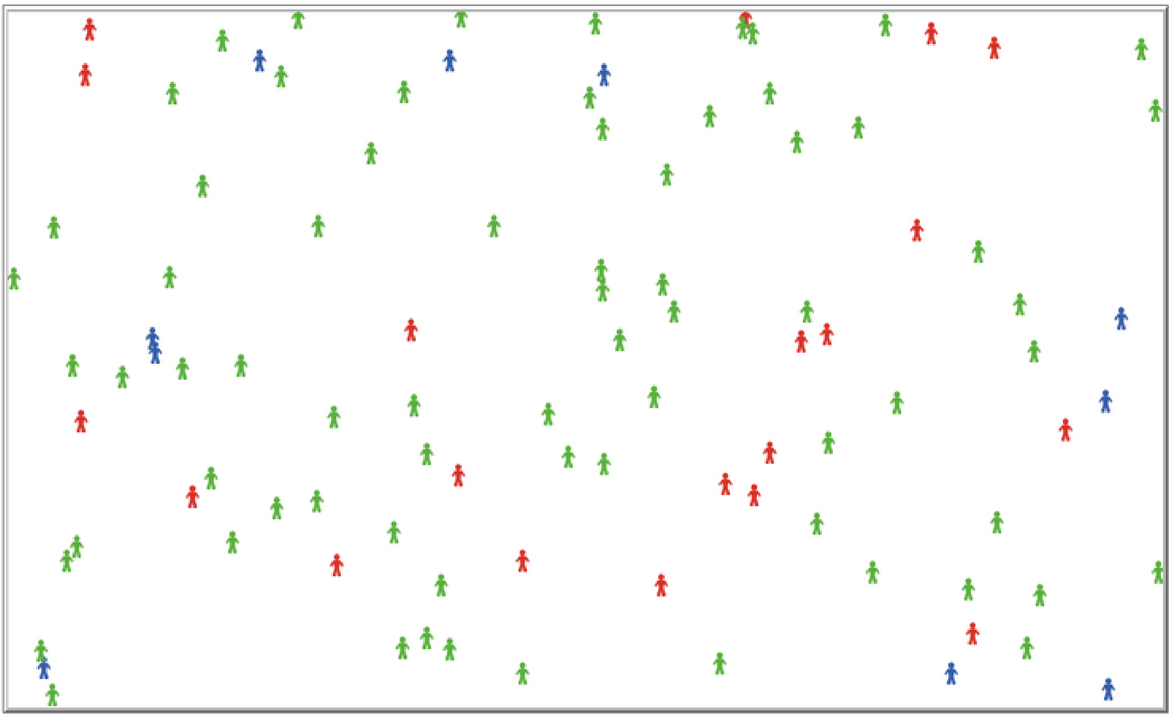
CALDAS LOUIS

AI961 REPORT

DOCUMENTATION



M2 DATA AI

I. WHAT IS IT

This model represents an (approximate) simulation of the **spread of an airborne virus** (similar to the covid19) and the influence of the different control measures against this virus.
This model is inspired by the netlogo virus model developed in 1998 by Uri Wilensky.

Wilensky, U. (1998). NetLogo Virus model.
http://ccl.northwestern.edu/netlogo/models/Virus.
Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

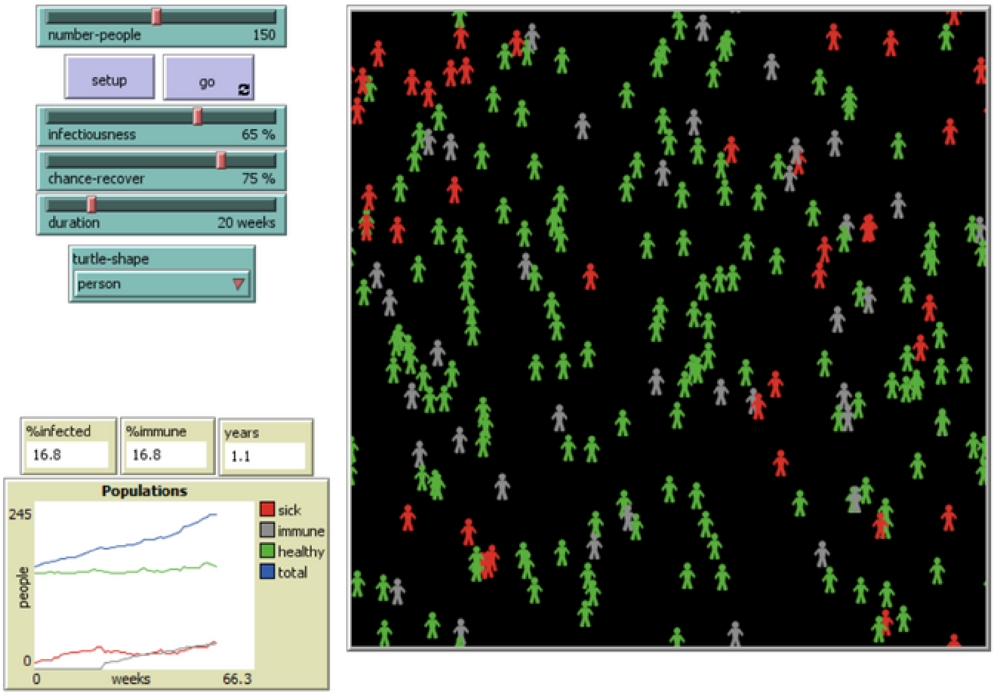


Figure 1 : Uri Wilensky Virus Model

II. HOW IT WORKS

The model is initialized with a certain number of people (configurable via population input) among which some are positive for the virus, some are immune. At each tick, the agents move randomly through their (user-defined) area of movement. These agents can be in one of these 3 states: infected by the virus (red), immune (blue) and healthy (green). It is also important to note that there are two shades of green, one representing the agents respecting the barrier gestures (configurable in the model). Through the evolution of this population, this model offers the possibility to follow the spread of a virus, the number of victims in particular.

At the level of interactions between agents, when an infected agent crosses another one, there is a certain probability that it will contaminate it. The virus also has a lifespan, at the end of this period of contamination, an individual can either recover and obtain immunity to the virus or die. It is important that here, the death of a turtle is not necessarily to be compared to the death of an individual in real life. Simply, it illustrates the power of a virus through a population, the more numerous the turtle deaths are, the harder the virus is to control.

The probability of contamination from one individual to another depends on several factors: the infectiousness of the disease, the respect of barrier gestures and the wearing of masks. The probability of infectiousness decreases by 50% if individuals respect the barrier gestures and by 70% if they wear a mask. The zone of contamination is also configurable by the user, whether it is its directivity or its distance of action.

In order to best fit the health situation related to covid19 , it is also possible to configure lockdown measures, either by limiting movement or by limiting the number of turtles that can move (equivalent to true lockdown). In case of lockdown, at each tick, only 10% of the agents are brought to move.

Note that it is also possible to customize the shape of the turtles.

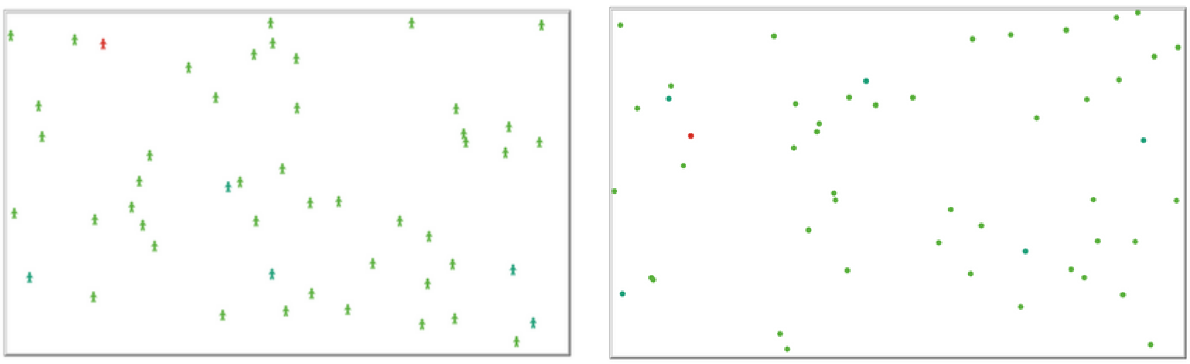


Figure 2 : Different shapes

II. HOW TO USE IT

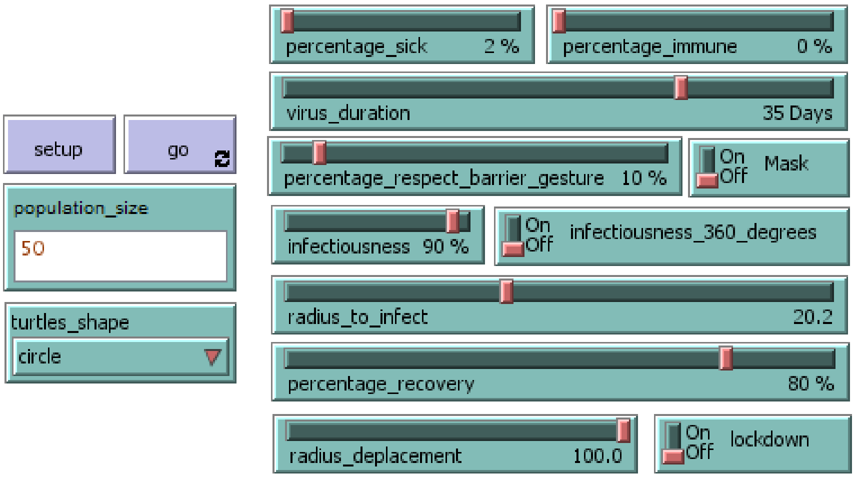
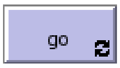
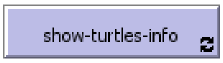


Figure 3 : User controls

Allows to initialize the simulation

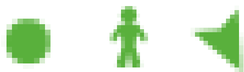


Launches the simulation (infinite button to make the simulation continuous), one tick = one day.



This button allows, when active, to have information about the turtles when you click on them: the time from which he is sick (in the console), the zone in which he can infect someone and the zone in which he can move.

Allows you to decide the shape of the agents.



Allow you to define the percentage of the population being sick at the start of the simulation.

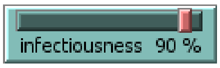
Allow you to definethe percentage of the population that is immune to the virus at the beginning.

Allow you to definethe lifetime of the virus after which an agent is either immune or dead.

Allow you to definethe percentage of the population respecting the barrier gestures.

II. HOW TO USE IT

Allow you to define whether or not individuals wear masks.



Allow you to define the probability of transmission of the virus when two individuals cross each other (100% corresponding to systematic transmission, 0% to impossible transmission). For covid19 for example, this rate is ~80%.

Allow you to define if an individual can infect another one all around him or only in the direction of travel (equivalent to someone in front of him, simulation of a discussion).

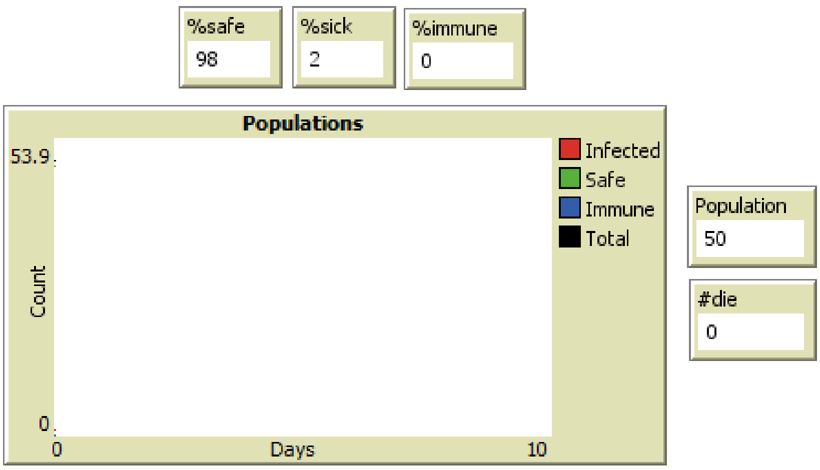
Defines the distance around which one agent can contaminate another (for example within a closed space this value can be considered high, and outside low).

Defines the percentage of chance that an individual has to recover from the virus and become immune (for example very low for Ebola and very high for Covid19).

Defines the distance (circular) within which the user can move (similar to the 1km limit in France for example).

Activate or not a “lockdown” mode, in the latter, only 10% of the agents move at each tick.

An alternative to lockdown is just isolate (no movement) for sick agent (self-lockdown).



You can track the state of the population (percentage of sick, healthy and immunized people) as well as the number of deaths.

III. THINGS TO NOTICE

Don’t hesitate to activate the show-turtles-infos button then click on the turtles to see the influence of the different parameters:

- range_deplacement
- infectiousness_360_degrees
- range_to_infect

Figure 4 : Turtles info on click

If we take a set of values corresponding to the beginning of the covid epidemic19 : a population of 1000 individuals, a very slight rate of infected people 1%, 0% immunized, no barrier/masked gestures, no containment, 35 days of infections and a great chance of recovery from the virus. With this set of parameters we realize that even if the virus seems harmless, it spreads very rapidly and infects the entire population. This seems to be consistent with the year 2020.
We notice a huge peak of infections, however, it is also interesting to note that if we add to the same simulation a percentage of 25% of compliance with barrier gestures and the wearing of the mask, we manage to smooth this curve of contaminations (which corresponds to a slackening on the hospital system) and to decrease its maximum.
Of course, as one can imagine if one adds containment measures, this also helps to better control the epidemic. Decrease the height of the maximum of the “wave” and smooth the peak.
In any case, we notice that a virus with a high rate of spread (such as covid19) is very difficult to contain within a population without applying strict containment, even if it is not enormously fatal, it causes deaths, and very quickly infects a large number of people.

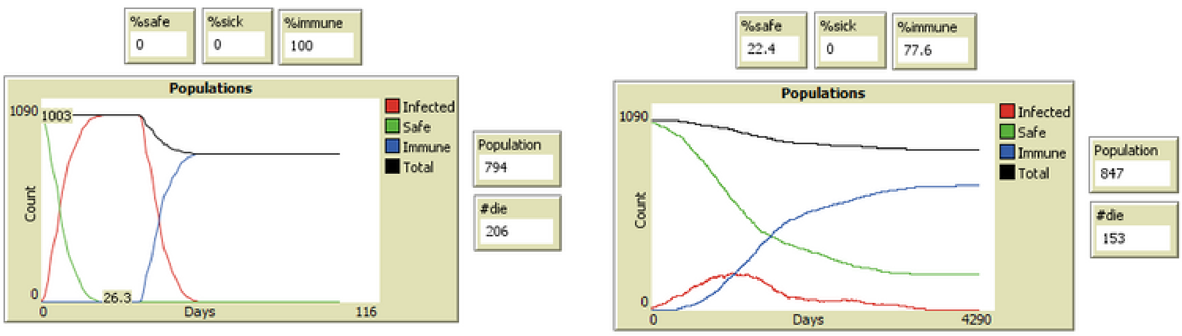


Figure 5 : Left (without lockdown and barrier gesture), Right (with lockdown and barrier gesture)

III. THINGS TO NOTICE

A second thing that may be interesting to notice is to simulate a indoor area using our parameters (for example a family gathering, night club…): no masks, little respect for barrier gestures but a very wide range of contamination (high range_to_infect parameter). Let's consider this situation with 50 individuals, and 1 originally contaminated individual. Although caricatured, this situation shows us that all the individuals are contaminated almost instantaneously…
This may explain some restrictive measures at the level of gatherings.

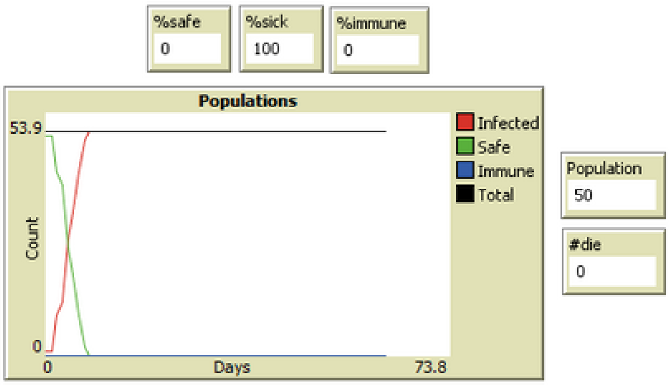


Figure 6 : High speed infection in this case

Finally, a positive perspective is that viruses that have a high rate of infection and a high rate of cure do not necessarily last in the long term (people die or become immune), which may give hope for good prospects in the case of covid19.

IV. THINGS TO TRY

- What happens in the case of a highly infectious virus with a very short lifespan and little chance of recovery? (Like the ebola virus)
- What happens in the case of a virus that is not very infectious with a very long lifespan and little chance of survival? (Like HIV)
- Do the use of masks and the respect of barrier gestures have a real impact on the spread of a virus?
- What is the most effective containment measure? Total lockdown or a large movement limitation? (low radius_deplacement)
- 60% of people immunized, is this a good value for herd immunity?

V. RESULTS

With our simulation we were able to:

- Simulate the way different viruses spread and observe the consequences of their propagation (through time, for instance HIV has a long propagation time)

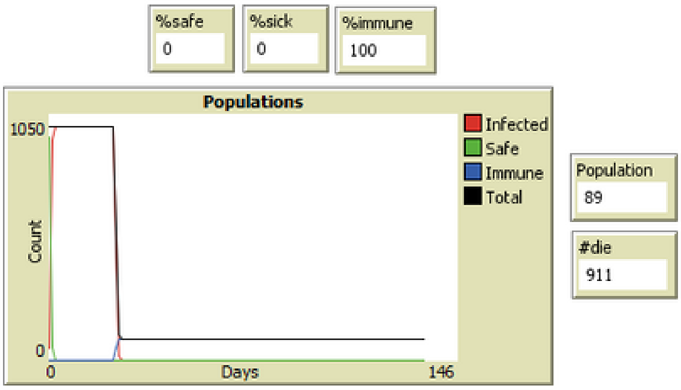


Figure 7 : Ebola virus

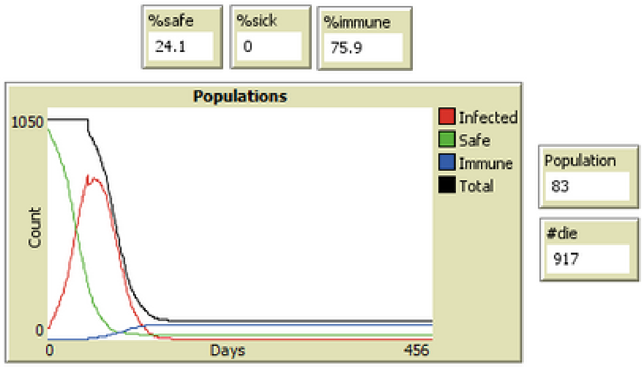


Figure 8 : HIV virus

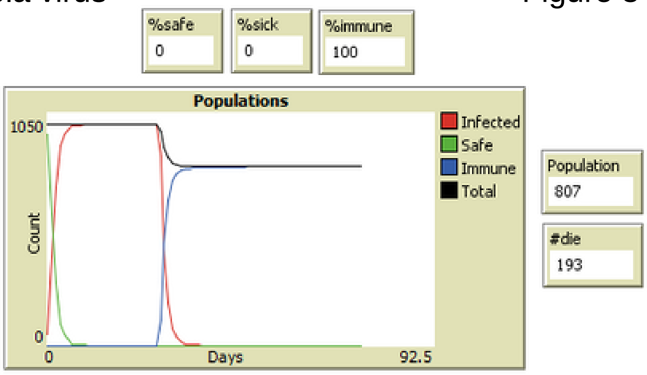


Figure 9 : Covid19 virus

Parameters use :

- **1000 agents**
- **10% sick**
- **0% immune**
- **No protective measures**

- Note that the most effective coronavirus protection measure is the strict limitation of movement (lockdown) although it is in any case difficult to contain the epidemic. Other measures are effective but on a much smaller scale. This measures aims to flattened the curve (but on the other hand the virus lasts longer).

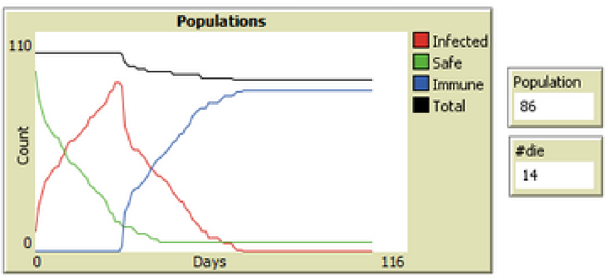


Figure 10 : Without measures

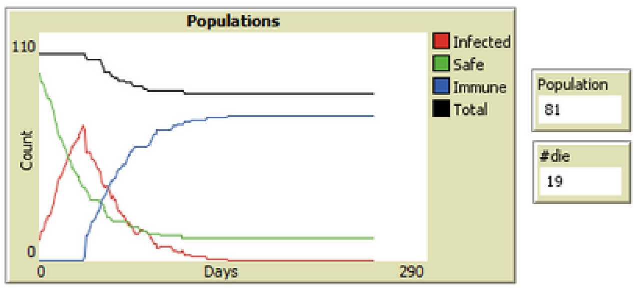
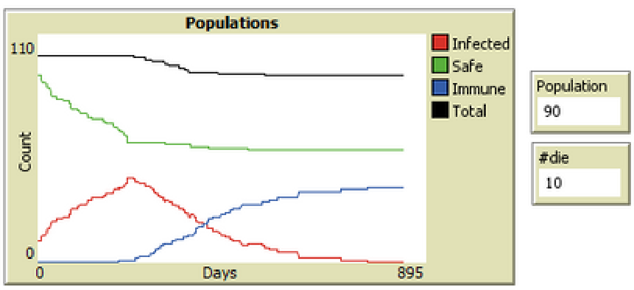


Figure 11 : With barrier gestures & mask



Parameters use :

- **Same as before**
- **Protective measures**

Figure 12 : With travel restrictions and lockdown

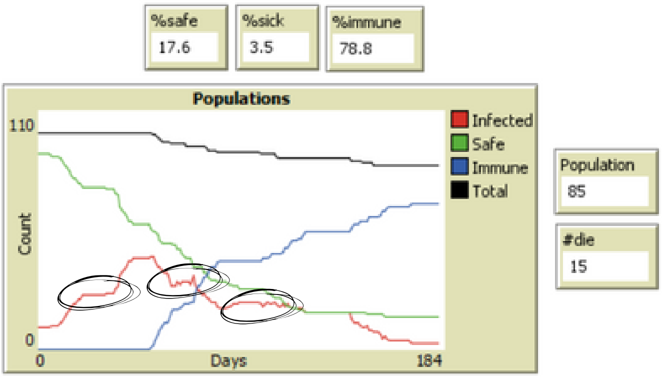
V. RESULTS

- Can't prove rigorously, that if you have 60% of a population immunized, then it is much more difficult to spread (herd immunity). This is probably due to the randomness of the displacements and also to the fact that this rule certainly applies to a large number of individuals (much more than our modeling would accept to make sense).

- We were able to observe that the influence of contamination indoors (which corresponds to a high radius_infection value, with airborne particles moving through the rooms) is indeed much greater than outdoors.

- We can notice that the isolation of sick people is an alternative to total lockdown, it allows to slow down the epidemic and to contain it if there are not too many sick people at the origin (<30% population_sick). As soon as too many people become sick, this strategy no longer works.

- If we use an alternating lockdown and non-lockdown strategy, we can notice the formation of tiers as the epidemic spreads. This strategy seems to mitigate the epidemic, but not as quickly as total containment or isolation of infected patients. It manages to stabilize the development of the epidemic but has difficulty in reducing the number of infected people. Combined with isolation of sick patients, the strategy seems almost as effective as total containment.



VI. EXTENDING THE MODEL

In order to improve the model it would be interesting to try to integrate the management of the time of exposure to the virus. That is to say, to reduce the random and systematic nature of the movements of agents in order to simulate public places where people meet in the long term (restaurants, stores, etc.) and this would of course have consequences on the transmission of the virus from individual to individual.

Implement a new policy of deplacement with less random to be clother to the real world.

A second possibility of improvement can also manage the age within the simulation and give different influence to the virus according to the age.

VII. CREDITS AND REFERENCES

- Wilensky, U. (1998). NetLogo Virus model. http://ccl.northwestern.edu/netlogo/models/Virus. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.
  I was inspired in this model for the different shapes of turtles, the display of graphics, the random displacement system, different global variables. I didn't take any function as is, nor any element, I adapted them to my model.
  I also tested my model and its capabilities on different viruses (ebola, HIV...) in order to find it consistent with the basic NetLogo model.
- Course AI-961, System multi-agents by Ada Diaconescu