An Agent-Based Model of Reoccurring Epidemics

Brendan Greenley
Computer Systems Research
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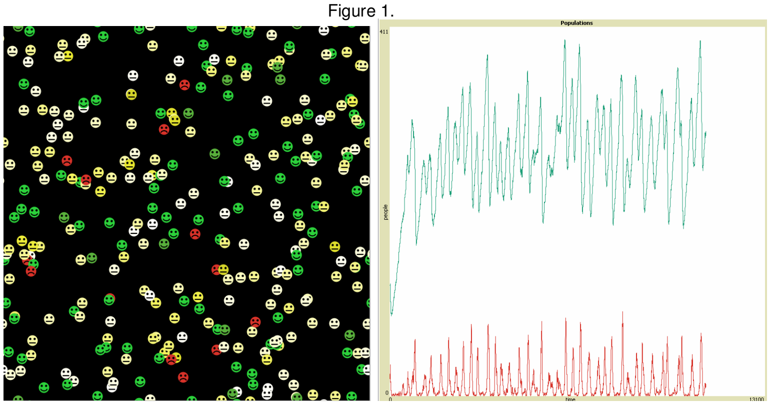
Abstract

Even with today's modern scientific and medical breakthroughs, there exists the threat of a widespread epidemic. Could the Avian Flu wreck havoc on the human population like the Spanish Influenza nearly a century ago? Widespread epidemics have historically acted as a population control, as seen by the Black Plague. What characteristics are needed by a virus to successfully control a population but not risk completely wiping out its hosts? How do reoccurring epidemics control a population over long periods of time?

Figure 1.



Background

If an epidemic were to occur, there would be two factors that would affect its duration and severity: The behavior and characteristics of the individuals within a population (interactions, movement, mating, immunity, and self-quarantine) and characteristics unique to the disease, such as its severity (in terms of mortality) and duration. By assigning different agents varying values representing characteristics such as susceptibility, and allowing for on-the-fly changing of outside factors such as the disease duration and base chance of disease transmission, one can find out how the population as a whole would react and change to a epidemic and any possible quarantine or response by government and health officials. Programming in NetLogo allows one to take advantage of a built in GUI that permits manipulation of values through sliders and input fields and has instantaneous visual output, as individual agents and their movements can be seen as well as a continuously updating plot of populations vs. time. (Figure 1)

Procedure & Methodology

So far, the agents have primitive movement and mating procedures: no matter the age or condition of a person, they move one space in a random direction, and children are hatched on the same location as a parent as soon as the parents mate. The chance for an agent to mate occurs when one agent who has not mated recently is next to other agents. The agent then checks to see if any of the agents around it are willing to mate. If so, a random number is generated, and based on it the agents either mate successfully and have child or fail and move on. If children are indeed created, their characteristics such as susceptibility are numerically represented as the average of their two parents' own characteristics.

Agent immunity is distributed over a distribution curve. As agents are assigned susceptibility values, the model determines whether or not they are immune. The value which a person's susceptibility must be to be granted immunity is set by the user on the immunity factor slider. Agents are visually represented by both varying color and facial expressions based on their susceptibility, immunity, or exposure to the disease. A green, smiling agent is immune, and regardless of the chance of transmission or its surroundings, it will not become sick (unless the virus mutates and the agent loses its immunity.) A white to yellow, neutral face represents a person susceptible to the disease, the more yellow an agent is the more susceptible they are. A red, frowning face represents an infected agent who can spread the disease to others.

Conclusions

As a student without a upper-level mathematics education, agent-based modeling allows for more complex modeling of epidemics than system-dynamics modeling, my original approach for this epidemic model. Rather than relying on long mathematical equations, I can allow hundreds of agents to behave independently, creating a immensely complex model that can be interpreted and understood easily by many. Epidemics modeling can yield quite volatile system's an initial setup might run fine for thousands of ticks only to have the population crash to 0. By finding a proper balance of mating frequency and virus mutation rates, a population can hover around a specific carrying capacity, albeit with many oscillations, and thus epidemics population control effects have been simulated by my epidemic model.