P2P Systems and Blockchains
Final Project
Academic Year 2018/2019

Cultural dissemination and self segregation and in social communities

1 Goal of the Project

The goal of the project is to implement a model describing how and if it is possible to observe *culture dissemination* and *self-segregation* within a given population. The model is derived from the proposals presented in [2, 3, 4].

2 Description of the model

In the proposed model, the individuals stay at *locations*, which are represented as nodes of a graph where an edge between two nodes represents a spatial neighbour relation between two locations. The graph includes N nodes (locations) and each node is inhabited by an individual with probability p.

Each individual i, associated with a non empty location is characterized by a *cultural code* $\sigma(i)$, which is a vector of length F where each element corresponds to a different cultural trait, and each cultural trait is represented as an integer value in the interval $[0, q-1]$. The F parameter defines the complexity of the cultural code, while the q parameter defines how many different cultures are present in the population, for each trait. At inizialization time, when a new individual i is generated, each of the F cultural traits in their cultural code $\sigma(i)$ is picked at random uniformly within this interval.

The behaviour of individuals is modelled as follows: at each step, each individual i picks a random individual j located in its neighbour locations (empty sites in the neighborhood of i are not considered), and computes the *cultural overlap* $\omega(i, j)$ between i and j, which is defined as:

$$\omega(i,j) = \frac{1}{F} \times \sum_{k=1}^{F} \delta(\sigma_k(i), \sigma_k(j))$$

where $\sigma_k(i)$ is the k-th cultural trait of i and δ represents the *Kronecker's delta function* that is 1 if its two arguments are equal, and 0 otherwise. The cultural overlap $\omega(i, j)$ corresponds to the proportion of cultural traits that are the same for i and j, and it is a measure of how culturally similar they are. Then, i randomly chooses a trait k out of the F cultural traits of j, and copies it with probability $\omega(i, j)$.

$$\sigma_k(i) = \sigma_k(j)$$

This means that individual i imitates a culture trait of individual j, and the more culturally similar they are, the more likely is that this copy happens.

If, instead, the copy of the trait does not occur (with probability $1-\omega(i,j)$), individual i computes the average cultural overlap $\bar{\omega}_i$ with all the individuals located in its entire neighborhood, which is defined as the average of the $\omega(i,j)$ values for each individual j that is a neighbor of i. This second measure defines the cultural similarity of an individual compared to their neighborhood as a whole and, as before, empty sites in the neighborhood of i are not considered. At this point, if $\bar{\omega}_i$ is lower than a fixed threshold T, individual i will decide to move to a random new site that is empty, chosen on the entire map, leaving its previous site empty. The parameter T represents a tolerance threshold of individuals towards other cultures, and is used to model stricter or more adaptable societies. If an individual is surrounded by only empty sites, and thus cannot perform any of the actions described above, it will move directly to a new site.

This process stops when, at a given step, no cultural imitations or moves on the network are performed by individuals, or after M simulation steps have been performed, where M is a threshold dependent on the parameters of the model and chosen to stop long running simulations.

[2] introduces the notion of cultural trait, while [4] the notion of self segregation. It is recommended to read [2, 3, 4] for a better comprehension of the model.

3 Implementation

The student should:

- implement a simulation of the previous model. The simulation may be implemented in $JAVA$ or by the *Peersim simulator* [1].
- present a set of experiments highlighting the most important aspect of the model.

Each experiment should employ a particular configuration of the parameters of the model: motivate the choices of parameters (in particular F, q, p and T), and try to relate them with real-world scenarios. Furthermore, repeat the same experiment multiple times, to ensure that your outcomes are not due statistical anomalies.

The first step of the simulation is to generate the initial graph and to populate it with individuals, generating for each individual a cultural code.

Then, at each iteration of the simulation, the individuals are considered in sequence, and their behaviour is simulated according to the model. An asynchronous model should be considered, i.e. the order according to the nodes are considered at each iteration may affect the resul of the simulation.

The experiment should highlight emergent social behaviors. For instance, it should be interesting to check if small, scarcely-connected neighborhoods tend to be highly segregated and uniform from a cultural point of view, or if an hyper-connected society leads to cultural homogeneity and to the disappearance of cultural minorities.

Finally, it is possible to experiment different topologies of the network corresponding to different spatial placement of the locations. For the generation of the initial graph, it is possible to use one of the following packages:

- Networkx: `networkx:https://networkx.github.io/documentation/networkx-1.9.1/reference/generators.html#module-networkx.generators.random_graphs`
- A JAVA library: `https://algs4.cs.princeton.edu/41graph/GraphGenerator.java.html`

or to write a new topology generator.

4 Project Submission Rules

The project must be developed individually. The material to be submitted for the evaluation is the following one:

- a report (pdf document) describing the main features of the project. The report should include: a brief summary of the project choices and of the implementation and a set of plots reporting the results obtained by the experiments
- a pdf document reporting the code of all the JAVA classes defined to set up the simulation.

The report and the code must be submitted both electronically, through the Moodle, and at the reception desk of the Department of Computer Science.
The project will be discussed a week after its submission. The discussion of the project consists in the presentation of a short demo, which can be run on the personal laptop and a general discussion of the choices made in the implementation of the system.

The oral examination (if required) will regard a review of the topics presented in the course. I recall that the oral examination is waived for the the students who have passed the Mid and Final Term.
Do not hesitate to contact us by e-mail (laura.ricci@unipi.it) or during the question time, Thursday 15.00 PM-18.00 PM.

References

[1] `http://peersim.sourceforge.net/`

[2] R. Axelrod, *The dissemination of culture: A model with local convergence and global polarization*, Journal of conflict resolution, 41, 2, pages 203–226, 1997

[3] C. Gracia et al. *Residential segregation and cultural dissemination: An Axelrod-Schelling model*, Physical Review E, 80, 4, 2009, APS

[4] Schelling, T. C. *Dynamic models of segregation.* Journal of mathematical sociology 1.2, pages 143-186, 1971