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Modeling and Simulation of Network Event Propagation Interference based on mSIR-CA

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Abstract: Network events are not completely independent in the communication process, and they will be affected by other events in the same communication process. In order to study the change of propagation law caused by the interference between network events, this paper first designs the interference framework of network event propagation according to the diffusion characteristics of network events and the view that different events in the same diffusion process will have an impact. In the framework, the mSIR-CA (multiple SIR-cellular automata) model is proposed by combining the cellular automata theory with the complex state transition rules which are improved based on SIR model and suitable for multiple event propagation, and the mSIR-CA model is used to simulate the event interference propagation under different conditions. The simulation results show that interference events can have a significant impact on the target event diffusion, and the whole process follows its inherent law, which can provide a new theoretical basis for the relevant departments to deal with public opinion and other application scenarios.

Keywords: internet public opinion, network event interference, cellular automata simulation, cellular state transition, propagation deduction

1. Introduction

The Internet has become an indispensable and essential way of obtaining information and exchanging information in the lives of our people. People express and disseminate various opinions and emotions through the Internet, the sum of the different views on specific popular events on the Internet is called network public opinion. Network public opinion is the cognitive, attitude, emotional, and behavioral tendencies of people who spread through the Internet due to the stimulation of various events [1]. Network public opinion is an expression carrier of public social opinion, but with the rapid development of the Internet and the characteristics of Internet information dissemination, the complexity of network public opinion and the speed of diffusion have far exceeded public social opinion. How to accurately capture the law of network public opinion dissemination and adopt countermeasures has strong practical significance, and it has become the research direction of many scholars.

With the development of modeling and emulation techniques, more and more researchers have begun to use modeling and simulation methods to study and analyze network public opinion events, for example, analysis of communication trends and laws [2], emotional changes in the process of communication [3], network public opinion of public health events [4] [5], topic evolution [6], and network rumor dissemination [7] etc. Moreover, Wang[8] introduced game theory in the public opinion propagation model and proposed a public opinion propagation model based on one-to-many games, Bolzern P[9] proposed the characteristics of group behavior in social networks with a dynamic view of stochastic multi-agent models, Yuhong Ma[10] established a rumor propagation model based on BA scaleless network to simulate and analyze the propagation laws of online rumors, Dezhi Wei[11] combined game theory with the SIMS model of infectious diseases to explore the laws of hot topic dissemination, Chen[12] used the SIRS model to study the polarization phenomenon of public opinion in the process of information diffusion, Lin [13] predicted online public opinion with IGWO-SVR, which has good stability and accuracy, Tao Qin[14] used the method of

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ranking learning to evaluate the evolution trend of network public opinion events, Ma Lin[15] focused on the evolution of public opinion under complex network structure, Haijun Cao[16] applied system dynamics theory to construct public opinion communication model. The above studies are all studying the properties of propagation laws of a single event itself, different methods which are adopted to deal with them in various stages of public opinion diffusion should be studied.

With the development of the research, we notice that there are many different events on the Internet at the same time, the proliferation of these events has a competitive relationship simultaneously, and few scholars have studied them systematically. In this paper, firstly, a model framework for network event propagation interference with platform versatility is designed by modeling simulation. Secondly, combining the cellular automata model with the complex multi-event propagation state transition rules based on the SIR model, the mSIR-CA model suitable for network event disturbance is proposed. Lastly, by simulating the propagation and diffusion of different events under different conditions in the same network, the feasibility and law of network event interference theory are verified, which can provide a specific theoretical basis for the response to the spread of public opinion.

2. Network Event Propagation Interference Model Framework Construction

In this paper, a network event propagation interference model is proposed and designed. The overall model framework is shown in Fig 1.

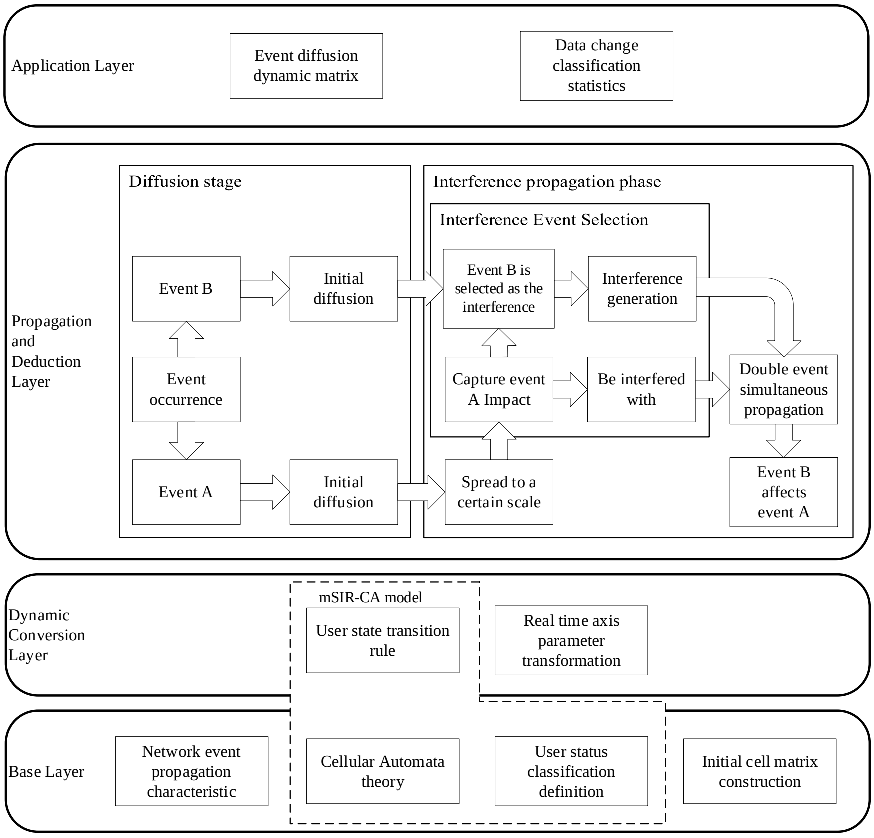


Fig. 1: Network event propagation interference model framework

The overall framework is divided into four layers from bottom to top: the base layer, the dynamic transformation layer, the propagation deduction layer, and the application layer. The basic layer comprises four parts: cellular automata theory, initial cellular matrix construction, user state classification definition, and network event propagation characteristics, which support the construction of the entire model as the basic theory. The dynamic conversion layer contains the conversion rules necessary for the operation of the model, which is divided into two sub-items: user state conversion rules and timeline parameter transformations. Driven by the basic layer theory and the dynamic conversion layer conversion rules, the propagation process of network events is deduced by two event lines. The event AB is two independent events that are not related to each other, which have a certain influence on the network after the diffusion stage. At the same time, event B and event A are selected for interference propagation to enter the interference stage, and at this time, the two events in the network from the original independent diffusion into interference diffusion influence each other, and ultimately achieve the purpose of influencing events through events. The application layer contains an improved dynamic matrix of event diffusion from cellular automata, which is used to visualize the full-cycle visualization of network event diffusion; a data module classifies records and counts the process data of the model through the timeline deduction.

The network event propagation interference model has the versatility of different platforms, such as news information service platforms, social network platforms, online culture platforms, and comprehensive communities. The model can adapt to the characteristics of the cyberspace of different platforms and can be applied to a single platform or multiple platforms to collaborate.

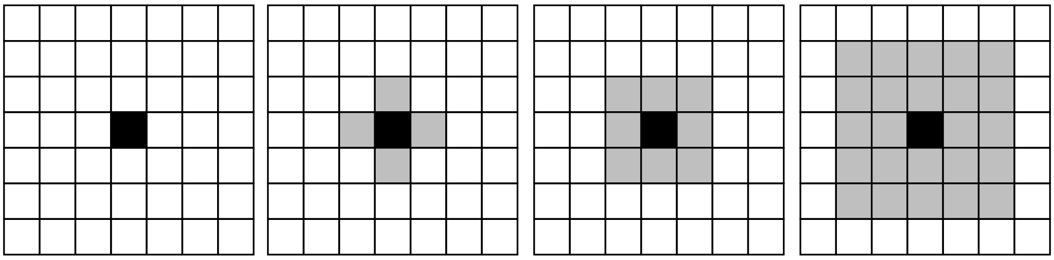
3. mSIR-CA Model

The mSIR-CA model is adopted in the simulation stage of this study. Based on the theory of cellular automata, this model improves the cellular automaton according to the propagation characteristics of network events. The specific improvement is to design m (multiple) SIR state transition rules that meet the requirements according to the network event disturbance propagation characteristics. Then it is applied to the cellular state transition in cellular automata to represent the multi-event propagation conditional network user states and transition rules, which constitute the mSIR CA model.

The mSIR-CA model combines the advantages of the SIR model in representing the state of network users with the parallel iterative operations of the cellular automaton to expand the model event capacity. In the simulation stage, by narrowing the iteration interval and subdividing the cellular matrix, the data recording and larger simulation scale than previous studies are realized to better explore the potential law of network event interference diffusion through data.

3.1. Initial Cellular Matrix Construction

The cellular space used in this study is a two-dimensional space cellular matrix A composed of rectangular cells, $A=\{C_{1,1},C_{1,2},......,C_{i,j}\}$. The A indicates that the cellular matrix is a two-dimensional finite element matrix, where i and j are abscissa and ordinate, and $C_{i,j}$ represents the cell on the corresponding coordinate. Because the cell state is affected by the state of adjacent cells, the cell neighborhood is usually divided into von Neumann type, Moore type, Extended Moore type. This is shown in Fig 2 (b), (c), (d).



(a) Cellular automata model (b) Von Neumann type neighborhood (c) Moore type neighborhood (d) Extended Moore type neighborhood

Fig. 2: Different cellular automata types

Due to the simple structure of the Von Neumann type neighborhood, the number of neighboring cells covered by the smallest number, the iteration process is too simple, which is not conducive to the diversity of the state transition of the cellular matrix in the iteration. The relationship between the extended Moore-type neighbor neighbors is complex, the cell relationship network is too extensive, and the sparse relationship between network users will amplify the influence between each other. This can result that the event spread speed is too fast in the iteration process, and the direction of the state conversion between the cells cannot be intuitively displayed. After comprehensive consideration, Moore type neighborhood is selected in the model. The state transformation formula of cell $C_{i,j}$ of coordinates (i, j) constructed according to Moore type neighborhood is as follows:

$$S_{i,j}^{t+1} = f(S_{i,j}^{t}, \sum_{m=i-1}^{i+1}(\sum_{n=j-1}^{j+1} S_{m,n}^{t}) \tag{1}$$

The m,n follow the Moore neighborhood coordinate range. In addition, considering that not all users in cyberspace are online and can receive event information, each user has its own online time slot. Different users are independent of each other and are not affected. And on the same platform, the proportion of online users at different points in time is different, leading to the need to consider the user online density problem when initializing the cellular matrix. Here we give parameters D_{to} to represent the initial time online user density and apply them to the initial cellular matrix construction. The randomly distributed cellular matrix used to generate a specific density represents the random distribution of platform users at the initial moment.

3.2. User State Classification Definitions

In a cellular automaton, different cells at the same time can exhibit a limited number $S_0, S_1, ..., S_n$ of different states, these states are independent of each other, and a single cell can only exhibit one state S_a at a single moment t. $S_{i,j}^{t} = S_a \; (S_a \in \{S_1, S_2, ..., S_n\})$, this formula means that a cell with i, j coordinates can only show a certain state S_a at a moment t.

When users browse network information, we can refer to the infectious disease SIR model of S susceptible, I infected, R immune, to construct three basic states for an event affected. Because the existing SIR models applied to the field of public opinion diffusion are for a single event, this paper considers multi-event interference, the necessary improvements to the model are required.

Considering that the two events are of the same type but produced independently, susceptible S can be affected by both event A and event B, so it is necessary to distinguish between users affected by different events, and once immune R is immune to one of these events, it will not be affected by a subsequent other event and stabilize in immune state R. Therefore, according to the application of the condition constraint, the cellular state has a transition order, and the order is irreversible, so the cellular state is divided into the current state S_{now}, post-order state S_{next}, the cellular will only be affected by the neighborhood cell from the current state S_{now} to the post-order state, but the conversion path is divergent. For example, after the cellular is disturbed by the event, it can choose to propagate or be immune to the event, and the two transition paths are mutually exclusive. The specific conversion rules are:

$$S_{i,j}^{t+1} = f(S_{i,j}^{t}, \sum_{m=i-1}^{i+1}(\sum_{n=j-1}^{j+1} S_{m,n}^{t}), P_{next}) \tag{2}$$

The f is determined by the current cellular state $S_{i,j}^{t} = S_a \; S_a \in \{S_0, S_1, ..., S_n\}$, the neighborhood cellular state $S_{m,n}^{t} = S_b$, m, n is determined by the coordinate range of the Moore neighborhood and the upper limit of random conversion probability P_{next}. The specific cellular state is defined as shown in the Fig 3.

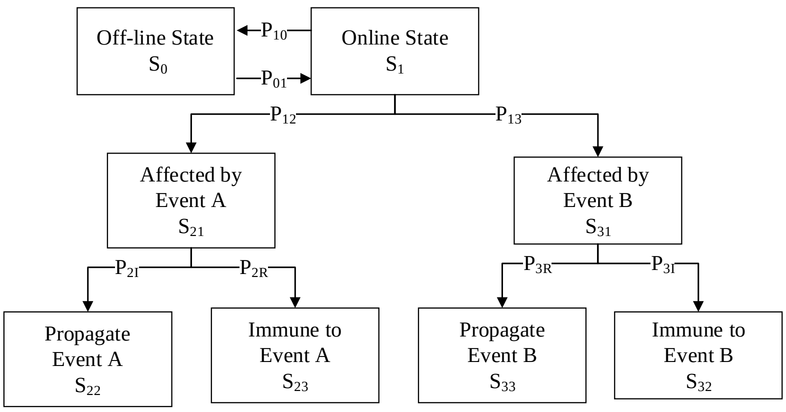
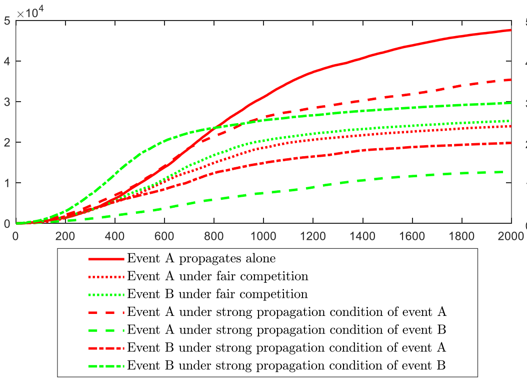


Fig.3: Cell state classification definition

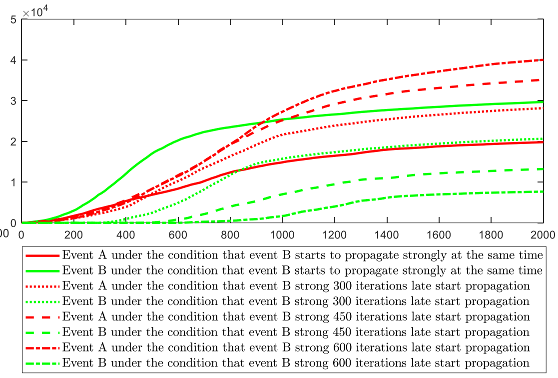
Among them, the offline user state S_0 means that the current state is not affected by the event information on the Internet. The user represented by the cell enters the online state S_1, becoming a vulnerable person in cyberspace, exposed to the public communication space of different events. When a user is exposed to the impact of an event, he will decide which event to focus on to enter state S_{21} or S_{31} through a probability-constrained selection process, and then enter a single event propagation branch. Receiving event information which is constrained by the probability decides propagate event information or immune event information, and enter the propagation event state S_{22}, S_{32} or the immune event information state S_{23}, S_{33} respectively.

4. Experiments

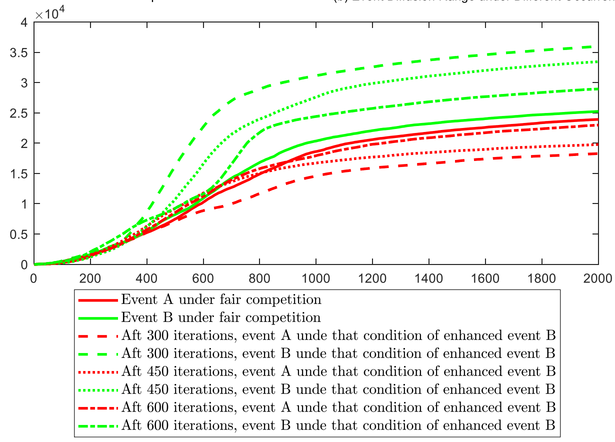
In this experiment, by adjusting the correlation conversion probability threshold in the model, the interference propagation of network events under different scenarios is deduced and compared from three angles. The cellular matrix is a two-dimensional square matrix with an initial online user density of $D_{to} = 0.70$ and the side length of 300 with online density; the coordinates and number of initial excitation points of the unified event are unified; the number of iterations of each group of experiments is 2000, A plots the event propagation range curve for the interference event for target event B. The result is shown in the following Fig 4.



(a) Event Diffusion Range Curves under Different Competition Condition



(b) Event Diffusion Range under Different Occurrence Time of Strong Interference Event



(c) Propagation Curve Under the Event of Midway Strengthening Interference

Fig. 4: Propagation range of model events under different conditions

Figure (a) shows the whole diffusion range curve of the simultaneous diffusion of the two events and the diffusion of the target event A exclusive space under different event intensities. It can be seen that compared with the propagation of target events alone, the existence of other events in cyberspace will have a competitive relationship with the target event, which will directly affect the scope of propagation of target event A. Figure (b) studies the effect of different occurrence moments of strong interference events on the target event. As shown in the figure, the later the occurrence of interference event B, the less the impact on the propagation range of target event A and the free propagation of interference events from the model, it has become difficult to significantly interfere with the extent of the proliferation of the target event. Figure (c) studies the strengthening of the propagation capacity during the propagation of the interference event. It can be seen that compared with the fair competition situation, the propagation intensity of event B is strengthened by changing the propagation parameters of the interference event B in the middle of the way, which can squeeze the propagation space of target event A to limit the propagation range of target event A from the side, and this restriction ability is weakened with the delay of the time point of intensification of event B.

With the help of mSIR-CA model, the propagation deduction of multiple events is carried out at the same time. From the above experimental results, it can be seen that the propagation interference between events will have a significant impact on the propagation trend and the overall diffusion range of events, which shows that it is feasible to interfere events through events, and the judgment of the interference effect can be realized according to the inherent law in the interference process.

5. Summary

This paper focuses on the interaction between different network events in the propagation process, and theoretically describes them with the help of the constructed network event interference model framework. After that, aiming at the defect of single event ability of existing models, combined with cellular automata and SIR epidemic model, the mSIR-CA model is proposed to make it have the ability to accommodate multiple events. This model is used to deduce and analyze the effects of network events on the existence of network events. Through experiments, this paper believes that the interaction between network events does exist and will significantly impact the propagation range of the target event. It provides a new theoretical basis for the relevant departments to deal with public opinion and other scenarios, and helps to better guide the network public opinion.

6. Acknowledgements

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