An Interplay Between Noise and Temperature in a Simple Coupled Model of Opinion Dynamics

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Abstract

Opinion modeling, despite decades of efforts by sociologists, psychologists, and even physicists, still remains a challenge. This task has become even more complex in today's world, where communication channels between people are diverse and multifaceted. Social physicists have adapted their flagship model from magnetism – the Ising model – to opinion dynamics. In this model, the temperature becomes a key parameter that controls how likely spins/agents are to adopt the opinions of their neighbors (encoded as $+1$ or -1). In the language of physics, we talk about a continuous phase transition, a shift from an ordered to a disordered state. It has been shown that a small modification of the Ising model, in which a randomly chosen spin interacts only with its q neighbors (q lobby), leads to a switch from a continuous to a discontinuous phase transition with hysteresis at q ≥ 4. Similarly, in the generalized voter model, instead of just one neighbor, we choose q neighbors of the node and change its state only if all neighbors share the same opinion. In the presence of stochastic noise, interpreted as "independence," a continuous phase transition is observed only for q ≤ 5, while for q > 5, the transition becomes discontinuous. In real social relationships, we often observe nodes belonging to many different networks. We communicate on the Internet via email or through social media. Each tool forms a separate network, yet a single individual can be a member of several of them simultaneously. To accurately model the dynamics of node/agent states, it is necessary to account for the influence of multiple networks, which becomes possible when we describe the system using a multiplex network. Both the q-voter model and the q-Ising model have been analyzed on multiplex networks. Depending on the value of the parameter q, interesting changes in the nature of phase transitions have been observed. Here we focus on a case where dynamics follow the q-voter model on one layer and the q-Ising model on the other, and an agent changes its state only when both layers permit it (no hypocrisy assumption). This problem appears especially intriguing as in the q-Ising model, the control parameter is temperature, while in the q-voter model, it is the noise associated with individual independence. An interplay between noise and temperature was analyzed for a fixed value of q. In the special case, when q=1 (the lobby consists of agent), the system undergoes a continuous phase transition, and the critical value of noise is connected to the temperature by simple relation p=tanh(1/T). Surprisingly, for q=2, we identify a range of noise that prevents the system from reaching an ordered phase regardless of the value of temperature. For q=3, only continuous phase transition is observed, while for lobby sizes 4 and 5, a shift from discontinuous to continuous transitions takes place. Finally, for higher q, only discontinuous transitions are observed. Performed Monte Carlo simulations show perfect agreement with the analytical approach for the full graph case. Although the limiting behavior of the model is clear (it reduces to a single-layer q-Ising model for p=1 and to a q-voter when T goes to infinity), our results point to possible translation between temperature and noise in opinion dynamics models and show how one can bring such a coupled system to a specific state (ordered or disordered) through an interplay between p and T.

Keywords

Opinion dynamics, Multiplex network, Agent based model, Phase transition, Sociophysics

Current status of the research is: Work-in-progress

Potential collaboration with Authors

I am open to collaboration