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Ising-based model of opinion formation in a complex network of interpersonal interactions

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Abstract

In our work the process of opinion formation in the human population, treated as a scale-free network, is modeled and investigated numerically. The individuals (nodes of the network) are characterized by their authorities, which influence the interpersonal interactions in the population. Hierarchical, two-level structures of interpersonal interactions and spatial localization of individuals are taken into account. The effect of the mass media, modeled as an external stimulation acting on the social network, on the process of opinion formation is investigated. It was found that in the time evolution of opinions of individuals critical phenomena occur. The first one is observed in the critical temperature of the system T_C and is connected with the situation in the community, which may be described by such quantifiers as the economic status of people, unemployment or crime wave. Another critical phenomenon is connected with the influence of mass media on the population. As results from our computations, under certain circumstances the mass media can provoke critical rebuilding of opinions in the population.

Keywords: Complex networks; Opinion formation; Ising model; Small world; Scale-free networks; Freezing by heating

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1. Introduction

The structure and the dynamics of complex networks have been extensively investigated in recent years [1–8]. It was found that many real-world networks, like the Internet [1], e-mail networks [2] and the web of human sexual contacts [3], have similar properties. They are called scale-free networks, because the probability that the number of k links connected to a node equals $P(k)\sim k^{-\gamma}$ [4]. Many authors have used this type of complex network to model a network of social contacts [8–12]. In particular, complex networks with a hierarchical structure corresponding to the real structure of human communities have been studied [7,13–15]. The most important properties of social networks are a small average shortest path between nodes (individuals) and a high value of the clustering coefficient [5,6], e.g. the probability that a friend of my friend is my friend in the community is high. These properties are typical for the structure of a social network and they have strong influence on the dynamical phenomena in the population e.g. the process of opinion formation.

For modeling of the process of opinion formation, in the case of two possible states (i.e., the positive or negative answer to a certain question), the Ising-based models are used by many authors [16–23]. In the human population the influence of one individual on others depends on their social status-authority. The individual who changes their opinion very often is not trustworthy. Hence, the authority may be connected to the probability of a change in opinion. The opinion of an individual is formed by their interpersonal interactions with other individuals which depends on the structure of the social network. Thus, the structure of a social network has an essential influence on the phenomenon of opinion formation.

In our work we investigate the process of opinion formation in the human population, treated as a scale-free network with nodes (individuals) of different degrees, taking into account their spatial localization and two-level hierarchical structure of interpersonal interactions (a similar model of network was used in Refs. [24,25]).

2. The model

In our model the population and its structure are described as follows: the population consists of $N = L \times L$ individuals S_{ij} with two permitted states meaning the opinion in a certain question: spin up ($S_{ij} = +1$) or spin down ($S_{ij} = -1$). Indices i,j in the two-dimensional lattice show the localization of an individual. To describe the social structure of a human population we take into account the location of each individual and the network of their interpersonal interactions. These interactions, i.e., connections and random contacts, have a hierarchical structure. The connections of each individual with k neighbors is the first level of interpersonal interactions (see Fig. 1a). All connections are symmetrical and have the same value. We have assumed that the network of the social connections is scale-free, i.e., the