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A topic evolution model with sentiment and selective attention

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HIGHLIGHTS

- Propose a hybrid dynamics model of opinion interaction and information diffusion.
- Effects of selective attention on diffusion and interaction are studied.
- Indirectly describe the appearance of isolated users.
- Constructive motivation goes against the propagation of topic.
- Constructive motivation can make more moderates and make extremists more extreme.

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ABSTRACT

Topic evolution is a hybrid dynamics of information propagation and opinion interaction. The dynamics of opinion interaction is inherently interwoven with the dynamics of information propagation in the network, owing to the bidirectional influences between interaction and diffusion. The degree of sentiment determines if the topic can continue to spread from this node, and the selective attention determines the information flow direction and communicatee selection. For this end, we put forward a sentiment-based mixed dynamics model with selective attention, and applied the Bayesian updating rules on it. Our model can indirectly describe the isolated users who seem isolated from a topic due to some reasons even everybody around them has heard about it. Numerical simulations show that, more insiders initially and fewer simultaneous spreaders can lessen the extremism. To promote the topic diffusion or restrain the prevailing of extremism, fewer agents with constructive motivation and more agents with no involving motivation are encouraged.

1. Introduction

During the last years, there is an interdisciplinary field of sociophysics where models inspired from physics are developed to describe a large spectrum of social phenomena and dynamics, including language dynamics [1,2], cultural dynamics [3,4], criminal activities [5,6], crowd behavior [7,8], information spreading [9,10] and opinion dynamics [11,12].

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Our actions and decisions are usually affected and shaped by our opinions and attitudes, whether in daily life or on the internet. Therefore, the study of how simple local interactions can lead to the global equilibrium state gradually developed into a relatively independent research field—opinion dynamics. However, opinion dynamics models always postulate that every agent has an idea about the topic, and ignore the process from unknowing to knowing about the topic, which is exactly the central question of information spreading. Especially in online social network, topic evolution is nonlinear combination of micro-process that every person experiences, from knowing about a topic to having a definite personal attitude on it. Hereby further attentions on the coevolution of opinion interaction and information spreading are deserved.

In recent years, opinion formation and evolution has attracted significant attention, and scientists more and more realized the importance of the spreading of opinions in social networks. Up to now, many researchers with different background have proposed various models to analyze the evolution of the opinions from various aspects. There are many classical models to describe opinion formation. Some models can describe scenarios when people must make a choice between two answers on a certain topic, e.g. Sznajd binary opinion formation model defines that just a pair of spins is associated with the decision making procedure [13,14], and Voter binary opinion model considers a set of interacting agents with the opinion alignment proceeding by a random choice of neighbors [15]. While some models explain the cases in which individuals opinion can vary smoothly from one extreme to the other, e.g. Deffuant model [16] and Hegselmann–Krause model [17,18]. Besides, there is another family of models, Continuous Opinions and Discrete Actions (CODA) model [19–22], where agents have the internal opinion or attitudes, which is expressed by a probability, and the external decision or action, which is a binary variable. To our knowledge, the CODA model is the first model where opinions are reinforced as a consequence of the dynamics, instead of requiring extreme opinions to be introduced in advance.

Information diffusion mimics the process of information spreading across the whole populations by defining simple differential-equation-based compartmental model. The research on information diffusion is inspired by epidemic dynamics, i.e. investigating how disease infects across populations. The paradigmatic models of epidemic dynamics include SusceptibleCInfected (SI) model [23], SusceptibleCInfectedCSusceptible (SIS) model [24,25], SusceptibleCInfectedCRefractory (SIR) model [26], et al. In the SI model, susceptible agents can be infected with a given probability by infected neighbors permanently to be new infectors, and the infected state is a stable absorbing state. It means that, all the agents would be infectors in the end of evolution. While in the SIS model, infected agents can recover and become susceptible again, and the disease is thus hard to infect all the population. The SIR model introduced refractory state, with which agents have immunity and cannot be infected again. Infected agents may become refractory with a refractory probability. The final absorbing states can be both infected and refractory state. Considering the similarity between infectious diseases and information diffusion, these epidemic spreading models are usually applied to analyze the propagation of opinions, news or rumors [27]. [28] demonstrated the feasibility of applying individual-based epidemic models to the spread of a research topic over the map of science, due to the better fit between two epidemic dynamics models and empirical data.

The prior efforts on the dynamics of information diffusion and on the dynamics of opinion evolution are both fruitful. However, topic evolution is nonlinear combination of micro-process that every person experiences, from having no idea about a topic, to knowing about it, to interacting with others, to having a definite personal attitude on it, in online social network. Considering that topic evolution is a mixed process of information propagation and opinion exchange, one limitation of the aforementioned efforts lies in that the two dynamics are studied separately. To address this, there is a need to study hybrid dynamics of information propagation and opinion exchange. Such hybrid dynamics, which combines the opinion exchange and information propagation, is a recent new research direction in the field of opinion dynamics. [29] proposed a three-state opinion model accompanied by information diffusion, in which agents form and exchange their opinions during information diffusion. [30] put forward a sentiment-based model with two propagation thresholds to describe the internet users microscopic behavior of determining whether to propagate an idea to interact with others according to degree of internal inclination.

The previous contributions on hybrid dynamics show a promising research direction. Especially, further attentions on the mixed dynamics of propagation and evolution are deserved, as the current researches are largely insufficient due to the inherent complexity of this subject of inquiry. Internet users exhibit complex online behaviors, for example, they have preferences on information or topics based on different individual feature biases in online social network, i.e. they always select some information or topics which they are interested in to read. We put our attention on the mixed dynamics of information propagation and opinion interaction from a socio-psychological perspective. Social psychology provides fundamental theories, i.e. Selective Attention, to study interactions among individuals in social contexts, for instance see Refs. [31,32]. Selective attention determines whether the spreading phenomenon and the opinion interaction happens, and thereby further affects the stability and convergence of the whole system. In this work, we analyze the role of selective attention, an important feature of individuals that influences a users spreading behavior and interacting behavior, by a sentiment-based model based on the CODA opinion updating rules.

The rest of this paper is structured as follows. Section 2 reviews CODA model briefly and presents a topic evolution model based on the CODA model, in which the dynamics of opinion interaction is inherently interwoven with the dynamics of information diffusion affected by selective attention. Section 3 represents numerical simulations and discussions about the model. Finally, concluding remarks are given in Section 4.