



Isolation, insertion, and reconstruction: Three strategies to intervene in rumor spread based on supernetwork model



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ABSTRACT

Online public opinion has become an important issue affecting national benefit and security. Based on system modeling and simulation, combining quantitative model methods and network topology analysis, this article establishes an Opinion SuperNetwork model to investigate different strategies of online public opinion intervention. We analyzed the effects of online opinion environments, opinion agents, psychologies, and viewpoints on the online public opinion formation and evolution. We further used these factors to investigate isolation, insertion, and reconstruction strategies. The results show that all the three intervention strategies produce good results, while insertion strategy is the best. And the mutual influence among superedges has the greatest impact on the result of intervention. Therefore, inserting positive superedges, meanwhile strengthening the mutual influence among superedges, is the optimal intervention strategy. This investigation will help quantify the research of online public opinion intervention, while provides a new method for rumor intervention.

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1. Introduction

Public opinion reflects people's beliefs, attitudes, views, and emotions on various social events [1]. It is a strong “soft power” that greatly impacts on the development of those social events. Successful public opinion intervention can benefit the country from economic, social, and political aspects. For example, during the Iraq war, the United States government implemented a number of public opinion interventions. By close monitoring and effective intervention, the government made the public opinion supportive for the war in the early stages, which ensured the progress of the war and reduced the pressure on the government from the people [2]. With the rapid development of information technology, individual viewpoints spread vastly and quickly through various online media. This also changes the formation and evolution mechanisms of online public opinion. Completely new intervention methods have been investigated.

Dynamic models have advantages in the research of traditional public opinion evolutions. Complex network models have advantages in investigating the new-fashioned Internet-based public opinions. Combination of the two has been proven an even better approach. This article also adapts this approach, but instead of combining single-layer network with dynamic models, we introduce the supernetwork model and combine it with dynamic models. Based on modeling and

simulation methods, we investigated different intervention methods quantitatively, and got desired outcomes.

The rest of this paper is organized as follows. Section 2 reviews the previous studies of opinion intervention, and discusses the advantages and disadvantages of them. In Section 3, we described the online public opinion by an Opinion SuperNetwork, and then built three intervention models based on this supernetwork. In Section 4, we picked the “Guo Meimei Event”, and applied the methods described in Section 3 to it. The results are presented in Section 5, and different intervention strategies are compared. Section 6 concludes, and suggests possible future research approaches.

2. Related work

Opinion dynamic models are the most commonly used tools in studying evolution and intervention of public opinion. Ising model is one of the earliest opinion dynamic models [3]. Spins present agents with different opinions in Ising model. Based on the Ising model, a number of classic public opinion evolution models start to emerge, that include voter model [4], Sznajd model [5], majority rule model [6–8], social impact theory [9], bounded confidence models [10–12], CODA model [13–16], and the gambling model [17,18]. These models simulate the process and final results of public opinion evolution. Detailed study of these models helps to understand the characteristics of public opinion evolution, and also shed light on the intervention of public opinion. Some scholars have adjusted various factors in the model of opinion formation, such as individual activity [19], personal authority [20], outside information impacts [21], and by doing so, successfully controlled the

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direction of the public opinion evolution and intervened in the public opinion model.

These models provide mathematical methods for studying public opinion evolution. But these models cannot provide fully interpretation on the complexities of the real public opinion network, in which the public opinions develop and evolve through the interactions among real people. In the recent years, with the rapid development of complex network theory, more and more complex network models are applied in the study of public opinion. Small-world network and scale-free network [22,23] are the most famous complex network models. A complex network model of public opinion provides us with the information of topologies and relationships among agents in public opinion network. Thus, the complex network theory has a growing role in the research of public opinion evolution and intervention [24–26].

However, single-layer network models cannot meet all the needs of studying the issue. The relationship between people is just one of the various driving forces of public opinion evolution. Therefore, we need to find out a more comprehensive way to study the online public opinion network. Thus, in 2012, supernetwork models came into the field. Supernetwork was first proposed by an American computer scientist, Peter Denning [27]. And it was applied in traffic network [28], supply chain (logistics) [29], ecological networks [30], knowledge networks [31,32], and etc. In 2012, we first applied the supernetwork model to public opinion research [33–36].

In this article, we built a four-layer Opinion SuperNetwork, based on which, the evolution of public opinion and three intervention strategies are studied.

3. Opinion intervention strategies

3.1. Opinion SuperNetwork

In the previous papers, the authors built a four-layer supernetwork model of public opinion. The four layers are agent, environment, psychology, and viewpoint. During the spread of opinion, agents are in certain opinion environment, and are influenced by the environment, which provides an external driving force. Psychological status of an agent is different from others', which is an internal driving force. Agents will publish their viewpoints under the influence of both internal and external driving forces [37]. According to this, we create a supernetwork model including Social Sub-Network, Environmental Sub-Network, Psychological Sub-Network, and Viewpoint Sub-Network, which is illustrated in Fig. 1.

In this model, Internet users and the replying relationships between them form the Social Sub-Network. Authorized information released by the government, opinion leaders, and mainstream presses forms the nodes of Environmental Sub-Network. The timing of release is also taken into account. Possible psychology status and the transformation relationships between them form the Psychological Sub-Network. On-line viewpoint keywords are nodes of Viewpoint Sub-Network. And if two keywords have appeared in one post, there will be an edge between them. The relationships between nodes of different sub-networks form the superedges of the Opinion SuperNetwork.

Nodes in each layer of the supernetwork can be classified as being positive or negative, whereas the negative nodes will benefit the spreading of the rumor, and vice versa. We can dig the reply network among netizens of the study case directly, and identify the main information during that time period by focusing on mainstream media. To identify the psychological status of a netizen (i.e. an Internet user) and its attribute of being positive or negative, we analyze the text of every post using ICTCLAS (Institute of Computing Technology, Chinese Lexical Analysis System), a specialized software that can split every sentence into words, and extract nouns, adjectives, and verbs. Then, HowNet software will further analyze the extracted words and classify them into 5 different psychological types according to Likert scale. Based on the same processing by ICTCLAS, we can also cluster the words which we

extracted before by barycentric clustering, and the cluster results are the main viewpoints [38].

Then, the superedges in the supernetwork can be divided into three types. The one that contains only positive nodes is a "positive superedge (SE^+)". The one with at least one negative node is a "negative superedge (SE^-)". If all nodes in the superedge are negative, it is classified as "pure negative superedges". In Fig. 1, color red represents a negative attribute. Color green represents a positive attribute. The solid red line in the figure represents a negative superedge, and the green solid line represents a positive superedge.

3.2. Intervention strategy-isolation model

According to the theory of two-step flow of communication [39], most people's opinions are influenced by "opinion leaders". Opinion leaders are influenced by the mass media. So ideas flow from mass media to opinion leaders, and then to a wide population. Opinion leaders play important roles of mediation or filtering in the process of communication and information spreading. Focusing on the "opinion leaders" is the idea of isolation strategy, i.e. removing opinion leaders will greatly change the spreading of information.

Isolating one negative superedge under certain rules will make changes of node attributes based on the changes of network structure, and further lead negative superedges in the supernetwork to change to positive ones. In Fig. 2, the solid lines represent the existing relationships between the elements. The superedge within the dashed box is the one under isolation. Dashed lines indicate the changed relationships between elements after isolation.

This article uses the ORA [40] to identify elite figures and key figures in supernetwork. A superedge containing elite figure is an elite superedge. A superedge with key figure is a key superedge. Accordingly, there will be three sub-strategies (expressed as S1-a, S1-b, and S1-c). S1-a: Isolating elite superedges; S1-b: isolating key superedges; and S1-c: isolating ordinary superedges. The implementation of these strategies in the Opinion SuperNetwork is carried out according to the following rules.

3.2.1. Rule 1. Evolution of Environmental Sub-Network

A negative environment is the one with spread of rumors, denoted by E^- . Environment of positive attribute refutes rumors, denoted by E^+ . After superedge isolations, superedge with agent A_i in it changes. It disconnects its connections of the isolated negative environment node, in turn connects to a positive node in Environmental Sub-Network. The new environment is E' . Its property depends on environment information E and its neighbors (other agents having reply relationships with it), namely,

$$E' = \frac{\sigma_E \times N + \sum \sigma_j \times 2}{N}. \quad (1)$$

$\sigma_E = +1$, it is the property of the new positive environmental information. A_j is the neighbor of agent A_i , and σ_j is his point of view. When the viewpoint is positive, $\sigma_j = +1$; otherwise $\sigma_j = -1$. $j = 1, 2, \dots, N$, and $j \neq i$. N is the total number of the neighbors of agent A_i .

3.2.2. Rule 2. Evolution of Psychological Sub-Network

Positive psychology, with which the agent is reluctant to believe the rumors, is denoted by P^+ . Negative psychology, with which the agent is willing to believe the rumors, is denoted by P^- , neutral psychology is P^0 .

Agent's psychology nodes connection changes with the environment changes. When the agent is exposed to a changed environment, no matter the change is caused by the change of the surrounding environment property in Environmental Sub-Network or by the change of the neighbors, we can calculate the new environment according to formula (1). And then calculate the psychology transition probabilities in this new environment. The probability

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