An Agent-Based Model of Reoccurring Epidemics in a Population with Quarantine Capabilities

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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. How do reoccurring epidemics control a population over long periods of time? If a population takes it upon itself to quarantine infected persons, is it effective in increasing the populations long-term carrying capacity?

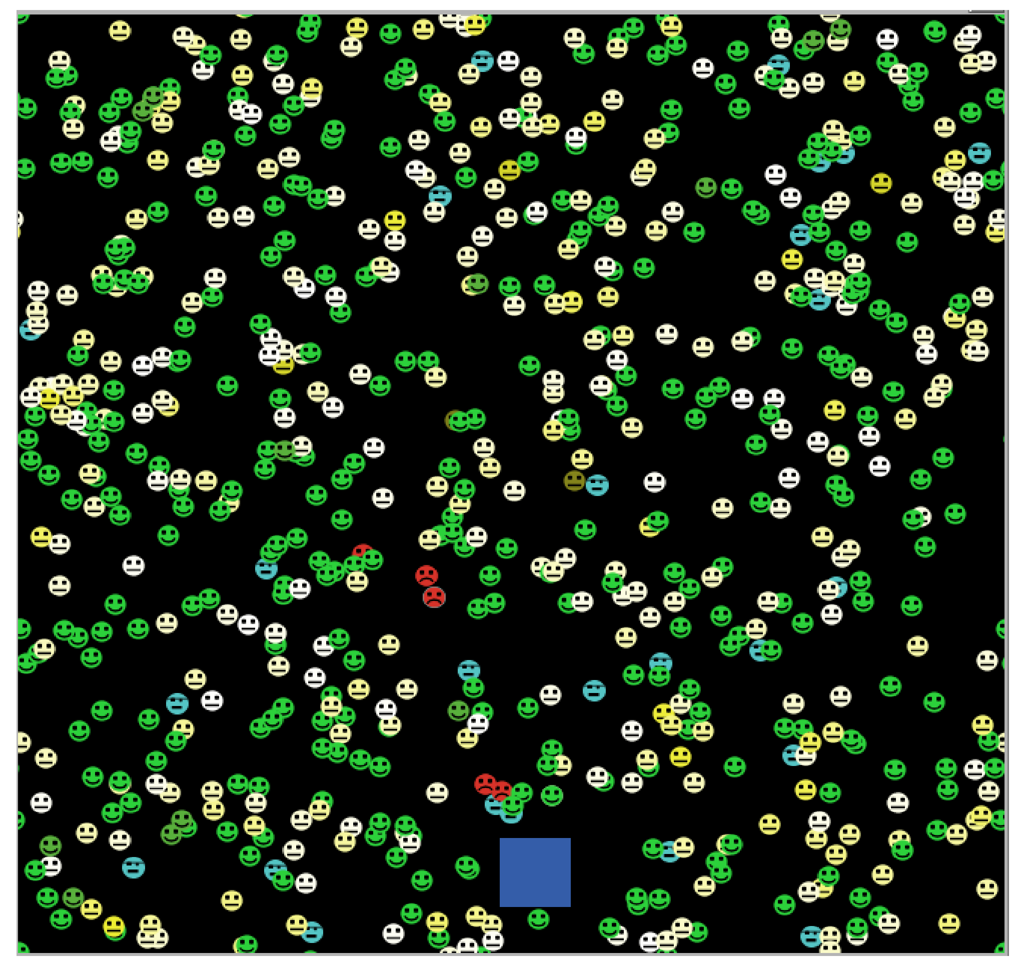

Figure 1. Infected (red) agents being led to the blue quarantine zone

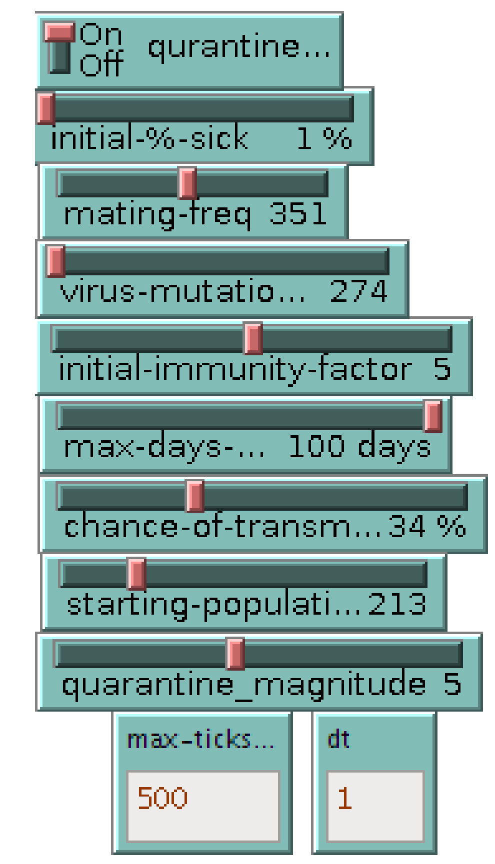

Figure 2. Modifiable settings allow for a plethora of run possibilities

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 to an epidemic and any following quarantine.

Procedure & Methodology

During a run with a quarantine, the world is populated with a input number of persons, some are sick, some are immune, and a few are infected. Next, quarantine officers are added to the world on the randomly placed 3x3 quarantine zone. Each tick, healthy agents step 2 spaces ahead in a random direction, attempting to avoid infected persons being impounded by quarantine officers and the quarantine zone. Infected persons move one space at a time, though if they come into the vicinity of a quarantine officer, they are forced to follow the officer to be impounded at the quarantine zone. Aging is controlled by a internal equation which increases an agent's chance of death every tick. If agents successfully mate, their children's characteristics such as susceptibility are numerically represented as the average of the two parents 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. Quarantine officers have unique shapes and a cyan color to emphasize their inability to mate, get sick, and die.

Conclusions

Rather than relying on long mathematical equations, Agent-Based Modeling lets hundreds of agents to behave independently, creating a immensely complex model that can be visually 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. Continuous efforts by a population to quarantine their sick during times of outbreak appears to correlate to a rise in carrying capacity. Numeric results will soon be available after a BehaviorSpace analysis.