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Political opinion formation: Initial opinion distribution and individual heterogeneity of tolerance

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HIGHLIGHTS

- We catch polarization, consensus and fragmentation in political opinion formation.
- Introduce the initial opinion distribution and individual heterogeneity on tolerance.
- We introduce the average ratio of near neighbours to evaluate opinion formation stage.
- We introduce a framework for simulating two-party systems based on network models.

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ABSTRACT

Opinion dynamics on networks have received serious attention for its profound prospects in social behaviours and self-organized systems. However, political opinion formation, as one typical and significant case, remains lacking in discussion. Previous agent-based simulations propose various models that are based on different mechanisms like the coevolution between network topology and status transition. Nonetheless, even under the same network topology and with the same simple mechanism, forming opinions can still be uncertain. In this work, we propose two features, the initial distribution of opinions and the individual heterogeneity of tolerances on opinion changing, in political opinion formation. These two features are imbedded in the network construction phase of a classical model. By comparing multi simple-party systems, along with a detailed analysis on the two-party system, we capture the critical phenomenon of fragmentation, polarization and consensus both in the persistent stable stage and in-process. We further introduce the average ratio of nearest neighbours to characterize the stage of opinion formation. The results show that the initial distribution of opinions leads to different evolution results on similar random networks. In addition, the existence of stubborn nodes plays a special role: only nodes that are extremely stubborn can cause the change of final opinion distribution while in other cases they only delay the time to reach stability. If stubborn nodes are small in number, their effects are confined within a small range. This theoretical work goes deeper on an existing model, it is an early exploration on qualitative and quantitative simulation of party competition.

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1. Introduction

Opinion dynamics, like epidemic spreading, rumour diffusion or the evolutionary dynamic framework, is one kind of dynamic problems on networks. Political opinion formation, as a reflection of political and social interaction, has received serious attention in social science and self-organized system. Previous works (before 1990s) mainly come from the disciplines of political science and social science, where many kinds of party systems are studied. Based on real world data, researchers propose a list of hypotheses and then design live experiments and questionnaires, do data mining and rigorous statistical analysis to verify conclusions [1–3]. For example, Noelle-Neumann [4] empirically substantiates the process of public opinion formation through the individual's observation of his or her social environment and verifies that an individual is more frightened of isolation than of committing an error, which causes that individual to join the masses even though the individual does not agree with the masses. Kim [5] explores the political tolerance within the mass public of the Soviet Union, and finds levels of education support for more general democratic values, but not directly to political tolerance.

Since 1990s, it has become popular to combine statistical physics with sociology or economics to study sociophysics and econophysics through computer aided research. This trend reached a boom around 2000. By studying dynamic processes on complex networks, researchers can evaluate the effects of network topology on opinion formation and other related topics. The classical agent-based modelling and new mechanisms are mainly proposed during this time by statistical physicists. These works build evolutionary opinion models based on mechanisms in the real world, with mathematical equations, or referred to rigorous studies about epidemic spreading or percolation processes. Opinions can be represented as discrete integers [6,7], continuous real numbers [8] or a vector with several features [9]; for applications, opinion formation is adopted in simulation of spin interaction [10], political negotiation, cultural transition and so on. Deffuant [11] introduces the process of negotiation and compromise to study the effects of extremists, in which opinions of nodes can interact and hence become closer in a bounded confidence range. Kozma [12] combines the edge rewiring process (node change neighbours) with persuading dynamics, and finds opinion formation on adaptive network is unequal to static ones. Durrett [13] further compares rewire-to-same and rewire-to-random mechanisms and elucidates the results through mathematical proofs. Agent-based models during this time mainly adopt simple mechanisms. Sometimes the mechanisms are from individual empirical experience, which lacks systematic real data validation and do not have clear and specific application scenarios.

In recent years, opinion dynamics and social influence become the central issue in modern societies. Works on opinion dynamics are not limited to innovation of new models or network topology evolution, but also extended for comparison with percolation, or adopted in more practical issues like rumour spreading [14], vaccine immunity [15], risk perception [16] and media competition [17], and even depict real voting process [18]. Just as the above states, research on opinion dynamics is on the way to thriving.

Here we concentrate on one typical problem: how do political opinions form? Unlike the generalized concepts of opinions or the public opinions on social networks, political opinions stand for the positions of individuals as well as political parties. There are various initial opinion distributions in practical situations like two-party system or multi-party system. Moreover, the individuals are heterogeneous on tolerance, the stubborn individuals (known as extremists) actually exist, and it is harder to change their opinions and they may affect the opinion formation in the crowd. As far as we know, though political opinion formation has been paid serious attention to, we have still a poor understanding of it. In this work, we embed the initial distribution of opinions and individual heterogeneity in the network construction phase of a classical opinion model, and we study the phenomenon of fragmentation, polarization and consensus both in persistent stable stage and during the process of opinion formation. We also introduce the average ratio of nearest neighbours to characterize the stage of formed opinions. Further, we have a deeper analysis for two-party systems.

The organization of the paper is as follows. In Section 2, we elaborate on the coevolution model and the initial setup. Then in Section 3, we analyse the parameters in the coevolution model to have an elemental understanding of the opinion dynamic process. The comparison of many simple party systems is given in Section 4 and a further analysis on two-party systems is in Section 5. Finally, we conclude in Section 6.

2. The coevolution model

We regard political opinion formation as a negotiation and compromise process. That is, each individual can freely choose one of his neighbours with whom to communicate. The pairs can exchange their opinions and reach a compromise or they break the relationship and build new ones. If their opinions are within a confidence range, they may compromise and gather their opinions to get closer; if they have a huge difference in opinions, they may rewire (break their connections) and choose new neighbours instead. This compromise mechanism has been well reflected in bounded confidence models, especially the Deffuant model [8,11,19] on static networks and Kozma and Barrat's [12] work on adaptive networks.

Here, the model we choose is almost the direct form of Kozma and Barrat's model, except for two differences: first, we treat the isolated nodes as always being linked to others instead of nothing; second, at each time step, we update all the nodes instead of randomly choosing one node or a pair. Work from Noelle-Neumann [4] shows that an isolated individual is unable to survive politically and he must acquire friends by all means. Also, since we think that the political opinion negotiation is a concurrent process, one step per pair may not suitable for this.

In this process, the network contains N nodes $\{v_1, v_2, , v_N\}$ and kN links, each with the property of a random opinion $o(i) \in [0, 1]$. The network can be static or dynamic. The opinion update process and the structure update process is