Final Project Report on

Disease Spread Simulation in Humans survival and infected bugs model

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Course Name:
Modelling and Simulation Theory and Application
CSC 8840, Fall 2016
Georgia State University

Introduction:

Transfer of diseases from one person to another is a quite common phenomenon and is a serious concern if the disease could lead to death of a human. One common disease which is contagious and occurs when an infected mosquito bites a human is dengue. Once a human is affected of dengue, then the whole area is under danger and there is a dire need to control this issue. One reason why this disease starts to spread is due to the poor sanitation in the area. Due to lack of sanitation, the density of the infected mosquitoes and the bugs increase and hence cause the increase in the number of people infected.

This model is based on amount of people being affected due to the poor sanitation in the area and the number of infected mosquitoes. The model also deals with the survival of humans by curing the humans who have been affected, and hence preventing them from being affected again by any infected mosquitoes. Members of humans are divided into normal humans and the humans who try to curb the mosquito population, trying to minimize the rate of transfer of infection and death rate of humans. This model attempts to cure the infected humans by setting up hospitals and maintains a statistics of the events taking place.

Goal of the project:

The goal of the project is about showing how important the prevention is over cure. This is done by curing the infected human by a vaccine which defends him from being affected again by an infected mosquito. The hospitals help in curing humans and the system tries to find the number of hospitals needed to cure the amount of people infected. It keeps track of the amount of people affected by the disease due the affected mosquitoes and the number of people cured due to the hospitals. And by doing that, we could make different attempts to minimize the number of deaths of humans due to the disease. If the number of infected humans are increasing drastically, then the model introduces another way of curbing the population of infected mosquitoes by introducing a new population of humans.

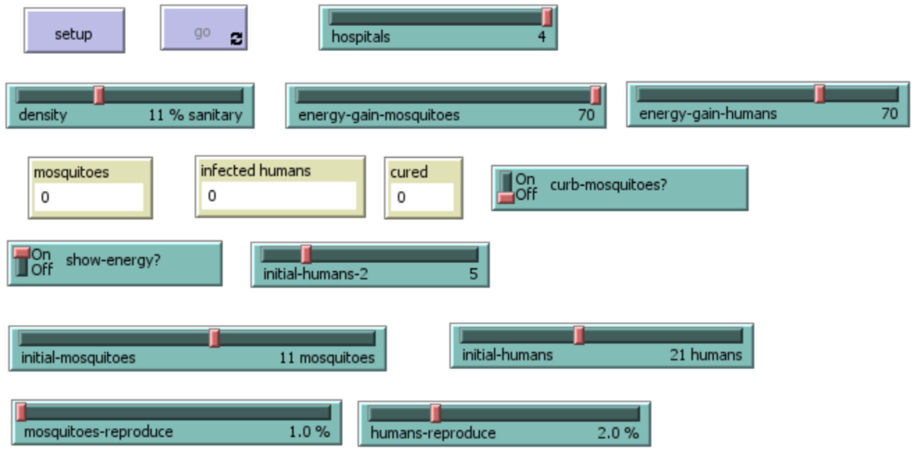
What can we observe in this model?

We can draw interesting conclusions about what parameters indicate success or failure at long-term survival. What we can actually observe in the simulation is that:

- How the increase in the density of the poor sanitation areas affects the number of humans.
- How the initial population of the mosquitoes affects the number of humans.
- How the change in number of hospitals varies the results of number of humans who are cured after being infected.
- And how when another tribe of humans are also present in the tribe, who are there to curb the population of mosquitoes, decrease the number of mosquitoes which are infected.

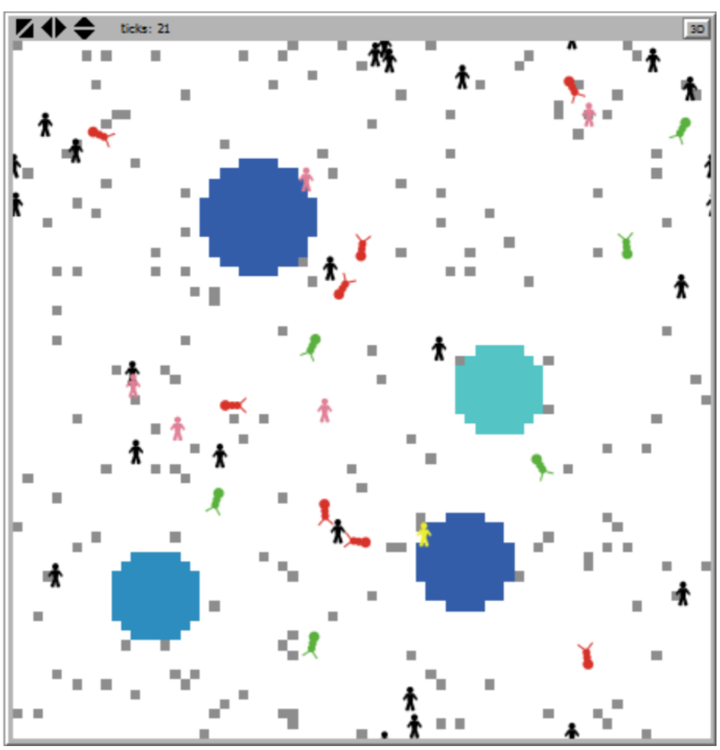
Implementation:

The model was implemented using three different breeds of turtle: two for humans – one are the normal humans and the other tribe is to curb the population of mosquitoes. And one breed for the mosquitoes itself. The initial populations of all breeds are controlled via sliders. Should one-tribe dynamics be preferred, the number of tribes can be toggled with a switch. The number of hospitals needed to cure the infected humans is also set using the slider. GO is a continuous procedure. As the dynamics are running, the two plots plot the number of humans infected vs number of mosquitoes infected and the number of humans infected vs cured.



Representation:

The initial population of humans are represented by black color, the sanitation areas are represented by grey patches. The initial population of mosquitoes is represented by green color and when the go to the sanitation areas and get affected, they turn into red color representing an infected mosquito. When the curb-mosquito switch is on, then the population of the other tribe of humans is represented by pink color. The infected humans are yellow in color and they turn brown in color after they are cured. Different hospitals are represented by different colors of their own.



Few Assumptions:

First, create the initial #number of humans, mosquitoes and the hospitals. Set it using the slider and then press setup to set the patches.
Second, Create chosen density of sanitation to gather and scatter those patches.
And the finally, if there is a necessity to use the other population too to curb the population of infected mosquitoes, then Create the population of another tribe humans when curb-mosquitoes? is switched on.

Movement of turtles:

At each tick, each mosquito:

- Move randomly by one step.
- If find a grey grain patch, get affected, turn red.
- If effected, find a human.
- If human not infected, infect him. Energy increases by 2.
- If energy is greater than 60, can reproduce; energy of the reproduced mosquito is taken as 60.
- When energy drops to 0, die (lose -1 energy every 2 ticks)

At each tick, each human:

- Move randomly.
- If infected by a mosquito, turn yellow and lose energy by 8.
- If infected, try to go to the nearest hospital to get cured.
- When got cured, turn into brown and gain energy by 10.
- If energy is greater than 100, can reproduce; energy of the reproduced mosquito is taken as 100. The energy of the reproduced human is taken as 40.
- When energy drops to 0, die.

At each tick, each human who decreases mosquito population:

- Moves randomly and searches for mosquitoes.
- When found a mosquito, kill it. Decrease the count of the number of mosquitoes.
- If energy drops to 0, die.
- If energy is greater than 100, can reproduce; energy of the reproduced mosquito is taken as 100. The energy of the reproduced human is taken as 40.

Analysis

Very detailed, slow-step Behavior Space experiments were attempted, but it was immediately clear that with the number of variables in play that the experiments would take a long time to run properly, and give an impossible-to-sort amount of data. In order to provide interesting results in a timely manner, a Behavior Space experiment was constructed that varied the Initial population of mosquitoes and human are varied and analyzed and varied the density of the sanitation areas. The multiple runs of the behavior may be examined and sorted for the system, according to changed variables in different cases, so that the final count of the population of different parameters can be fairly compared.

The number of variables in play made any graphical comparison nearly impossible. Too much information had to accompany each point, so charts have been included to describe the phenomena observed. Here are few analysis done to test the model:

Density of the sanitation was tested at 5% and 20%.

Initial population of mosquitoes and human are varied and analyzed.

The number of hospitals set up is changed from 1 to 4 to analyze number of humans infected vs cured.

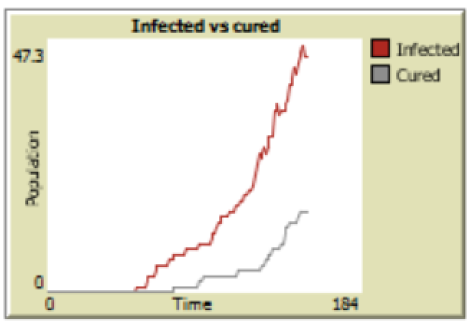
Curb-mosquitoes is switched on to decrease the population of mosquitoes and analyze the number of humans effected in this case.

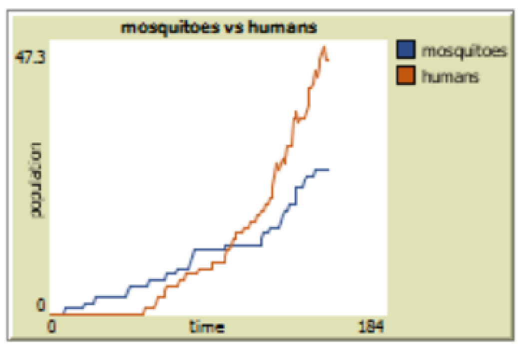
Observations and results:

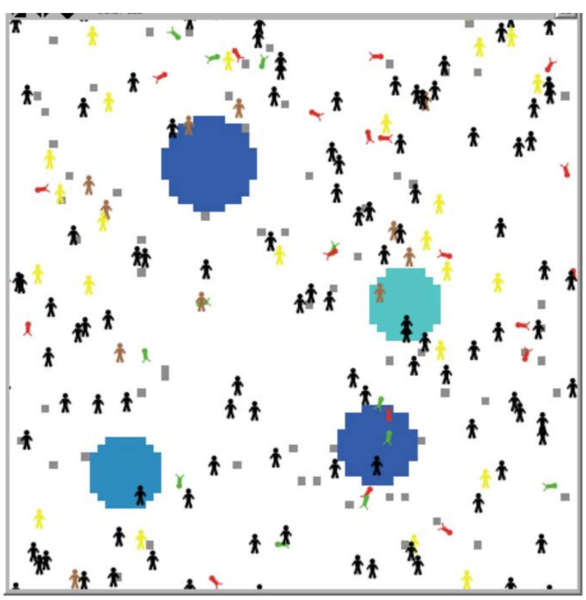
1. **Low Density**

Density: 5%, Hospitals: 4, Curb-mosquitoes: off, initial- humans: 21, Initial mosquitoes: 11

Ticks	Infected Mosquitoes	Infected Humans	Cured Humans	% of cured humans
50	9	2	0	0
100	16	8	1	12.5
150	25	44	15	34.09090909



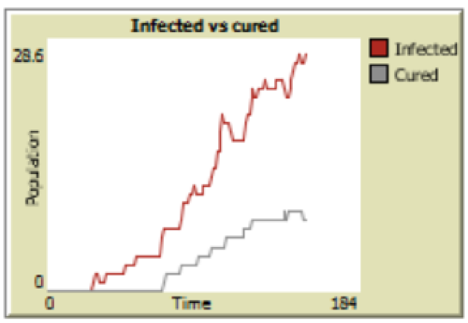


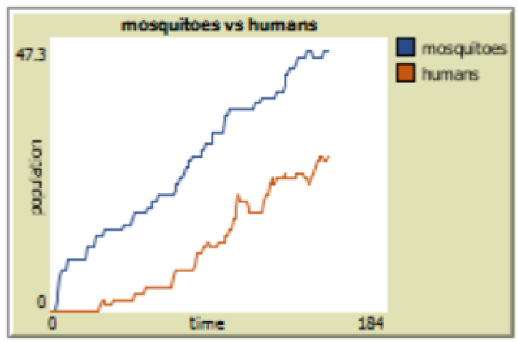


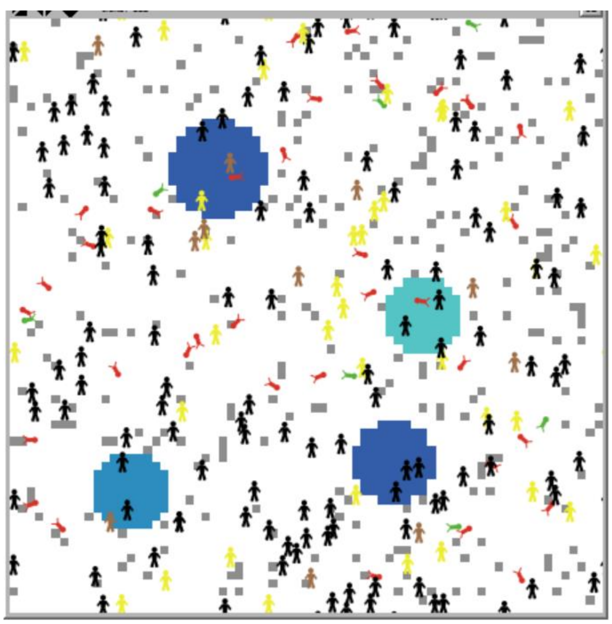
2. **High Density**

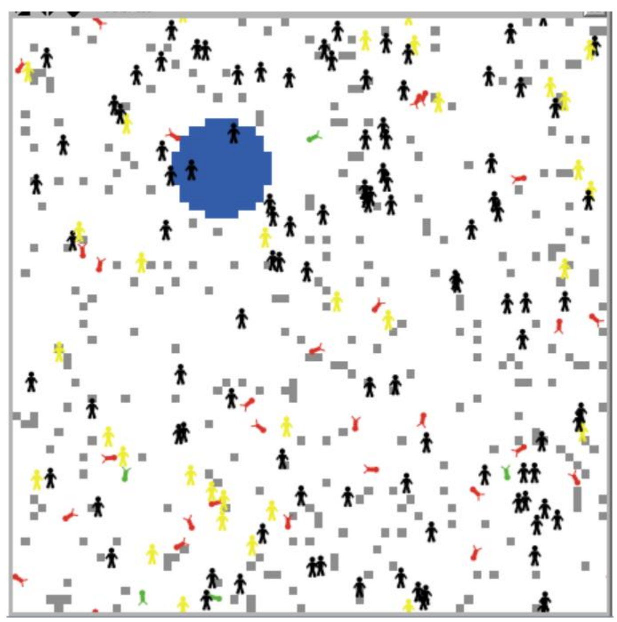
Density: 20%, Hospitals: 4, Curb-mosquitoes: off, initial- humans: 21, Initial mosquitoes: 11

Ticks	Infected Mosquitoes	Infected Humans	Cured Humans	% of cured humans
50	11	2	0	0
100	19	12	3	25
150	45	27	12	44.44444444









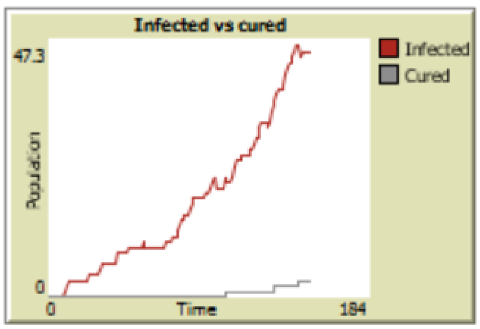
Simulation for Case 2

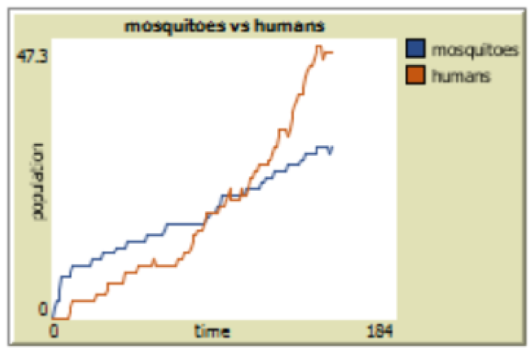
Simulation for case 3

3. **Less number of hospitals**

Density: 20%, Hospitals: 1, Curb-mosquitoes: off, initial- humans: 21, Initial mosquitoes: 11

Ticks	Infected Mosquitoes	Infected Humans	Cured Humans	% of cured humans
50	14	9	0	0
100	21	22	0	0
150	29	45	3	6.666666667

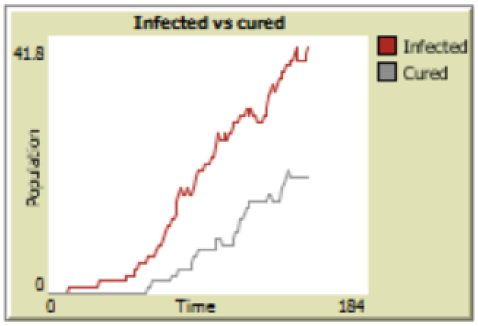


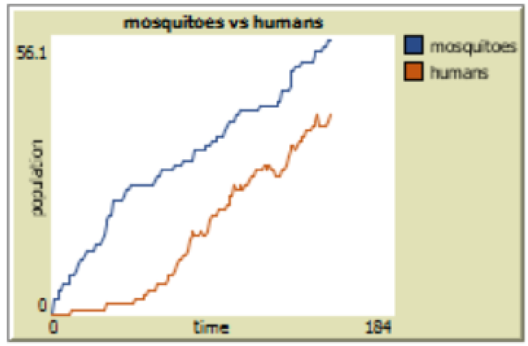


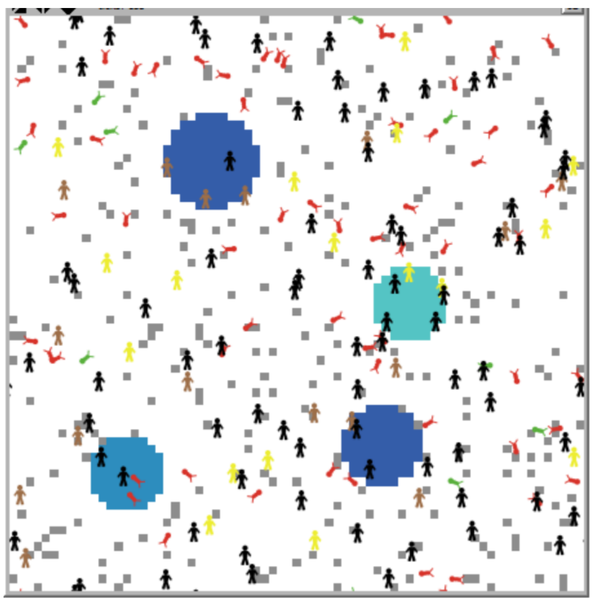
4. **High initial number of mosquitoes**

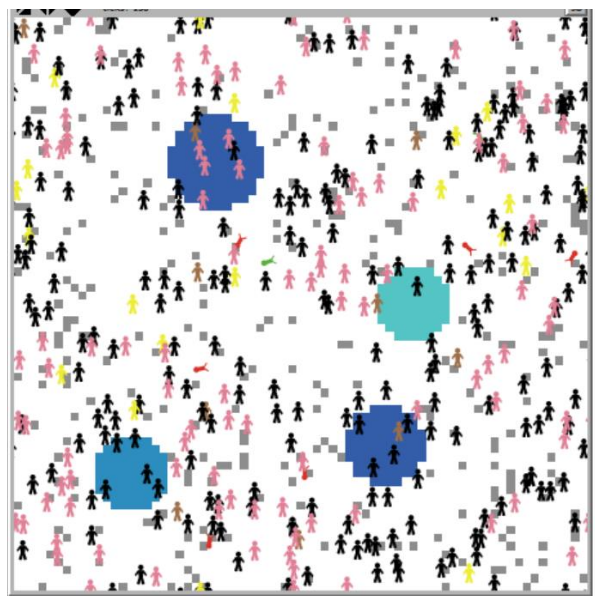
Density: 20%, Hospitals: 4, Curb-mosquitoes: off, initial- humans: 21, Initial mosquitoes: 20

Ticks	Infected Mosquitoes	Infected Humans	Cured Humans	% of cured humans
50	27	4	0	0
100	40	25	8	32
150	55	40	19	47.5







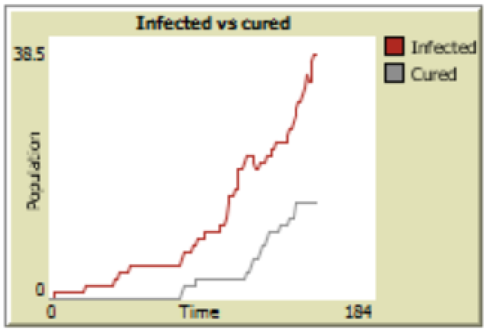


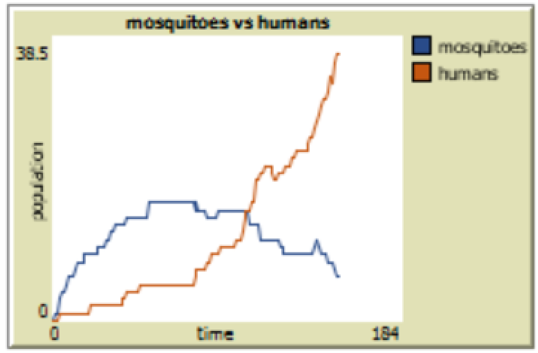
Simulation for Case 4 Simulation for case 5

5. **Other human population to curb mosquito population introduced**

Density: 20%, Hospitals: 4, Curb-mosquitoes: on, initial- humans: 21, Initial mosquitoes: 10

Ticks	**Infected Mosquitoes**	**Infected Humans**	**Cured Humans**	**% of cured humans**
50	14	5	0	0
100	15	15	3	20
150	6	36	14	38.88888889





The above show analysis of five different cases taken in the model.

Table 1 shows the situation when the density of the poor sanitation areas is very less, i.e. 5%. In this case, due to less sanitation areas, the number of mosquitoes being affected is less and hence the number of people being affected is also low. Number of mosquitoes affected in this case: 25.

Table 2 shows the situation where the density of the poor sanitation areas is very high, i.e. 20%. In this case, due to high sanitation areas, the number of infected mosquitoes is high and as a result when compared to table 1, the number of people affected is also high. The number of mosquitoes infected in this case is 45, which is way more than that of the first case. Also observe that the number of humans infected in this case has also decreased to 27.

Table 3 shows the situation where the number of hospitals is reduced to 1. This results in a drastic decrease in the percentage of humans cured. In the first two cases, where the hospitals are 4, the cure % of humans came upto 34 and 44 respectively. But in this case, the cure % has dropped down drastically to 6%.

Table 4 shows the situation where the initial number of mosquitoes in the area is increased to 20. This leads to more mosquitoes being affected and hence more humans being infected. The number of mosquitoes infected in this case at 150 ticks has come up to 55, where as in the previous cases it is comparatively low. Consequently, the number of humans affected has also increased in this case.

Table 5 shows the situation where the number of mosquitoes being curbed due to another population of humans is also introduced. In this case, due to the killing of mosquitoes, the number of infected mosquitoes present in the particular area is lowest when compared to all other cases. And due to this, the number of humans affected is also low. The number of mosquitoes infected is 6 in this case at 150 ticks, and the number of humans infected is 38.

Note: **All the values and tables and the simulation images generated are for 150 ticks. And as the turtles in the model move very randomly, the results at same 150 ticks might vary every time the simulation is run.**

Conclusion:

Different situations are analyzed and the motto of the model was to find out the best situation, where we could decrease the population of the infected mosquitoes and provide the best cure for all the humans who are affected in the area. When we check the values we achieved by running the model, we can see that the least affected population of mosquitoes was when the population of humans who kill the mosquitoes was also present. And the maximum cure percentage was there when there were four hospitals present. So the best way to make sure less number of people are affected is when both the curbing mosquito population and maximum number of hospitals are present. However, we should keep in mind that, the density of sanitation areas and the initial number of mosquitoes also affect the humans. So it's the responsibility of the humans to make sure they have a good sanitation around them, which will make them live a healthy life.