Rumor-telling activity in polarized opinion networks

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In the past, rumors have ignited revolutions, undermined the trust in political parties, or threatened the stability of human societies. With the constant development of online social networks, rumors propagation and fake-news dissemination are becoming ever potentially dangerous for harmonious living in a society of differing opinions. Rumors are frequently affected by whatever alignment the population has with relation to it.

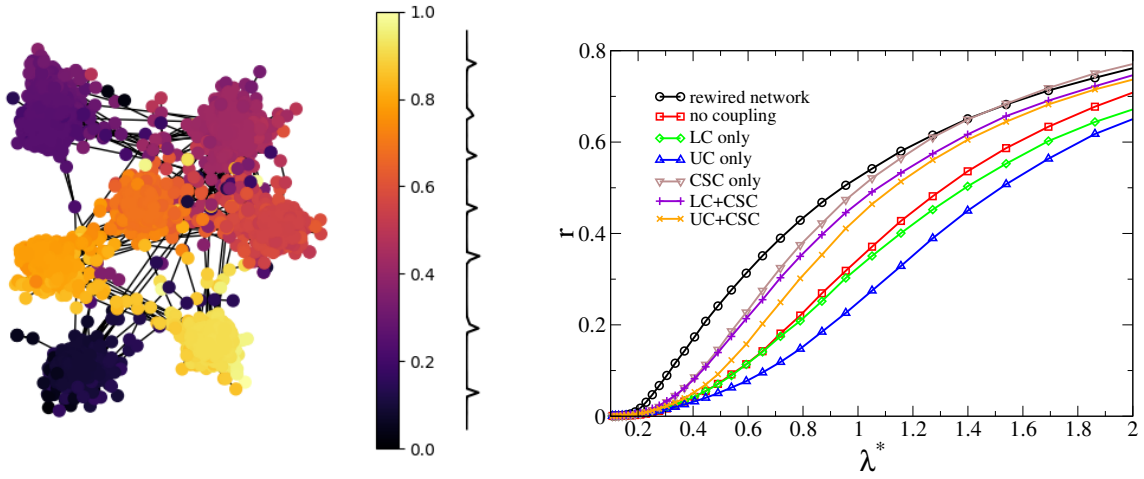
Several theoretical and empirical studies have been devoted to understanding rumor-spreading dynamics [2, 3]. Recent empirical works have observed that the structure of online communication networks frequently exhibits echo chambers, in which beliefs are reinforced due to repeated interactions with individuals sharing the same points of view [4, 5]. Moreover, these communities form a new topological structure of the communication network as weakly interconnected modules. So, besides the heterogeneous degree distribution, there is an additional level of heterogeneity associated with community sizes in modular networks.

We investigate rumor spreading models on complex networks generated by an adaptive opinion formation processes [6] that leads to loosely connected modular networks forming echo chambers (as shown in Fig. 1(a)). Here, rumors are coupled with the opinion of the interacting agents according to different rules that alter the individual's spreading rate λ_i and each link's stifling rate α_{ij}, leading to a modified rumor model. The model for the dynamics of spreaders (I), ignorants (S) and stiflers (R) can be summarized as follows:

$$I_i + S_j \xrightarrow{\lambda_i} I_i + I_j \qquad I_i + R_j \xrightarrow{\alpha_{ij}} R_i + R_j \qquad I_i + I_j \xrightarrow{\alpha_{ij}} R_i + I_j$$

A linear coupling (LC) between rumors and opinions was investigated, following from the assumption that if a rumor is ideologically aligned to an individual's opinion, he will be more prone to disseminate it. An unimodal coupling (UC) was also investigated, in which not only individuals aligned to the rumor are more likely to spread it, but also individuals of opposite alignment who spread the rumor as a criticism. In addition, a controversy-seeking coupling (CSC) where contrasting opinions hampers lost of interest on an issue was also proposed and investigated.

We show that the highly modular structure of opinion polarized networks strongly impairs rumor spreading. However, the introduction of couplings between agent's opinions and their spreading/stifling rates has a striking effect on rumor-telling. In Fig. 1(b), the final fraction of stiflers is shown for different combinations of couplings to compare the general rumor spreading capability as a function of the overall individual's average spreading rate λ^*. Indeed, depending on the nature of the couplings, information propagation can be either further inhibited or enhanced up to the level observed in unpolarized networks, thus suppressing the modularity bottleneck. Information percolation and permeability are also studied for the analysis of how rumors originating from an extreme alignment can affect those of opposite alignment. The time to reach the absorbing state and a variability analysis for the final density of stiflers were also studied for different combinations of couplings and compared to unpolarized networks, revealing that controversy-seeking behavior not only is capable of overcoming the bottleneck hurdles, but also drastically extends the rumor's lifespan.



(a) (b)

Figure 1: (a) Typical network obtained with the opinion formation model of Ref. [6]. Colors represent individual's opinions. The opinion distribution is presented besides the color bar; the latter indicate the opinion scale in range $[0, 1]$. (b) Final fraction of stiflers r as a function of λ^* for different types of opinion couplings. Rewired networks are used as a control case, the opinion distribution is kept but links are reshuffled while preserving the degree distribution in order to eliminate the network modular structure. Acronyms: LC - linear coupling; UC - unimodal coupling; CSC - controversy-seeking coupling.

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