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How the government's punishment and individual's sensitivity affect the rumor spreading in online social networks

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HIGHLIGHTS

- The impact of punishment of government and sensitivity of individuals on the rumor spreading are taken into account.
- Two types (SIS and SIR) of rumor spreading model are considered.
- The mean-field methods are used to calculate the spreading threshold.
- The rumor spreading process is performed in real world datasets.

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ABSTRACT

We explore the impact of punishment of governments and sensitivity of individuals on the rumor spreading in this paper. Considering the facts that some rumors that relate to the hot events could be disseminated repeatedly, however, some other rumors will never be disseminated after they have been popular for some time. Therefore, we investigate two types (SIS and SIR) of rumor spreading models in which the punishment of government and sensitivity of individuals are considered. Based on the mean-field method, we have calculated the spreading threshold of SIS and SIR model, respectively. Furthermore, we perform the rumor spreading process in the Facebook and POK social networks, and achieve that there is an excellent agreement between the theoretical and numerical results of spreading threshold. The results indicate that improving the punishment of government and increasing the sensitivity of individuals could control the spreading of rumor effectively.

1. Introduction

Rumor is an important form of human communication, its spreading can shape public opinion [1,2], and cause social panic and instability afterward [3]. Especially, with the increasing prevalence of online social network, such as the Facebook, LiveJournal, Twitter etc., which make the spreading of rumor faster and wider than ever before [4,5]. In recent years, various sorts of rumors sweep over China through online social network, and the Chinese government has taken actions to regulate Internet rumors, such as deleting the rumor texts, closing the websites, even detaining the core spreaders in accordance with the law [6]. It is not surprising that rumors are prevailing in an emergency, which is marked by period of uncertainty and anxiety about the possible damage to individuals. Numerous studies have looked at the negative impact of rumors on the society [7,8].

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The rumor spreading process in social networks is often compared with epidemic spreading process. There are a set of well-studied epidemic models that can be used to describe different disease spreading mechanisms [9–20]. The most famous ones are those named the SI, SIS and SIR models with S standing for susceptible, I for infectious and R for recovered individuals [21,22]. A simple translation from epidemic to rumor model vocabulary is in order here. A susceptible node is an agent who has not known the rumor, therefore it is called an "ignorant" [23]. An infected node can spread the rumor to its neighbors, thus it is regarded as a "spreader". The recovered nodes correspond to "stiflers" who have already known the rumor but will no longer spread it. Before the rumor starts to spread in the network, all nodes are ignorant. At the initial stage some nodes will become spreaders and disseminate the rumor until they become stiflers.

The classical models for the spread of a rumor within a population were introduced by Daley and Kendall [24] and Maki and Thompson [25]. Zhao et al. [26] modified a classical SIR rumor spreading model in the new media age and introduced an extra condition by noticing that ignorants will inevitably change their status once they are made aware of a rumor. Qian et al. [27] further developed the classic SIR model of rumor diffusion process by considering the phenomenon that individuals can obtain the rumor from different sources and investigated the independent spreaders involved SIR tumor model in complex networks. Xia et al. [28] proposed a modified SEIR model with hesitating mechanism by considering the attractiveness and fuzziness of the content of rumors. Other spreading models considered different types of individuals and an interaction mechanism based on the SIR model and mean-field method, including the SIHR model [29], SIRaRu model [30], SICR model [31] and 8-state-ICSAR model [32].

Rumor spreading influences how rational individuals assess risks and evaluate needs, especially, it affects authorities to make decisions in an emergency-affected environment. Conversely, authorities' response to emergency will induct public opinions as well. Zhang et al. [33] presented a model for describing the interplay between rumor spreading and emergency development. Huo et al. [7] constructed an interplay model for rumor spreading and authorities' actions in emergency situation based on utility theory and found that authorities' proactive actions can improve rumor management and yield positive social utility. Zhao et al. [34] explored the interplay mechanism among authorities' media, rumor spreading and the evolution of emergency. Besides, some researchers have taken serious consideration about the role of individual behaviors and different mechanisms in the spreading of rumors, such as the forgetting, remembering mechanism [6] and education rate [35]. However, the above literatures study influential factors on the process of rumor spreading either from the government perspective or from the individual role. In fact, authorities' decision and individuals' behavior are interacted and influenced each other. Therefore, we will study the double factors from the perspective of both government and individual.

In this paper, we perform the rumor spreading process in the Facebook and POK social networks (Facebook dataset contains the friend relations of New Orleans Facebook social network as well as the wall posts records of users during a period of nearly two years. POK dataset contains the entire sequence of messages sent by users in the POK community. The two datasets are obtained from Professor Hernan Makse' Lab [36]). From the role of government and individual, we investigate the impact of punishment of governments and sensitivity of individuals on the rumor spreading in online social network. The rest of this paper is organized as follows: In Section 2, we analyze the rumor spreading dynamics and calculate the rumor spreading threshold. Section 3 presents the conclusions.

2. Rumor spreading model with government's punishment and individual's sensitivity

Many methods could be used to control the rumor spreading [37], this section will investigate the impact of punishment of governments and sensitivity of individuals on the rumor spreading in online social networks. Considering the fact, although the SIS model can describe the rumors spreading dynamics about hot events in which individuals can spread them repeatedly, there also exist many rumors about cold events will never be disseminated after they have been popular for some time. For this class of rumor, the favorite approach to describe the spreading process is the SIR model. Thus, we explore both the SIS and SIR rumor spreading model in this section.

2.1. SIS rumor spreading model

We first study the SIS rumor spreading model, each individual can be in one of the two states: spreader (S, who are spreading the rumor) or ignorant (I, those are not aware of the rumor). The probability of an ignorant becomes spreader is as follows:

$$P_{I\to S} = 1 - [1 - (1 - \delta_t)(1 - \xi\gamma)\lambda]^n, \tag{1}$$

where $\gamma \in [0, 1]$ is the degree of punishment which relates to the government's attitude toward rumor, when $\gamma = 1$, that means all the spreaders will be punished. ξ is the sensitivity of individuals to the degree of punishment. λ is the spreading rate. n is the number of spreading neighbors of an ignorant. $\delta_t \in [0, 1]$ is the sensitivity of individual to the number of its neighbors who are punished by government at time t, the larger of the value of δ_t, the more sensitive and cautious of the individual. $\delta_t = 1$ implies that once individuals realize some of their neighbors spreaders are punished, they will never spread the rumor.

The sensitivity of individual to the number of its neighbors who are punished by government at time t could be described as follows:

$$\delta_t = \alpha\gamma n/k, \tag{2}$$

where $\alpha \in [0, 1]$ is the fixed sensitivity coefficient, k is the total number of its neighbors.