Model of the spread of a disease in a population of mobile agents

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A Introduction

The modeling of spatial segregation proposed in the 1970s by Thomas C. Schelling made an impression because of the perverse effect she suggested: a strong segregation could be the collective result of individual decisions that are not aimed at such segregation. We would be dealing with an almost spontaneous phenomenon. The problem is that such a conclusion outright contradicts the entropy principle. An exam more attentive to the model makes it possible here to identify no less than four biases which condition the results. We will study here the impacts that population density and the dissatisfaction rate can have on segregation.

B Model presentation

Schelling's model is a model of spatial segregation. It takes the form of a matrix of n * n boxes. Each cell is represented by an integer between -1, 0 and 1. Empty cells are represented by 0 while cells occupied by an individual are represented by a -1 or 1. We therefore obtain a stylized representation of two populations which share an urban area.

Initially, the agents are placed at random to simulate the mix of populations. We then add a rule of movement of agents: they will change boxes if, in their immediate neighborhood, there is not at least "n" agents of the same type as them. When an agent is not satisfied, we generate a random place among the empty cells and we place the agent in this box; which frees up its old place. This operation is carried out until all the agents are satisfied, or until the defined maximum time is reached. Under these conditions, we obtain groupings of populations which appeared without being intentionally provoked.

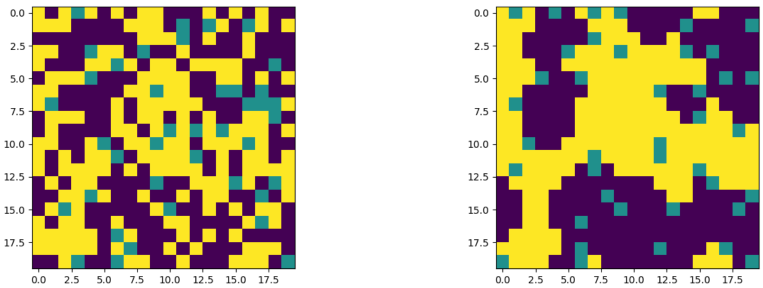


Figure 1: Graphic representations of the initial and segregated populations with Schelling's model

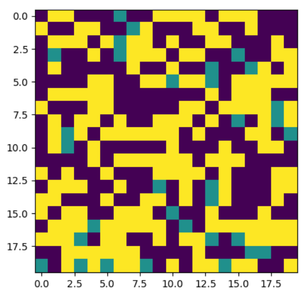
C Experiments, results

With this model, we were able to study the effects of population density and insatisfaction rate on movements agents.

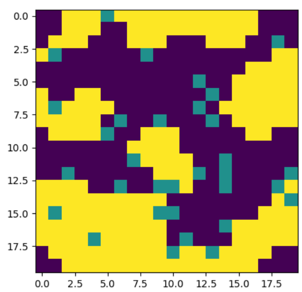
C.1 Population density

As said, we have run several simulations with different population density values. In other words, we wanted to study whether the number of free sites played a role in the separation of populations.

We varied the number of free cells from 15 to 24 and obtained the following results:

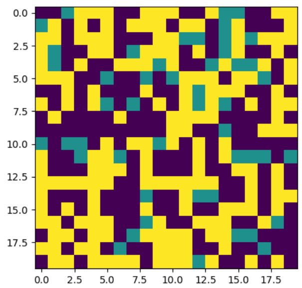


(a) Initial state

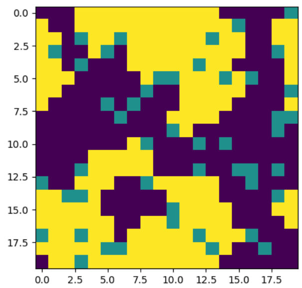


(b) Population segregation after simulation

Figure 2: Graphic representations of the initial and segregated states of Schelling's model with 16 free cells over 400 at an insatisfaction rate of 0.5



(a) Initial state



(b) Population segregation after simulation

Figure 3: Graphic representations of the initial and segregated states of Schelling's model with 24 free cells over 400 at an insatisfaction rate of 0.5

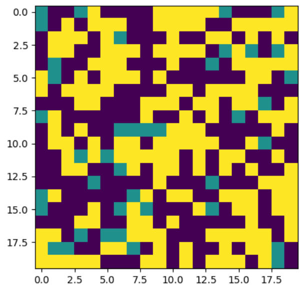
It is observed that in both cases, the agents separated into two distinct groups according to their color. So we have represented the time taken by our agents to arrive at a stable situation according to the population density.

Figure 4: Graphic representations of the time spent by the agents to reach a stable state with a variable population density at an insatisfaction rate of 0.5

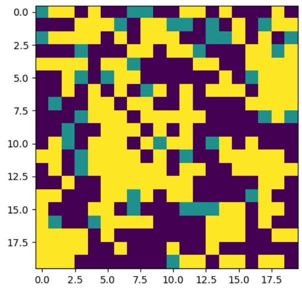
We can see that the convergence time towards a stable state is longer as the population density increases. This is due to the decrease in the number of free cells.

C.2 Insatisfaction rate

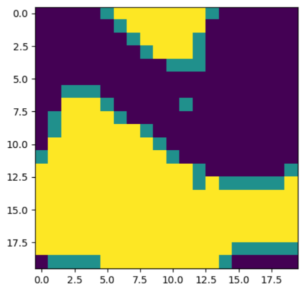
This time we have varied the dissatisfaction rate over a range of values from 0.1 to 0.9 with a step of 0.1. For these nine simulations, we obtained very different results from each other:



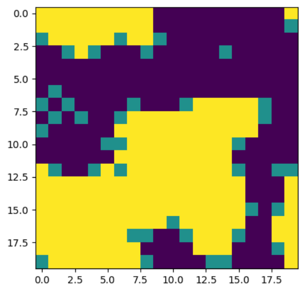
(a) Insatisfaction rate at 0.1



(b) Insatisfaction rate at 0.2



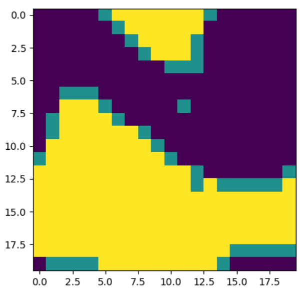
(a) Insatisfaction rate at 0.3



(b) Insatisfaction rate at 0.4

Figure 5: Graphic representation of the organization of populations at the end of the simulations for a given dissatisfaction rate

It is clear that the tendency of the population to separate regardless of the rate of dissatisfaction. With a threshold when the rate is 0.3 (1/3) from which this segregation is becoming much more important. This rate, 1/3, is the rate found by Schelling for which it is impossible to obtain anything other than a state where populations are separated. This is called the "law of thermodynamics".



(a) Initial state

Figure 6: Graphic representations of the initial and segregated states of Schelling's model with 24 free cells over 400 at an insatisfaction rate of 0.5

D Conclusion