Research on the Application of Fluid Dynamics in Internet Rumor Dissemination

Yijie Wang a, *, Fengming Liu b

Business School Shandong Normal University Ji’nan, China.
* Corresponding author e-mail:yijie83492@163.com, liufm69@163.com

Abstract. The spread of network rumors has always been a research hotspot. How information flows in social networks is a question of interest to us. Based on the theory of fluid mechanics, the dissemination model is constructed, and the dissemination mechanism of network rumor is explored. Through numerical simulation, it is found that the flow of rumor information has a strong correlation with the subject of rumor dissemination and their relationship. The dissemination law of rumor information is revealed, which provides theoretical support for rumor control and governance.

1. Introduction

The most immediate and influential way for people to get information every day is through the interaction of interpersonal networks. As the carrier of information dissemination, network penetrates into all aspects of life. Rumor information spreads rapidly in the interpersonal network, and the flow of information flows along the network of relationships. The mild one influences people's behavior imperceptibly, and the severe one will bring people flood impact, affecting social stability and national security. Exploring the mechanism of information dissemination, visualizing the process of information flow, and timely predicting the path and development trend of rumor information dissemination can provide theoretical basis and technical support for rumor dissemination control and governance.

Domestic and foreign research on online rumors mainly focuses on qualitative and quantitative research. Qualitative research mainly investigates the spread of online rumors from sociology, psychology, communication and other disciplines, focusing on its classification, impact, communication characteristics, communication channels and government response mechanism. Quantitative research mainly includes differential equation modeling [1], crowd dynamics modeling [2-3], social network modeling [4], evolutionary game modeling [5], etc. Because of the similarity between the spread of rumors on the Internet and the spread of infectious diseases, early studies on rumor dissemination mainly drew on the research ideas of infectious disease model, revealed the dynamic behavior and steady-state mechanism of rumor dissemination from the macro level, and simulated the dynamic process of rumor dissemination in social networks through simulation experiments, revealed the general law and special mechanism of rumor dissemination, mainly including SI model, SIS model, SIR model [6], SEIR model [7], and SIHR, RSIRa [8-9], SCIR [10], PSEIR [11], etc.

Harold D. Lasswell, an American political scientist, put forward the information dissemination theory of "Mass Communication Model Theory" [12]. The theory holds that the mode of information dissemination includes five links: who, what to say, through what channels, to whom, and what effect has been achieved. In the process of rumor production and dissemination, "who" is the producer and disseminator of rumor, that is, the outflow point of rumor information. "What has been said" is the flow
of rumors and information. "Through what channel" mainly refers to the channel of dissemination, which is used to convey rumor information flow, that is, the path through which rumor information flows. "To whom" refers to the receiver of rumor information, that is, those who believe rumors and participate in the dissemination. "What effect has been achieved" refers to the impact of rumor information after its dissemination, which is manifested in the flow of rumor information flow, accompanied by more nodes being eroded, that is, the coverage of rumor flow to the network is increasing.

Based on the principle of fluid mechanics, the dissemination of rumor information in the network is analogized with the flow of fluid in the pipeline. The difference of information amount between nodes is represented by the fluid pressure in the fluid model. Users with high information amount are called "high pressure" users, i.e., the amount of information is represented by the pressure level. The spread of rumors in the network is compared to the flow of "rumor fluid" in the network. The main factor driving rumor flow is the difference of transmission pressure caused by the unequal amount of information among users, which is called the gradient of information measurement, and is expressed as the pressure difference between nodes. Therefore, the node pressure difference is the key factor to determine the flow state.

2. Model building

The initial state of the network is static, that is, the equilibrium state of the network. This equilibrium state has two manifestations: macroscopically, there is no rumor flow, that is, the network is stable as a whole; microscopically, it means that each user node has the same amount of information as its neighbors, and there is no flow trend. That is to say, the pressure difference between nodes $\Delta P = 0$, and the network is in equilibrium.

$P_0$ represents the pressure attached to rumor flow. When the rumor flow enters the first node of the network, the pressure of the node is $P_0$, and the propagation pressure is the highest. To simplify the calculation, we set $P_0=1$. As rumor flows from this node to other nodes, the initial node pressure decreases. For each outflow node, the pressure $P_{out}$ formula of the outflow node is as follows:

$$P_{out} = P_0 - \varphi v t$$

$P_{out}$ is the pressure of the outflow point of rumor; $\varphi$ is the intensity of rumor, to simplify the calculation, we set $\varphi = 1$.; $v$ is the flow velocity of information flow, and $t$ is the time taken for information flow to flow from one node to the neighbor node. The product of the $t$ and $v$ can be expressed as the reduced flow, that is, the flow pressure reduction.

The formula for calculating the pressure of the rumor inflow node is as follows:

$$P_{in} = P_0 + \varphi v t$$

The whole network time of rumor flow is $T$, and the unit time of each rumor flow is $t$. The relationship between them is as follows:

$$T = \sum t$$

The velocity of flow from each node to its immediate neighbor node can be considered to be the same, and this phenomenon manifests as the same pressure difference, thus forming an isobaric surface. The upstream rumor information received by the receiving point on the isobaric surface has the same impact force, which is reflected in the way of speed. Each node in the relational network is constantly scourd by the waterfall of the high-pressure node, and flows to the low-pressure node at the same time. In this model, pressure gradient is formed by different pressure difference. Under the influence of path width, the velocity of fluid is different, so the formula of velocity $v$ is as follows:

$$v = w I$$

$W$ stands for the intimacy of the relationship between nodes. When rumor flows between different nodes, the degree of connection between pipelines will inevitably affect the flow state. This degree of connection is considered to be the intimacy of the relationship between two nodes. The high degree of intimacy represents the high degree of friendship and interdependence between the two nodes, so information exchange is more timely. That is, information flows more easily between each other. The
pressure gradient of neighboring nodes is expressed by I in the velocity calculation formula. According to the calculation method of hydraulic gradient, the expression of I is as follows:

\[ I = \frac{\sqrt{\Delta p}}{D} = \frac{\sqrt{p_i - p_j}}{D} \]

Among them, the I node represents the outflow node of rumor flow, and the j node represents the inflow node of rumor flow. Δp is the pressure difference between the flow entry and exit points; D is the distance between the friends, because the flow unit is the adjacent nodes, so D is taken as 1.

3. Simulation analysis

In this paper, a network of 500 individuals is selected for simulation.

Nodes in the network are classified according to different isobaric surfaces. The flow of information between directly adjacent nodes of different levels is called a phase propagation. In the first stage, when the rumor information flows from the 0-level nodes at the starting point of the entire network to the 1-level nodes, the flow pressure at the starting point declines with the outflow of information. When the flow of information stops, it means that level 0 nodes and level 1 nodes hold the same amount of information with each other, and it means that they have the same knowledge of the same rumor information, thus losing the flow trend, and the information flow at this stage ends. Similarly, the propagation of rumor information from level 1 to level 2 nodes is stage 2, and from level 2 to level 3 nodes is stage 3, etc. In order to distinguish different stages, figure 1 shows the flow velocity of different stages with different colors.

![Figure 1. The trend diagram of propagation velocity](image)

In Fig. 1, first of all, it can be seen that there are five different color velocity markers, indicating that the rumor flow is divided into five stages: red, blue, green, purple and yellow represent the velocity of the first, second, third, fourth and fifth stages respectively. The velocity markers in the figure clearly indicate that the flow velocity of each stage is generally lower than that of the previous stage, that is, the farther the inflow node is from the level 0 node, the smaller the flow velocity will be. Because it is not a direct neighbor of a level-0 node, the farther it is from the level-0 starting point, the less it will be directly affected by it, and the less pressure it will exert on the propagation of rumor information, and the lower the propagation speed driven by it.

This characteristic shows that the information communication between people is influenced by the degree of intimacy in interpersonal relationship. With the degree of familiarity with each other changes, the speed at information dissemination is affected. Therefore, in the face of information, people should not only think about the information itself, but also calmly, objectively and earnestly verify the source of the information. Specifically, friends should be classified, and the information conveyed by friends with different degrees of intimacy should not be treated equally. For friends who are not close and do not know each other, they should be cautious to slow down or block the spread of rumor information, and at the same time, make the transmission speed v from the starting point lower.
Secondly, it can be seen from the graph that the speed difference is most evident in phase 1, 2. In the second stage, the speed is much lower than that in phase 1 generally. This is because the 0-level node is the "initiator" who deliberately and subjectively carries rumor information to the network, and its propagation force is extremely strong. Therefore, the velocity difference between the first stage and other stages is relatively large. That is, the pressure gradient is small, which leads to the decrease of flow velocity.

This characteristic shows that in order to control the spread of network rumors, attention should be paid to the reduction of rumor makers, the elimination of online rumors from their roots, and the strangulation of online rumors in the cradle, which requires citizens to improve their moral cultivation and become a rational and qualified person.

Finally, from the velocity diagram middle intensity can see, green and purple marking points, this shows that when the spread of rumors, explosive spread did not occur in the spread of the starting period, but in the middle and later periods of the transmission, it also shows the complexity of the interaction of human network, based on the idea of sharing information, people mouth, make the rumor spread of information explosion.

This feature indicates that even if the harmfulness and trust of online rumors are put aside, if the rumor information has been refuted, the information will be known to the public, but the destructive and critical nature of the information will be lost when it is spread. Next work, should pay attention to is that Internet rumors explosive before transmission, combining the government and related professionals, hurry up rumors, enables people to receive the information is not the rumors themselves, but the official has been revised, with professional interpretation of information, so as to avoid the dangers of Internet rumors, also can further enrich people's life common sense, reducing the social panic, maintaining social stability.

At the same time, it is necessary to further popularize the popular science knowledge to cope with rumor propagation, improve the public opinion monitoring system, and enhance the emergency response capacity. In this way, the discrimination of information can be improved, which will reduce the desire of propagation and further slowdown the propagation speed.

Repeated propagation is an innovation found in the study of Internet rumor propagation in this paper. At present, there is no research on the aspect of repeated propagation of rumors, which will be the research focus of this model in the next step.

It can be seen from the pro curve in figure 2 that how the scope of rumor information spread: at the same stage, there were relatively many ignorant people in the network at the beginning, so pro increases

![Figure 2. T-pro& T-alltime growth trend](image)

Figure 2 shows the growth trend of pro& alltime. FIG. 2 is the growth trend of pro&alltime. The precondition of pro counting is that the inflow node is ignorant, which is represented by the red curve. Based on the different meanings of the two expressions, it can be seen that the trend charts of the two are quite different, which proves that "mutual friends" in the interpersonal network is a factor that must be taken into account, and that mutual friends make the network closer to the actual network.

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rapidly. As time goes on, the number of ignorant people decreases sharply, the number of repeated transmission increases, and the speed of Pro increases slows down. In addition, the curve in the figure is segmented, because at the beginning of each stage, people are full of freshness for new information, and curiosity drives the rapid diffusion of information. As time goes on, the freshness decreases and the speed of information diffusion slows down, and the two curves tend to be flat to different degrees.

From this feature, we should advocate that people should treat their curiosity correctly, not become "puppets" of curiosity, become reckless and simple, but on the basis of reason, appropriate restraint to curiosity.

It can be seen that the red and blue curves have different growth rates, which indicates that the rumor information exists the phenomenon of repetitive propagation. With the increase of time, the two curves are farther and farther apart, indicating that the number of repetitive propagation increases with time. That is, in the initial stage, due to the unknown person many, the number of repeat propagation occurs rarely, so the initial stage of red and blue curves are basically identical. In the second half of the dissemination, there are more upstream friends with more rumor information. That is to say, some nodes have information inflow that accepts more than one node, which is the explosive propagation phenomenon seen in Figure 1 above. The explosive propagation in Figure 2 is also obvious. In the simulation, in order to make the propagation phase more complete, the preparatory stage of rumor propagation is added, that is, the 0-1 day, that is, the preparatory stage of rumor propagation before $T=1$. Starting from $T=1$, that is, the second day, Internet rumors enter into the relationship network and start to spread. From the graph, we can see that $T = 5$, that is, four days after the information source was released, the number of nodes aware of rumor information increased significantly, and the growth trend accelerated significantly, indicating that the social group's awareness of online rumor increased rapidly at this time. In order to make the mutual influence of various factors more visible, we present a three-dimensional diagram of the propagating infection ratio, time and velocity evolution, as shown in Figure 3.

From Figure 3, it is more obvious that with the increase of time, the propagation speed between nodes and the awareness of rumor information in the network change. As can be seen from the figure, for a 500-person network, it takes about half a month from the rumor spreading to everyone knowing the rumor information.

Through simulation, combined with Figure 2 and Figure 3, we can clearly see the change of the spreading speed of network rumors, and have a certain understanding of the trend of the rising awareness of rumors. The analysis and interpretation of the time, awareness and speed of the spread of network rumors is of great significance to the study and governance of the spread of network rumors, which points out the direction for our subsequent in-depth study of online rumor propagation and the blocking of online rumor, and provides strong theoretical support.

4. Conclusion
This paper elaborates the inherent consistency between hydrodynamics and the spread of network rumors in detail. Through in-depth analysis of relevant theories of hydrodynamics and exploration of relevant information dissemination literature, the diffusion law of network rumors in the network based
on hydrodynamics is found, and the model simulation is carried out by MATLAB. Finally, the simulation results are analyzed and the corresponding suggestions are put forward. Through simulation, we find that there are many factors to be considered in the process of studying the spread of online rumors, such as repetition, intimacy and trust, which will be explored in the next research work.

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