Patterns of Migration and Adoption of Choices By Agents in Communities

(Extended Abstract)

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ABSTRACT

We study the migration and behavior adoption patterns of agents situated in geographically distributed communities. We consider agents with two types of states or opinions, binary and continuous. Agents either probabilistically adopt the predominant state in their community or migrate to another community more supportive of their state. We observe an interesting range of emerging population patterns based on different migration and adoption biases.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multiagent systems*

General Terms

Experimentation

Keywords

Opinion dynamics, Emergence, Migration, Adoption

1. INTRODUCTION

We are interested in studying emerging patterns of opinions in population of agents in a society adopting one of several choices or opinions as a convention or norm [1, 2]. We believe that agents are governed, among other forces, by two somewhat conflicting but important influences: the desire to "fit in" in their social environment, and the attraction of environments more receptive or supportive of their preferences. We are therefore interested in investigating the issues of "peer pressure" and migration inertia on the emergence of divergent opinions in spatially distributed, yet connected, sub-populations (communities). We believe that better understanding of opinion dynamics under such constrained interactions and the interplay of behavior adoption and migration patterns can improve our understanding of real-life multiagent systems and help us better design effective interaction models and infrastructure to facilitate smooth, coherent functioning of such open multiagent systems.

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We assume that agents are communities that are connected in some known topological structure. Each agent may start with a bias for one of the several available opinion options but can be influenced by other agents in its community to change its choice. Agents also can leave for "greener pastures," i.e., if an agent is unsatisfied with the emergent convention or opinion in its community, it may move to a community perceived to have a more widespread support for the option it prefers.

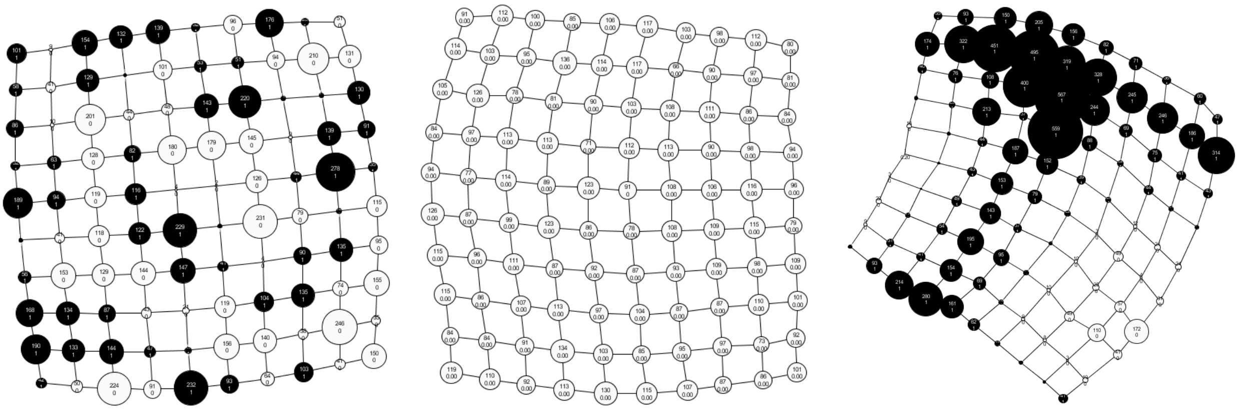
Agents' opinions (choices) are represented by either binary or continuous valued variables. The opinion o_i of a binary agent i can be either zero or one: $o_i \epsilon \{0, 1\}$. In real life, people have different degrees of preference for the opposing opinions. For modeling this situation, the opinion of a continuous agent, $o_i \epsilon [0, 1]$, can be interpreted as the probability of adopting one of two possible states.

A community is assumed to have reached *opinion consensus*, when all agents present in the community have the same opinion. The entire population is said to have *converged* if all communities have reached opinion consensus. The *state* of a community is the average opinion over all its members.

We assume that agents prefer to interact with other agents having similar opinions. Our agents are assumed to be cognizant of the state of their community as well as those of the immediate neighboring communities. Agents decide to stay or migrate based on the dissimilarity between its opinion and the state of its community. The migration probability, P_i^M, is a function of the disparity between opinion of agent i, o_i, and the state, s_j, of its community: $P_i^M = |o_i - s_j|^\beta$, where β determines the migration inertia. If an agent decides to migrate, it migrates to a more supportive neighbor community with a higher probability.

Adoption is a result of social influence in communities. Binary agents adopt the opposite opinion with a probability proportional to the fraction of agents having opposite opinion. Adoption probability of binary agent i in community j, $P_{i,j}^A$, is defined as follows: $P_{i,j}^A = |o_i - s_j|^\gamma$, where γ is used to modify the adoption rate.

Continuous agents use an interaction based adoption. Each agent randomly picks another agent in its community, they flip coins biased by their respective opinion values; the result of the coin toss is either zero or one. If both agents pick the same value, they are coordinated. Otherwise, there is a conflict. When coordinated, agents increase or decrease their opinion values simultaneously by a certain amount, Δ. When a conflict occurs, they change their opinions in the opposite way to the result of coin toss.



(a) Heterogeneous communities: moderate migration, conservative adoption (b) Unanimous communities: eager migration, conservative adoption (c) Clustered communities: eager migration, eager adoption

Figure 1: State and population distribution of communities of continuous agents

2. RESULTS

Simulation proceeds in discrete timesteps, where first migration and then adoption takes place in each timestep with synchronous updates. We present results from experiments with communities situated in a two-dimensional toroidal grid. There are 100 communities and the initial population is 100 in each community. Agent opinions are initialized by using a uniform distribution.

For conservative, moderate, and eager migration, the values of β are 10, 1, and 0.25, respectively. Binary agents use γ parameter with a value of 0.33 for eager adoption and 3 for conservative adoption. Conservative, moderate, and eager adoption of continuous agents are represented by the values of Δ: 0.01, 0.05, and 0.1, respectively. All combinations of migration levels and adoption rates are analyzed.

Results show that increasing the migration tendency and reducing the adoption tendency primarily affect the distribution of community sizes. We observe an interesting emergent pattern for high standard deviations of populations (eager migration and conservative adoption), the population of some communities declines drastically or they can even completely "die out". It is very likely such smaller communities are attached to larger communities by the end of simulations, thus demonstrating an *emergent phenomena of big cities with smaller suburbs*.

The entire population converges in all cases except communities of binary agents using eager adoption irrespective of migration inertia. This is because even when the opposite opinion is supported by only a small minority, eager adoption makes them switch from the majority opinion. In this case, binary agents become incredibly capricious: they change their opinion frequently.

Figure 1 presents snapshots of the communities of continuous agents at the end of typical runs. A community is represented by a circle whose size is proportional to its population size. The size and state of a community are written on the circle. The color indicates the state of the community: black (white) circle means the *state* is 1 (0). Mixed states are indicated with different shades of gray proportional to its value.

Using low values of Δ for adoption and relatively higher migration tendency, we obtain a heterogeneous grid with respect to the community sizes (see Figure 1(a)). Interestingly, unanimous population (all communities converge to the same opinion) is obtained with the continuous agents using eager migration and conservative or moderate adoption (see Figure 1(b)). The entire population is homogeneous with respect to both community sizes and opinions. The population converges to one or zero, depending on the initial average opinion of the entire population (whether it is above or below 0.5).

The most interesting emergent pattern is shown in Figure 1(c) for continuous agents using eager migration and eager adoption. This grid consists of clusters of communities of same opinion. Additionally, in contrast to the general trend, the standard deviation of community sizes increase as the adoption tendency increases in this case. The grid is almost unanimous except for a couple of small communities converging to a differing opinion. When we look at the convergence time versus the final population of communities: the larger communities appear to be converging earlier! With the aid of high migration and adoption, some communities converge to a stable state earlier and become attractive for the agents, who are willing to find a community where they will be satisfied. It can be thought as agents appear to be flocking towards the completely converged communities since they are eager to migrate. These early adopters act as "black holes" by sucking in deserters from surrounding communities! The difference in the patterns of community sizes in Figures 1(b) and 1(c) is due to the different convergence time of the communities.

3. REFERENCES

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