Cellular Automata as models in Social Sciences

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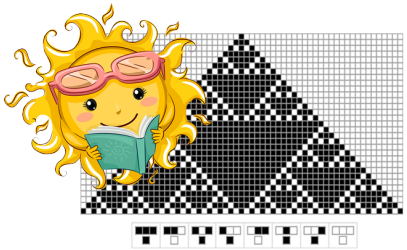

In this project we were interested in the use of 2 dimension cellular automata in social sciences , we were very flexible in the last point as we also inculed models in urban modeling.We also did not restrict ourselves to the formal definition of cellular automata as we considered also interesting models that may be considered close to cellular automata. We realized programs for all models

Schelling's model of segregation is a model developed by economist Thomas Schelling. Consider two social categories (State 1 , State 2). At each step a cell will check if the rate of its neighbors corresponding to the same social category is higher than a threshold B_a.If so than the cell remain unchanged otherwise the cell will migrate if an empty place is available. Many criterion may be applied to find a suitable migration place it ranges from just finding the nearest empty place to finding a complete ideal place i.e. where the cell has no more need to migrate.

Example 1 Update the indicated cell according to rates (1) 40% and (2) 75%. If we want to update the cell indicated in the Figure. 1a, we have the following situations :

1. Rate 40% : Here the cell has 4 neighbors in the same social category so in this case the cell will remain unchanged.
2. Rate 70% : Here our cell needs 7 neighbors in the same social category so in this case the cell will migrate.

While studying the dynamic Schelling established that there is a value B_{seg} such that if $B_a < B_{seg}$ then the population will be "uniformly" distributed i.e. the two categories are mixed and if $B_a \geq B_{seg}$ you have a compact block distribution i.e. islands type configurations.

The value B_{seg} is estimated in to be $B_{seg} = \frac{5}{9} \approx 0.55.56\ \%$.

Definition 0.1. Consider the cellular automaton on the alphabet $\{0,1,2\}$ defined by

$$Seg\left(x_{ij}\right) = \begin{cases} x_{ij} \text{ if } \sum_{k=i-1}^{i+1} \sum_{k=i-1}^{i+1} \chi_{\{x_{ij}\}}\left(x_{kl}\right) \geq r.9 \\ 0 \text{ else} \end{cases}$$

where $r \in [0,1]$ is the segre*gation rate and χ is the characteristic function* . Here 0 stands for empty state and 1,2 for social categories 1,2 respectively.

Definition 0.2. Consider the function $Mig : \{0,1,2\}^{\mathbb{Z}} \to \{0,1,2\}^{\mathbb{Z}}$ defined by :

$$Mig\left(x\right)_{i,j} = \begin{cases} if\ Seg\left(x_{ij}\right) \neq 0 \text{ then } \left| \begin{array}{l} r = 1 \\ if\ \exists x_{lm} = 0 \in V_r\left(x_{ij}\right) \text{ then } x_{lm} \leftarrow x_{ij}\ and\ x_{ij} \leftarrow 0 \\ else\ r \leftarrow r+1 \end{array} \right. \\ x_{ij}\ if\ Seg\left(x_{ij}\right) = 0 \end{cases}$$

notice that we are using a local rule with unbounded radius.

In our program we used the following color scheme Green = social group 1 ; White = social group 2, we added another state empty (0 = red square) If after applying the local rule a cell a_{ij} has to migrate then we find an empty cell a_{mn} elsewhere, then a_{mn} takes the value a_{ij} and a_{ij} is switched to empty state.The following figure represents two typical configurations we find in simulations after some iterations and if the rate is higher than 55% the configuration space is successively homogenized (see in Figure. 1b and Figure. 1c).

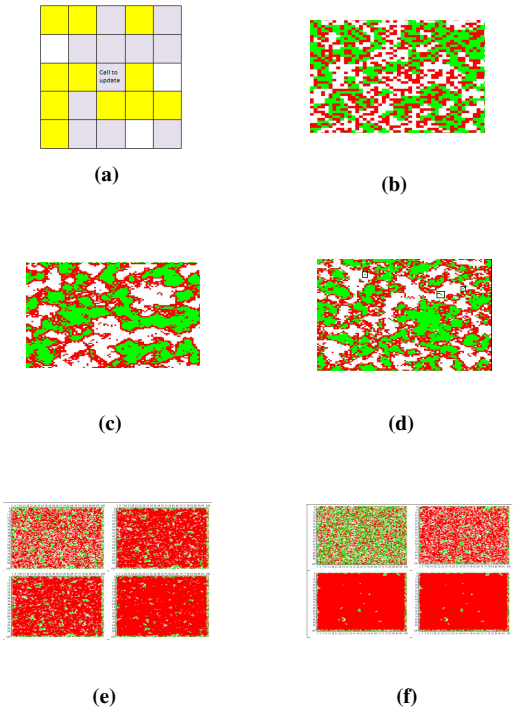

Figure 1: (b) Rate 45% Number of iterations : 40; (c) Rate 80% Number of iterations : 40 ; (d) Black boxes highlights surrounded cells; (e) From upper line from left the 4 first iterations of the model for $S_b = 10$ red pixel $= Dl$, green pixel $= SL$; (f)From upper line from left the 4 first iterations of the model for $S_b = 10$ red pixel = Dl, green pixel = SL;

We considered an asynchronous version of the Schelling model, In this model we consider that each cell decide to migrate depending on time. In our program, we used a random time generator for each cell and a program parameter named "$time$" when the random generator give a value greater than "$time$" then the state cell is updated. During simulations and because of randomness of migration the configurations will not be homogenized as in the synchronous model , some cells may remain unchanged despite begin "surrounded" by islands of different social categories, see the Figure. 1d.

Considering the case of Algeria in many geographical regions there is a social pressure to maintain the amazing language (Kabylie region, Chaouia region and in the desert among Touareg population) the pressure is somewhat less or in existent in other regions. Here we consider a partition of the lattice depending of the geography of the country, on each element of the partition we define a version of the cellular automaton S but with adequate parameters.