Locality enhances consensus in opinion dynamics

Abstract

Social dynamics is a multidisciplinary field that encompasses a wide range of subjects. Opinion dynamics, one of the subjects of social dynamics, is investigated to understand how individual opinions shape the whole of society. Some of the common models of opinion dynamics include discrete and continuous models. For discrete opinion dynamics, the majority rule and voter models have been introduced. For continuous opinion dynamics, the Deffuant model and Hegselmann-Krause model have been introduced. This work has primarily focused on the Deffuant model. Past literature on the Deffuant model assumed a two-dimensional grid (square lattice), a complete graph, a random graph, and a scale-free graph.

However, these graphs do not treat the effect of local connectivity. In reality, we have some intimate peers who surround us. To explore how local connectivity affects macroscopic consensus, a graph that is between a square lattice and a complete graph is proposed to hypothesize how local interactions may influence the whole population. Therefore a spatial parameter representing “globality” is introduced into the model. (Figure 1)

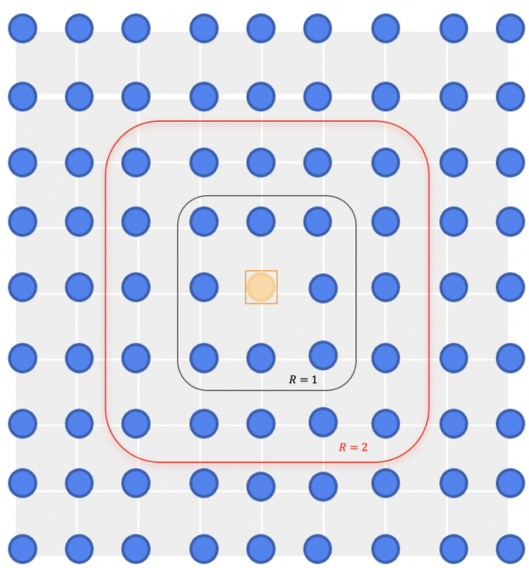


Figure 1: The definition of globality R on a two-dimensional lattice

The length of the two-dimensional vector is defined by the maximum of the absolute values of the vector, denoted as $||v||=\max(|x|,|y|)$. The length of this vector is assumed to satisfy $||v||<R$, where again R represents “globality”.

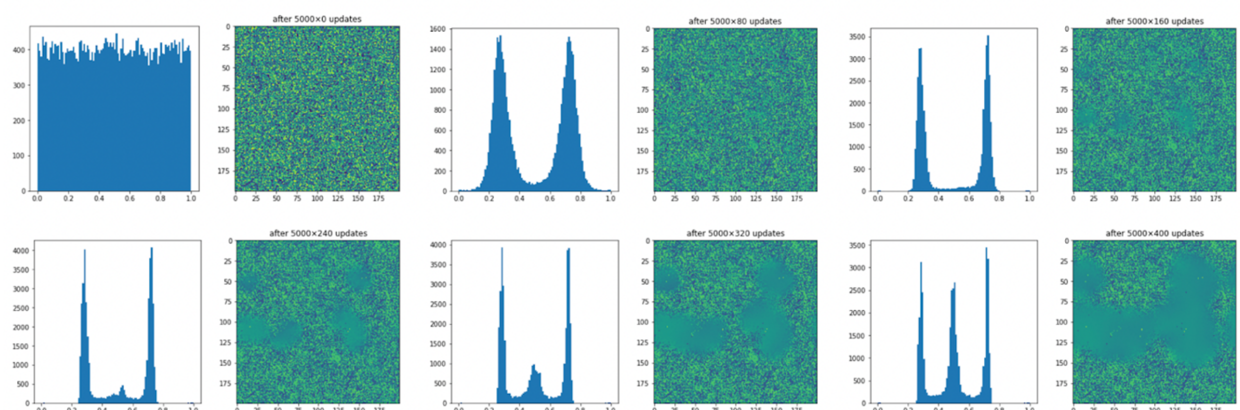
Setting the distance vector allows us to model a local community and describe intimate relationships. For example, when $R=1$, an agent interacts with another agent existing within the difference vector of 1. This means an agent can interact with one, and only one, of the 8 candidates within its vicinity.

It is found by numerical stochastic simulations that the strength of globality and the value of specific confidence bound have an impact on the threshold for “almost consensus”, defined as 80% consensus. (Figure 2) In addition to the previous findings that larger confidence bounds increase the probability that the population attains a state of “almost consensus”, it is found that a smaller number of neighbors, or “low globality” in other words, increases the likelihood of attaining “almost consensus”, regardless of the value of the confidence bound.

	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.3
local	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
3	0.9	1	1	1	1	1	1	1	1	1	1
4	0.3	0.5	0.9	1	1	1	1	1	1	1	1
5	0.1	0.2	0.3	0.6	1	1	1	1	1	1	1
6	0	0	0	0.3	0.3	1	1	1	1	1	1
7	0	0	0	0	0	0.6	1	1	1	1	1
8	0	0	0	0	0.2	0.2	0.9	1	1	1	1
9	0	0	0	0	0	0.2	0.9	1	1	1	1
10	0	0	0	0	0	0.1	0.6	1	1	1	1
15	0	0	0	0	0	0	0.1	0.9	1	1	1
20	0	0	0	0	0	0	0	0.8	1	1	1
30	0	0	0	0	0	0	0	0.9	1	1	1
40	0	0	0	0	0	0	0	0.4	1	1	1
global	0	0	0	0	0	0	0	0.5	1	1	1

Figure 2 : A heatmap constructed on the map of probability of reaching “almost consensus”, elucidating a certain threshold of globality over different values of confidence bound.

As a population capable of attaining “almost consensus” evolves toward this state, clusters of centrists are found to appear and grow in size until the whole population is covered. (Figure 3) There may be minority agents with outlying opinions scattered across the two-dimensional space, but the overall trend is not affected.



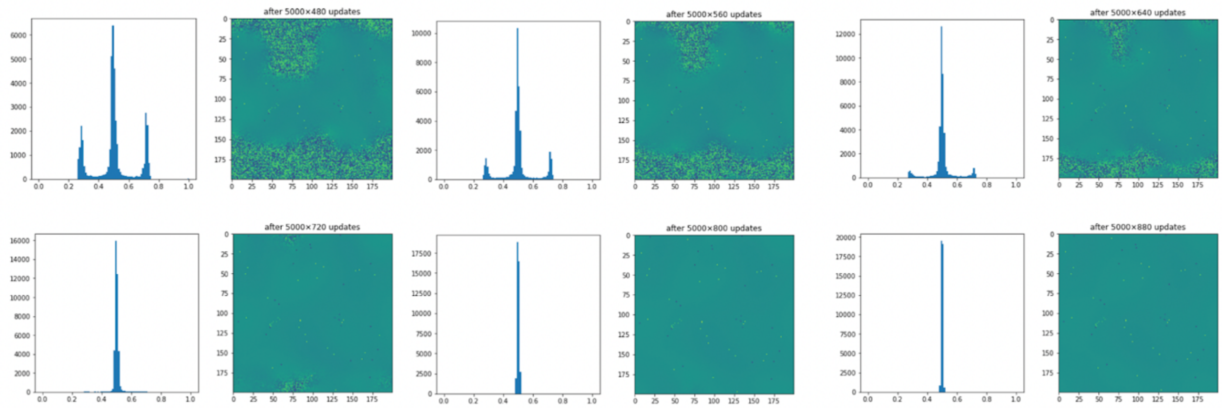


Figure 3 : The histogram and spatial distribution after 880 iterations of 5000 updates at ε=0.24, R=5. As the centrist cluster starts growing on histogram, small agglomerations of agents with centrist opinions emerge in the population. As the small agglomerations grow, they sometimes merge with nearby agglomerations, until they cover the entire population. This phenomenon may be compared to nucleation of crystals when liquid freezes. The same process appears to be followed regardless of the value of ε and R. Nonetheless, the details of this process, such as the number of agglomeration nuclei, may be different.

It is hypothesized that conversion of agents to centrist agents occurs at the interface of growing clusters of centrists. It is also hypothesized that small confidence bounds and large globality prevent nucleation of centrist clusters, resulting in polarization of the population. (Figure 4) We remark that polarization of opinion occurs without spatial polarization.

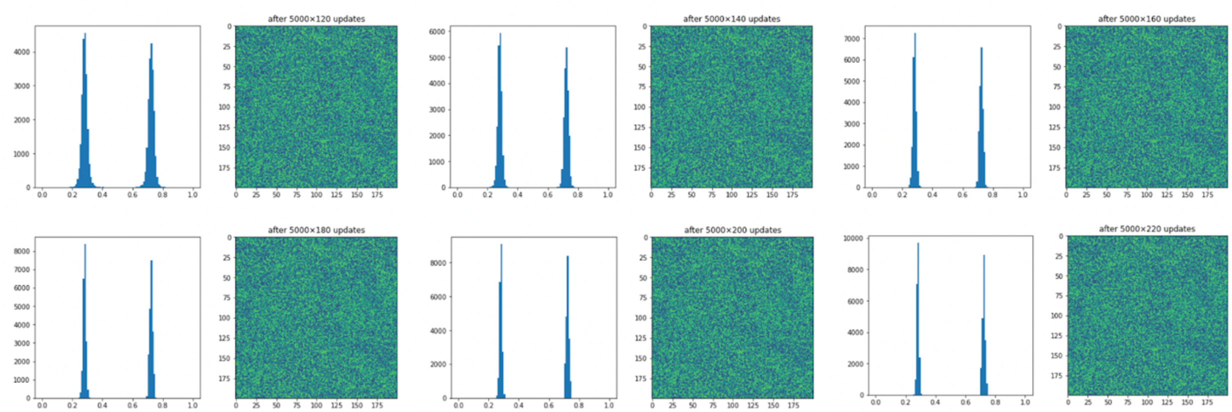


Figure 4 : Evolution of clusters and spatial distribution at ε=0.24, R=10 over 220 iterations of 5000 updates. Polarization of opinions on the histogram does not induce spatial polarization of opinions.

Spatially defined phenomenon, such as the growth of centrist clusters, is also quantified and investigated. This might be achieved by employing image processing methods, such as clustering algorithms, and dimensionality reduction.

The analysis of the formation process of spatial clusters using clustering algorithms and data analysis techniques is a future work. Understanding these underlying dynamics of opinion formation may contribute to a better understanding of social phenomena modeled by opinion dyanamics.