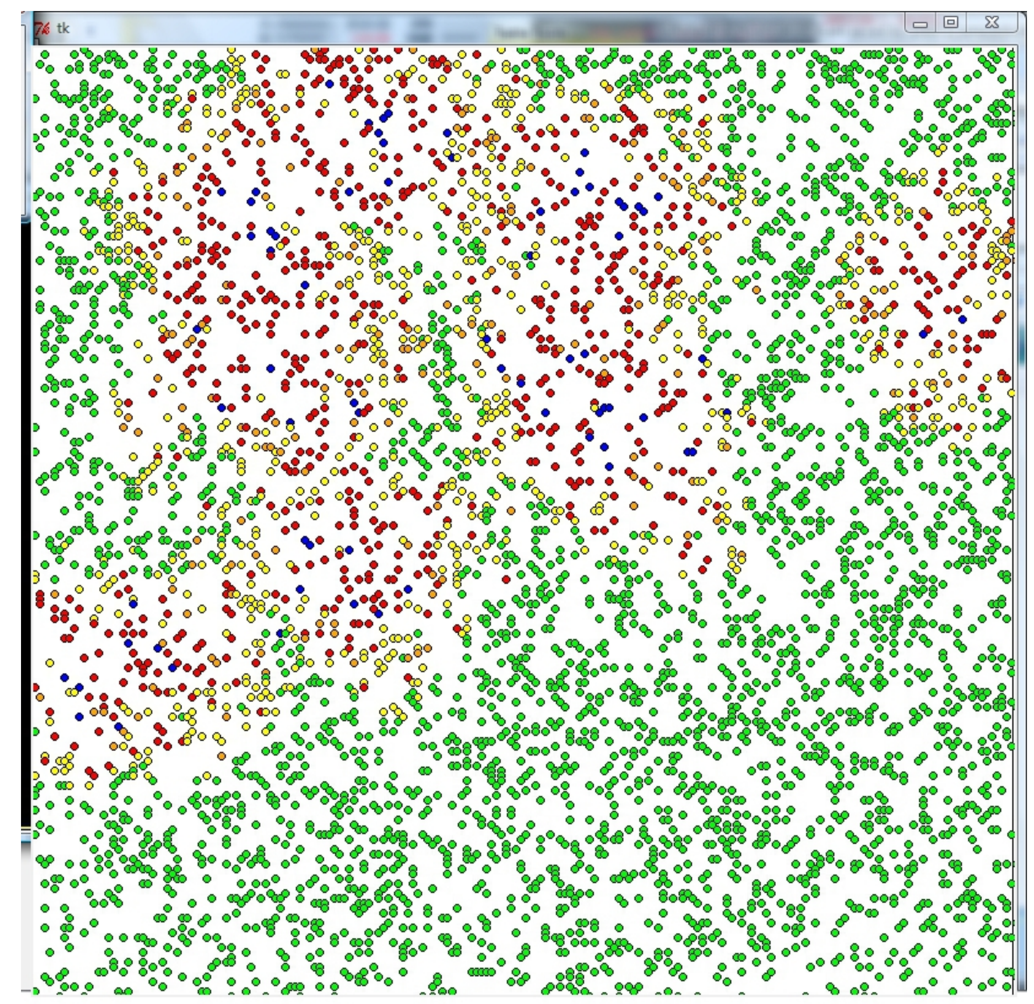

Figure 1: A typical display of the world where green agents are healthy, red are infected, orange are in the prodromal phase, blue are immune, and yellow agents are carriers of the smallpox virus – this image is from the early stages of the attack, about 20 days in; 8 days after the first symptoms are shown in the faction infiltrating the public.

Background and Introduction

Smallpox, also Variola Major, is a fast-spreading disease with a 100% susceptibility rate in humans who have not been immunized in the past 10 years. The only populations recently immunized are military or emergency health control workers. Smallpox has a 33% fatality rate and spreads like wildfire because of the 2 week incubation period in which no symptoms are shown from the infected person, as they travel around, moving to uninfected cities or healthy sections of a population before the sudden outbreak catches them by surprise, creating many more victims for the disease.

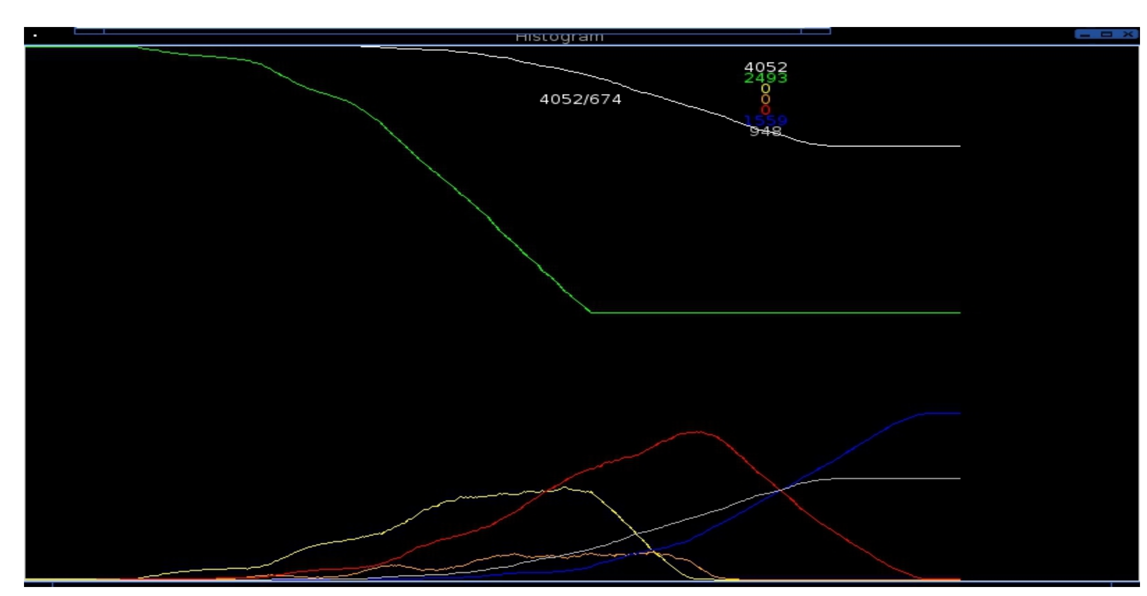

Figure 2: a visual representation of the population over time using the color scheme described above. Time span graphed is about 4 months with quarantine implemented at around 2 months.

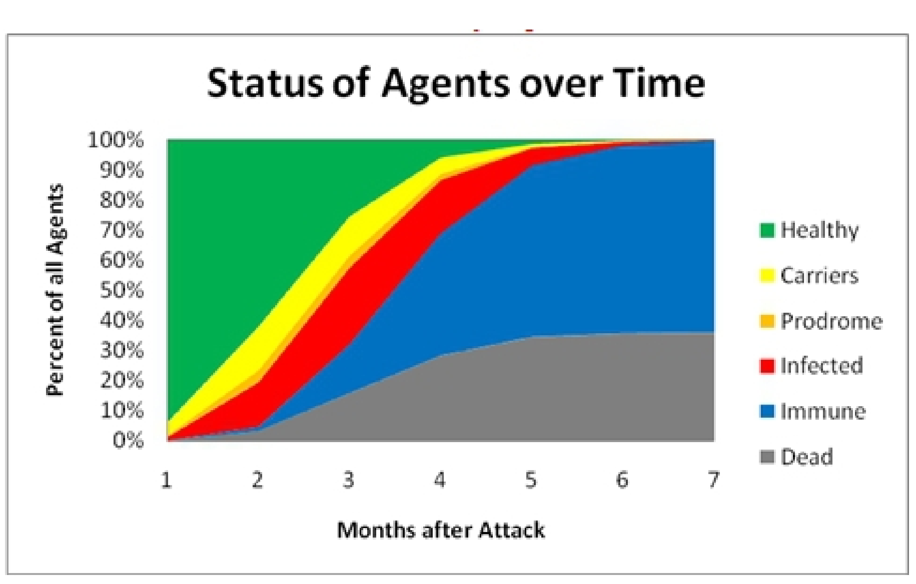

Figure 3: the above graph shows the average results of a run in which no control is taken over the population.

Discussion

Python is used in the final project in which a simulation of the scenario described in the Abstract will be run. Methods to begin a full military quarantine on the city in which the initial infection takes place, where all agents can no longer travel, reducing the risk of infection of other agents nearby to zero.

Results and Conclusions

This project provides an understanding of the fatalities and infection rates of such a population in a major city in a scenario as described in the abstract. The chance of this type of scenario being a possibility ranges from predictions of 60% to 80%, and fatalities are estimated to be about 35-40% of the population in the city if left unchecked, as infection rates are estimated to be about 80% of the population of the city targeted after 4 months without control of the population, and the quarantine method implemented can be used to simulate the fatality and infection rates of a city which is quarantined at a certain time.

In the graph above, the population of the city has gone from 5000, the initial value, to 4052; a fatality rate of 20%. However, the population in this situation has been quarantined after two months of the simulation, while the rate of infection was still increasing, which would lead to many more cases of smallpox and many more fatalities. Throughout the simulation, about half of the agents became infected, which raises the relative fatality rate to slightly less than 40%.

After the quarantine was implemented, the number of healthy people levels off at 2495, as can be seen in the graph, while, at the same time, the number of carriers no longer increases after that time, immediately after the number of infected people becomes greater than the number of carriers in the simulated world. From the graph, it is possible to notice the increases in the number of carriers, infected agents, and immune agents as they progress, defining the generation of infection. After the last generation becomes infected, defined by the time of quarantine, all of the values drop off after the generation progresses to the next stage of disease.