Modeling the Effect of Virus Transmission on Population Dynamics using Systems Dynamics

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Abstract

This project models the effect of virus transmission dynamics on populations based on user input. The goal of this project is to be able to model the general trend in the way viruses affect populations of real situations, such as the Swine Flu. Using statistics about the 1918 Spanish Flu, the outbreak can also be recreated in the model.

Background

This project has two purposes, to create a virus model which accurately represents society, and to create a project that primarily uses Systems Dynamics but also uses functions of Agent Based Modeling. The idea of integration is from research done by Schieritz et al. This model currently presented was based on a predator prey model done by Uri Wilensky in Northwestern University. There is a combination of Systems Dynamics Modeling and Agent Based functions, though there are no actual agents. The Systems Dynamics flowchart is represented in Fig-1

Development

This model is created using NetLogo, a program which uses a GUI interface(See Fig-2) for easy user access. It displays the graphs of the data the user defines and can show visually the patterns in the data. Testing of the model is done as soon as a new component is added. Since the model is dynamically affected by every new parameter, the testing is ongoing and was a main part of the research. The final test of the model includes modeling a real situation, so the results of the model will be compared against the real situation to see how the model fared in predicting an outbreak. NetLogo includes a built function called BehaviorSpace, which tracks the values of every Variable and outputs it into a .csv file which can be viewed in excel. That data can be used to plot and test whether the model works. Fig-1 shows the flowchart for the Systems Dynamics model. Fig-2 shows the central "command center" for the model.

Results

When this model was tested against published sample runs, the model performed consistently with the results. After the additions, the model was used to predict the swine flue. The results are represented in Fig-3. This graph represents the total number of immune people in purple, and the total number of people at a point in time in green. It is noticeable that as the concavity changes to concave down, the immunity increases.

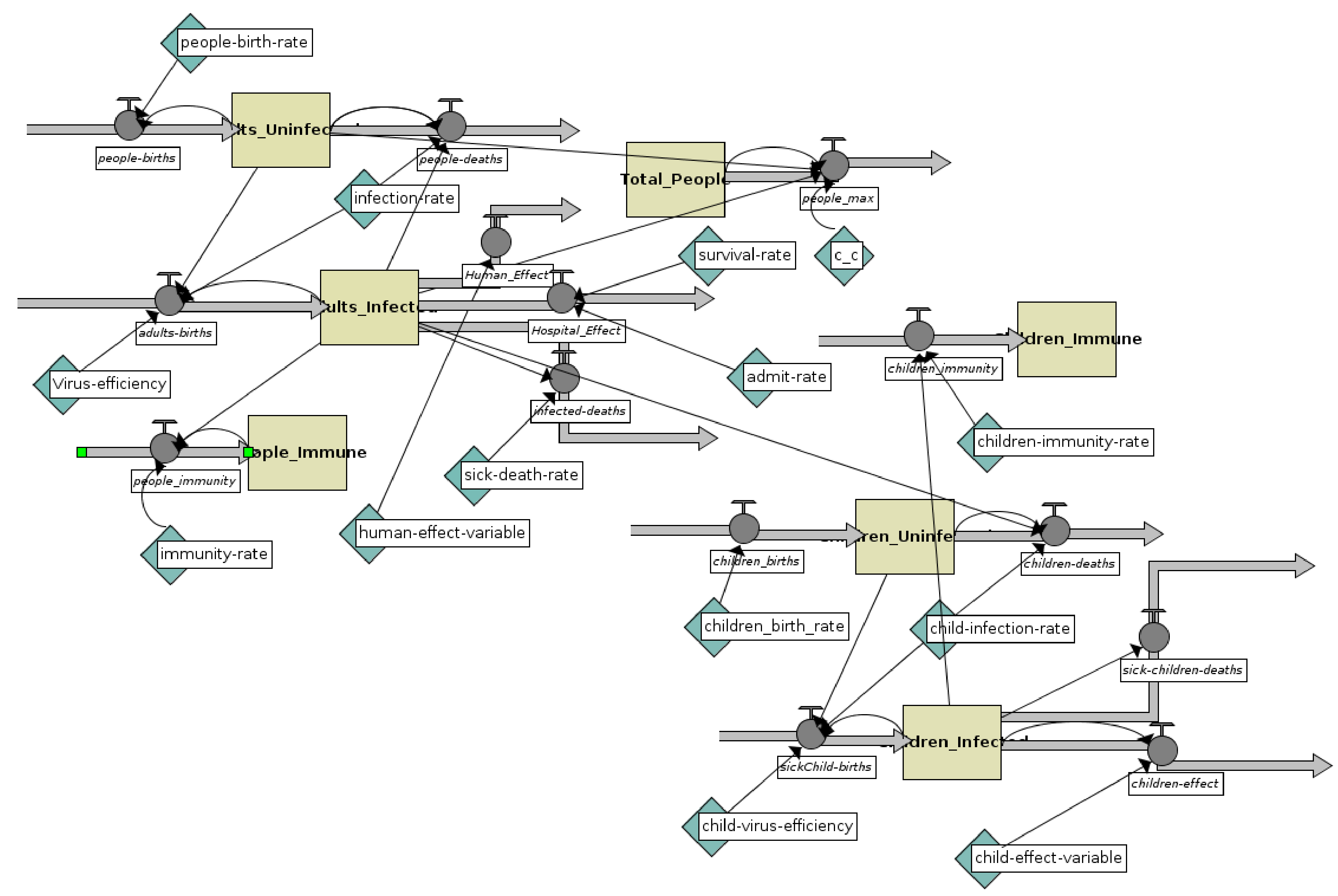

Fig-1-represents the stocks and flows of the Systems Dynamics methods.

Methods

As stated in the Background section, this model used a primarily Systems Dynamics model with certain Agent Based functions. In the model, certain functions such as births, deaths, immunity, infections, mutations and other human concern factors are modeled for each adults and children. The Lotka-Volterra equations were used to model the predator-prey system with the virus as the predator and the people as the prey.

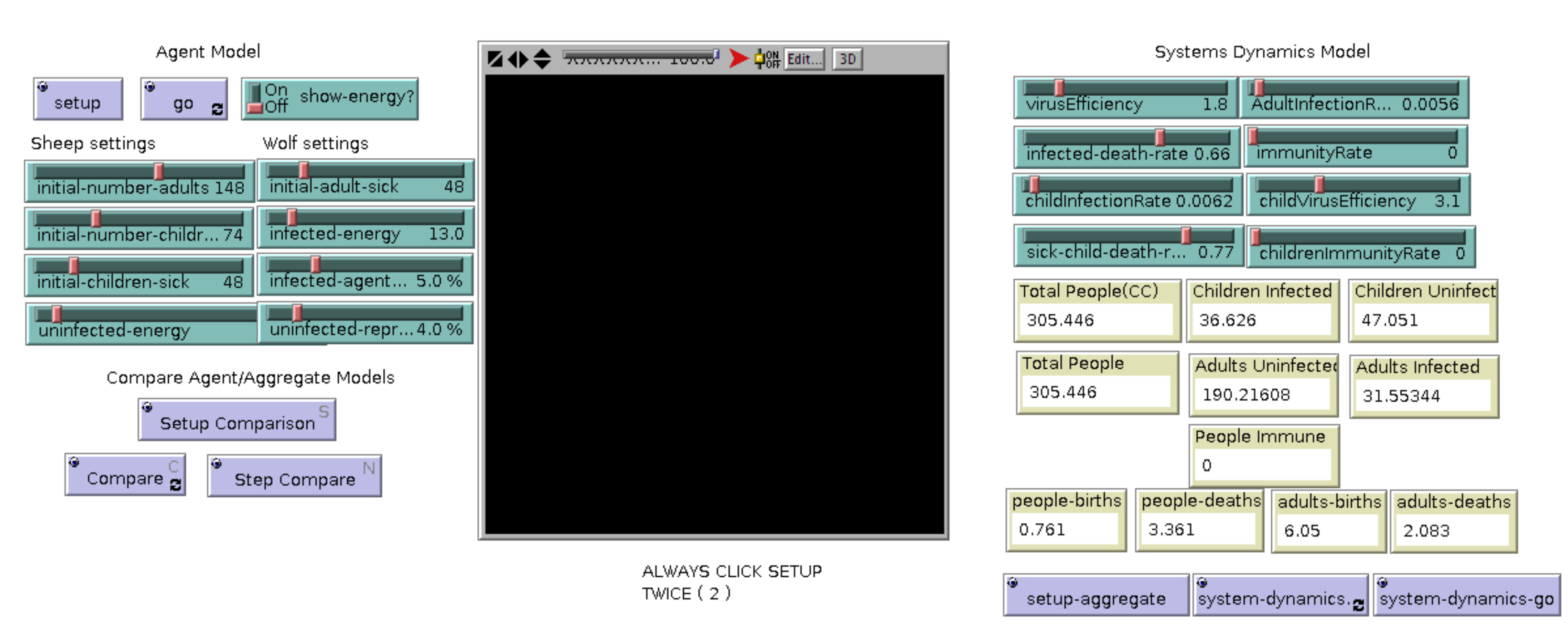

Fig-2, the main user interface to change variables to change the graph of the output.

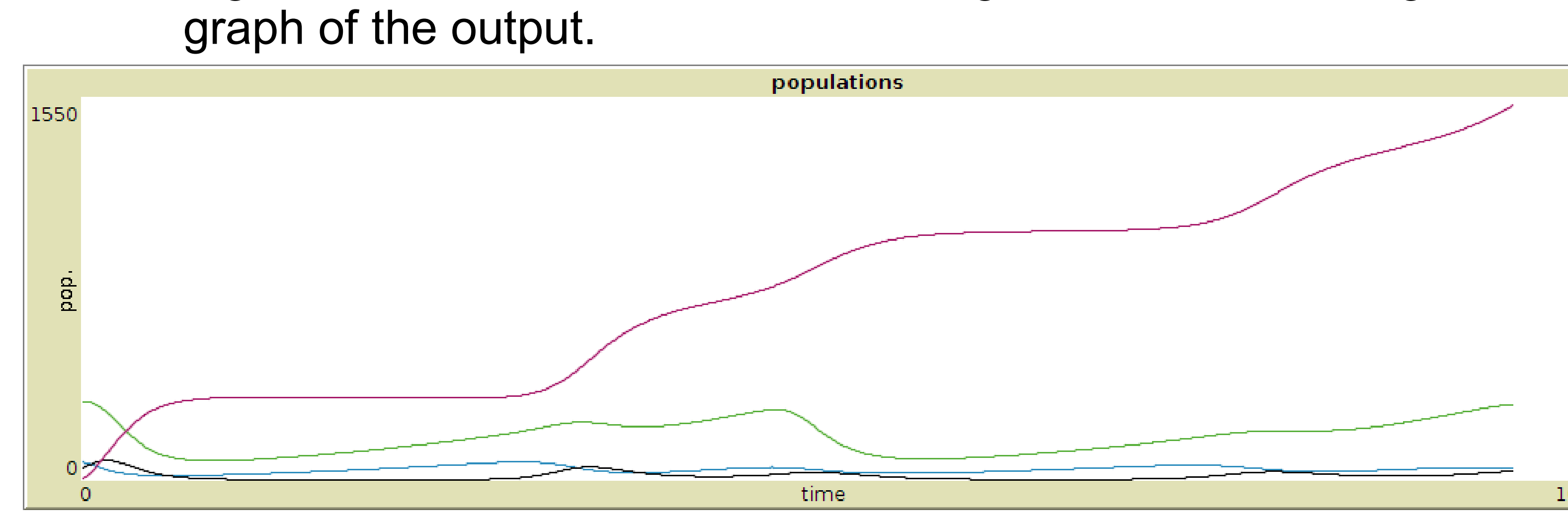

Fig-3. During the first outbreak, the population dramatically drops, but as time goes on, the population builds back up and immunity increases.