FFR120, Simulation of Complex Systems

Project scheme report
Group 4

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Updated project description and purpose

The aim of this project is to simulate the active spreading of a deadly virus in a population and to investigate the effects of added features to the basic SIR model. Agent based simulations will be made in an environment inspired by a scenario of bio-terrorism for the purpose of finding strategies to counteract a bio-terrorism attack or protect a society against bio-terrorism.

Progress so far

We have implemented an efficient version of the model from homework 1 in Python and have also added many new features to this basic model. These new features are:

- day and night time,
- airports,
- incubation time,
- death rate,
- deliberate outbreak location and
- difference in behaviour between healthy, infected and symptomatic.

Some of these features are added solely to make the model more realistic and more complex and others are added for the purpose of simulating a bio-terrorism scenario. Days and nights are implemented such that during the day the agents move around randomly with some probability d, just like in the basic model. During night time however the agents stop where they are and stay there throughout the night. Susceptible individuals can still be infected during the night if they are in the same spot as at least one infected individual. "Airports" are locations that help the agents move from one spot on the grid to another. This is done so that if an airport is entered the agent is directly transferred to one of the other airports with certain probabilities. An incubation period for the infection is also added so that if an agent is infected a random normal distributed incubation time is calculated, for when that individual will start to show symptoms.

In a real bio-terrorism scenario the goal of the attack might be to kill as many people as possible. For this reason we added a death rate and a deliberate outbreak starting location.

The outbreak is set to start in the most densely populated area/location after the random initialization of the population. Another possibility that will be explored is to start the outbreak in one of the airports. A virus used in a bio-terrorism attack might also be engineered to cause as much damage as possible. We have added a version of this element to our model by allowing faster movement of agents which are infected but not yet symptomatic. The idea is that it will make the infection spread more, together with a higher infection rate of course. When individuals become symptomatic, it's more reasonable that they slow down instead, so that possibility has also been added to the model.

Remaining work

To expand the project we will try to train a simple neural network on our simulations for the purpose of predicting the spread of the decease in each time step based solely on the location and symptomatic status of agents. The idea is that this could be used in reality to look at possibilities for how wide spread a decease is, from the time when patient zero starts to show symptoms, i.e. when the outbreak is first discovered. This result could be shown nicely as two parallel videos of the actual progression of the outbreak in a simulation and the networks continuous predictions about where infected people are located.

We will also work on fine tuning the parameters for our added features and report the changes in the results caused by each added feature.

Studying how the human behaviours would make a difference in disease spreading is also an option. For example, to stop the disease from spreading, when people saw someone with symptoms and they are close to the infected, they should probably stay where they are instead of running away from the spot. While in reality, when people encounter this kind of situation, they tend to run away from the spot. We can see if the latter one would lead to a wider population infection. Other features like airline flow control could also be investigated.

Another possibility would be to find the best way of delivering vaccines once they are available. Given limited doses of cures, how can we save as many people as possible.

We have set an inside deadline for the code to be finished by the beginning of week 50 (9/12-11/12). From now on two people will start to work on the report and the other two will implement the final features of the model and produce the results.