Microblog Public Opinion Dynamic Evolution with SIRL Model in the Background of Micro-era
Based on Multi-agent Modeling and Simulation

Xiaoting Yang and Baosheng Zhang(✉)

School of Management, Harbin Normal University, Harbin, China
155173428@163.com

Abstract. In the context of the micro-era, microblog public opinion has become a new field of network public opinion. Correctly grasping the trend of microblog public opinion is helpful for governance of public opinion. Based on the perspective of multi-agent modelling and simulation, this paper adopts an interdisciplinary research method to constructs a SIRL multi-agent microblog public opinion evolution model, and designs the interaction rules of four types of subjects among microblog ordinary users, government, network media and public opinion leaders. Finally, with the help of the Netlogo simulation platform, this paper describes the evolution process and laws of microblog public opinion through the analysis of whether the government is involved, the influence parameters of the media, the influence of public opinion leaders, and the changes in the parameters of attitude and tendencies.

Keywords: SIRL model · Microblog public opinion · Multi-agent modeling

1 Introduction

With the rapid development of information technology, the development of new media has entered the "micro era". People in the public opinion ecology in the micro era express their opinions and emotions through public opinion carriers, and participate in social construction. Therefore, the characteristics of public opinion in the micro era are accompanied by the "information cocoon effect" [1]. The "2020 microblog User Development Report" shows that microblog had 511 million monthly active users in September 2020, and the number of microblog users is huge, and the speed and influence of its spread makes any user possible to become a disseminator of information. Therefore, in order to reduce the negative impact of public opinion on society in a short period of time, the government has begun to further improve the public opinion scheme of information aggregation [2]. In terms of microblog public opinion research combined with infectious disease model, it studied the impact of changes in parameters such as infection rate on the spread of public opinion under the ubiquitous media environment system [3]. Based on the SEIR model, a topic propagation model was proposed with latent individuals that conforms to the microblog network environment [4]. The forwarding behaviour of

Z. Zhan et al. (Eds.): EIMSS 2022, AHCS 7, pp. 1051–1062, 2023.
https://doi.org/10.2991/978-94-6463-024-4_109

microblog users was simulated through simulation [5]. Kwon built a new network public opinion dissemination model based on factors such as users' psychological characteristics and behaviours [6]. Enatsu proposed an improved SIR public opinion dissemination model on microblog network [7]. Based on the existing research, this paper constructs an evolution model of SIRL multi-agent microblog public opinion in order to promote the modernization of the network public opinion governance system and governance capacity in the "micro era".

2 Model Building

2.1 Model Description

According to the traditional infectious disease model [8–10] and the idea of multi-agent system, it constructs a SIRL multi-agent model of microblog public opinion. When information about a hot public opinion event appears, the interaction among the four types of subjects in the model, including ordinary users, the government, network media and public opinion leaders. There are in five states of "Ignorant" (which does not disseminate microblog information but has possibility), "Spreader" (which disseminates microblog information and has the ability to spread), "Recuperator" (which become a restorer may no longer spread information, or may become a latent secondary spreader to spread information), "latent secondary communicator" (lurker for short. There is the possibility of secondary transmission) and Recovery (R_0, no longer spreading information). The model is constructed as shown in Fig. 1.

2.2 Model Assumptions

(a) It is assumed that the five states can be converted to each other according to certain rules. State I is infected into S with certain rules, state S is restored to R with certain rules, state R is derived into L with certain rules, and state L is restored to R_0 with certain rules.

(b) Assume that ordinary users have three attitude tendencies: positive, neutral and negative, and their initial attitude will change due to the attitudes of other agents; the

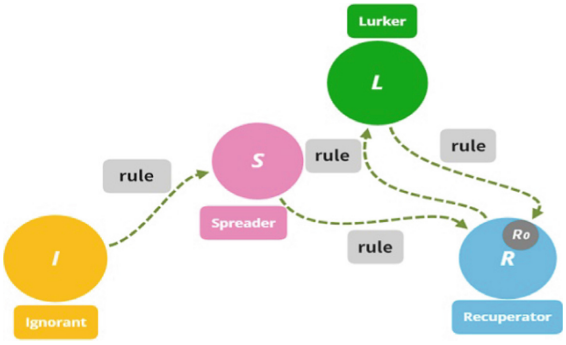

Fig. 1. SIRL multi-agent model of public opinion. Photo credit: Original

Table 1. Attributes of various agents

Agents	Microblog information	Ordinary users	Network media	Government	Public opinion leaders
Attributes	importance	state	State	state	state
	credibility	Attitude tendency	attitude tendency	transparency of information disclosure	attitude tendency
		conformity	Influence	Speed of information disclosure	influence

attitude tendencies of network media and public opinion leaders are both positive and negative, and their influence can be divided into two levels, namely A-level and 2A-level.

(c) It is assumed that the state of the four types of agents will change from the S to the R after the information is disseminated.

2.3 Description of Various Agents' Attributes

Based on the theory of complex adaptive systems and multi-agent modeling methods, and according to the existing research and the interaction of different agents in microblog public opinion. This paper designs the attributes and interaction rules of various agents. The attributes of the agents are listed in Table 1.

2.3.1 Attribute Description of Microblog Information

The attribute function of microblog information is $F[I_{ak}, C_{ak}]$. I_{a_k} and C_{a_k} represent the importance of microblog information to users and the credibility of microblog information, respectively. The closer the values of I_{a_k} and C_{a_k} are to 1, the higher the importance of the microblog information to the user and the stronger the persuasive force to the user, respectively.

2.3.2 Attribute Description of Ordinary Users

The attribute function of ordinary users is $F\left[S_{c_j}(t), A_{c_j}(t), B_{c_j}(t)\right]$, where $S_{c_j}(t)$ represents the state of ordinary users at time t, and its value range is $\{-2,-1,0,1,2\}$, corresponding to the five states of R_0, L, I, S and R respectively; $A_{c_j}(t)$ represents the user's attitude tendency on a microblog event at time t. If the values of $A_{c_j}(t)$ belong to the interval [0, 0.33], (0.33, 0.67], (0.67, 1], it corresponds to negative, neutral and positive attitudes; $B_{c_j}(t)$ represents the conformity of ordinary users at time t. If the values of $B_{c_j}(t)$ belong to the interval [0,0.2], (0.2,0.8], (0.8,1], corresponding to low, medium and high conformity of users respectively.

2.3.3 Attribute Description of Network Media

The attribute function of network media is $F[S_{e_g}(t), A_{e_g}(t), I_{e_g}(t)]$, where $S_{e_g}(t)$ represents the state of network media at time t, and its value range is {1, 2}, corresponding to the two states of S and R respectively; $A_{e_g}(t)$ represents the attitude tendency on a microblog event at time t. If $A_{e_g}(t) \in [0,0.5]$, it means a negative attitude. If $A_{e_g}(t) \in (0.5,1]$, it means a positive attitude; $I_{e_g}(t)$ represents the influence of network media at time t, and the closer the value is to 1, the greater the influence of the network media. If $I_{e_g}(t) \in [0,0.5]$, the influence is small and expressed as grade A. If $I_{e_g}(t) \in (0.5,1]$, the influence is large and expressed as grade 2A.

2.3.4 Attribute Description of Government

The attribute function of the government is $F[S_{h_i}(t), P_{h_i}(t), V_{h_i}]$, where $S_{h_i}(t)$ represents the state of the government at time t, and its value range is {1, 2}, corresponding to the two states of S and R respectively; $P_{h_i}(t)$ represents the transparency of the government's information disclosure at time t, and the closer the value is to 1, the more real and transparent the event is; V_{h_i} indicates the speed of the government's information disclosure, and the closer the value is to 1, the faster the government's information disclosure speed.

2.3.5 Attribute Description of the Public Opinion Leaders

The attribute function of the opinion leader is $F[S_{q_n}(t), A_{q_n}(t), I_{q_n}(t)]$, where $S_{q_n}(t)$ represents the state of the opinion leader at time t, and its value range is $\{-2,-1,0,1,2\}$, corresponding to the five states of R0, L, I, S and R respectively; $A_{q_n}(t)$ represents the attitude of opinion leaders towards a microblog event at time t. If $A_{q_n}(t) \in [0,0.5]$, it means a negative attitude. If $A_{q_n}(t) \in (0.5,1]$, it means a positive attitude; $I_{q_n}(t)$ represents the influence of the opinion leader at time t, and the closer the value is to 1, the greater the influence of the opinion leader. If $I_{q_n}(t) \in [0,0.5]$, the influence is small and expressed as grade A. If $I_{q_n}(t) \in (0.5,1]$, the influence is large and expressed as grade 2A.

$A_{c_j}(t)$, $B_{c_j}(t)$, I_{a_k}, C_{a_k}, $A_{e_g}(t)$, $I_{e_g}(t)$, $P_{h_i}(t)$, V_{h_i}, $A_{q_n}(t)$, and $I_{q_n}(t)$, and the above-mentioned values are randomly selected in the continuous interval [0,1].

3 Interaction Rules Between Agents

In this paper, the interaction rules between agents in the SIRL multi-agent model of microblog public opinion mainly include the interaction rules between ordinary users and ordinary users, network media, government, and public opinion leaders. Due to the numerous and detailed rules settings, only the interaction rules between ordinary users and ordinary users and opinion leaders are specifically shown here.

3.1 Interaction Rules Between Ordinary Users

(a) In the process of microblog public opinion dissemination, ordinary users will also influence each other. If the state of ordinary user c_j is I, the information dissemination of ordinary user y_j will affect the state of c_j. Assume that the influence function of ordinary

user y_j on c_j at time t is $f(y_j, c_j, t) = l_1 B_{c_j}(t) + l_2 I_{a_k} + l_3 C_{a_k}$, and the $B_{c_j}(t)$ represents the conformity of c_j at time t.

(b) The rule for changing the state of c_j from R to L is: $f(y_j, c_j, t)/\beta 1 = [l_1 B_{c_j}(t) + l_2 I_{a_k} + l_3 C_{a_k}]/\beta 1$, and the rule for changing the state of c_j from L to R_0 is: $f(y_j, c_j, ,t)/\theta = [l_1 B_{c_j}(t) + l_2 I_{a_k} + l_3 C_{a_k}]/\theta$.

3.2 Interaction Rules Between Ordinary Users and Opinion Leaders

The information or opinions published by public opinion leaders will affect the state and attitude of ordinary users. Therefore, this paper assumes interaction rules between ordinary users and opinion leaders based on the agenda "setting function theory" [11] and "secondary communication theory" [12].

(a) If the state of an ordinary user c_j is I, then the state influence function of the opinion leader y_n on c_j at time t is

$f(y_n, c_j, t) = o_1 B_{c_j}(t) + o_2 I_{a_k} + o_3 C_{a_k} + o_4 I_{q_n}(t)$.

$I_{q_n}(t)$ is the influence of opinion leaders at time t.

If $f(y_n, c_j, t) \in [0, \gamma]$, then let $S_{c_j}(t) = 2$ and the state of c_j changes from I to R.

If $f(y_n, c_j, t) \in (\gamma, 1]$, then let $S_{c_j}(t) = 1$ and the state of c_j is changed from I to S.

(b) Suppose the number of all users in microblog is N, and the function expression of the number of users influenced by opinion leaders is: $g(y_n, c_j, t) = N^* I_{q_n}(t)$

(c) The functional expression of the state of y_n is: $f(y_n, t) = o_5 \frac{N(t)}{N} + o_6 I_{a_k} + o_7 C_{a_k}$, where N(t) represents the number of microblog public opinion spreaders.

If $f(y_n, t) \in [0, \gamma 1]$, then let $S_{y_n}(t) = 2$ and the state of y_n is R.

If $f(y_n, t) \in (\gamma 1, 1]$, then let $S_{y_n}(t) = 1$ and the state of y_n is S.

(d) The rule for changing the state of y_n from R to L is: $f(y_n,t)/\beta 1 = [o_5 \frac{N(t)}{N} + o_6 I_{a_k} + o_7 C_{a_k}]/\beta 1$, and the rule for changing the state of y_n from L to R_0 is: $f(y_n,t)/\theta = [o_5 \frac{N(t)}{N} + o_6 I_{a_k} + o_7 C_{a_k}]/\theta$.

(e) The attitude tendency and influence of y_n will have an important influence on the attitude of users, mainly affecting ordinary users with a neutral attitude and high conformity. Here we discuss the influence of y_n's attitude on c_j.

When the conformity of c_j is high, that is, when $B_{c_j}(t) \in (0.8,1]$:

If $A_{c_j}(t) \in (0.33,0.67]$ and $A_{q_n}(t) \in (0.5,1]$, then $A_{c_j}(t+1) = A_{c_j}(t) + 0.33$.

If $A_{c_j}(t) \in (0.33,0.67]$ and $A_{q_n}(t) \in [0,0.5]$, then $A_{c_j}(t+1) = A_{c_j}(t) - 0.33$.

(f) The extreme attitude of users is determined by the influence of opinion leaders. Only the influence level of public opinion leaders is 2A can influence users with positive or negative attitudes. At time t, when y_n's influence $I_{q_n}(t)$ is at level 2A, that is, $I_{q_n}(t) \in (0.5,1]$:

If $A_{c_j}(t) \in (0.67,1]$ and $A_{q_n}(t) \in [0,0.5]$, then $A_{c_j}(t+1) = A_{c_j}(t) - 0.33$

If $A_{c_j}(t) \in [0, 0.33)$ and $A_{q_n}(t) \in (0.5,1]$, then $A_{c_j}(t+1) = A_{c_j}(t) + 0.33$

γ, $\gamma 1$, $\beta 1$ and θ, all of which are constants mentioned above, and their value range is [0,1], and their values can be dynamically adjusted according to the situation. o_1, o_2, o_3, o_4, o_5, o_6, o_7, l_1, l_2 and l_3 are all constants, and $o_1 + o_2 + o_3 + o_4 = 1$,

$o_5 + o_6 + o_7 = 1$, $l_1 + l_2 + l_3 = 1$, and their value can be dynamically adjusted according to the situation too.

(g) Due to the complexity and cyclicality of the interaction rules among the agents, only the interaction simulation algorithm process between ordinary users and opinion leaders is shown here.

4 Simulation Research Based on Multi-agent Modeling Method

4.1 Simulation Experiment Setup

It conducts simulation experiments based on the Netlogo platform. In the small world of the system, "human type" is used to represent ordinary users. The user attitude belongs to [0,1], and the "human type" user attitude * 2.5 times is displayed, that is, the larger the value of the user's attitude is, the larger the "human type" is. The "flag" means the public opinion leader. The "house" means the government. The "box" means the network media, and its size is also affected by the attitude like the "human type", that is, the larger the value of online media attitude is, the larger the "box" is. The main colors in the small world are orange, pink, blue, green, and gray, and the corresponding main states are I, S, R, L, and R_0.

The initial values for the model simulation are set as follows:

U-Num (the number of ordinary users in microblog) = 300, L-Num (the number of opinion leaders in microblog) = 6, M-Num (the number of media in microblog) = 4, G-Num (the numberof the government in microblog) = 1,β1(derivation rate) = 0.1,θ (immunity rate) = 0.2, C_{a_k} (reliability of microblog information) = 0.8, I_{a_k} (importance of microblog information) = 0.8, $B_{c_j}(t)$ (conformity of ordinary users with unknown public opinion) = 0.9, $I_{e_g}(t)$ (influence of media) = 0.4, $I_{q_n}(t)$ (influence of public opinion leaders) = 0.2, V_{h_i} (transparency of government information disclosure) = 0.6, $P_{h_i}(t)$ (speed of government information disclosure) = 0.6.

4.2 Analysis of Experimental Results

4.2.1 The Impact of Government Intervention on the Status of Ordinary Users

Considering the influence of government intervention and non-government intervention on the dynamic development of microblog public opinion evolution, it is assumed that the number of governments in microblog is 0, and other initial values remain unchanged. Figure 2 and Fig. 3 are plots of the number of users in different states when the government is not involved and when the government is involved, respectively.

When the government did not intervene, the spreader of microblog information continued to increase until they traversed the entire simulation world. After the government intervened, the number of ordinary users dropped sharply after the peak of information dissemination. Although the number of spreaders would increase during the process, and the overall trend was roundabout, and users affected by the government had fewer spreaders and more immunized people.

4.2.2 The Influence of Media Influence on the Status of Ordinary Users

In the simulation model, the effect of increasing the influence of the media from 0.4 to 0.8 on the ordinary user state is explored, and other initial values remain unchanged.

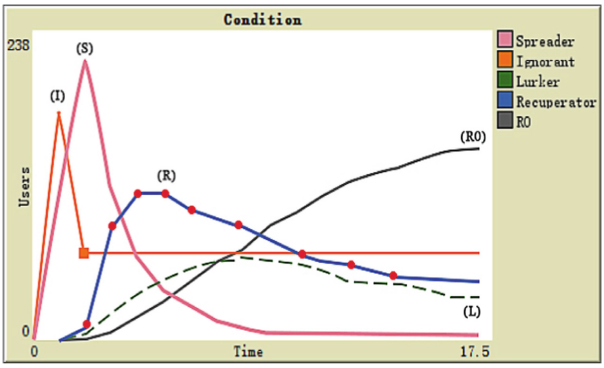

Fig. 2. The influence of government intervention on simulation results (a). Photo credit: Original

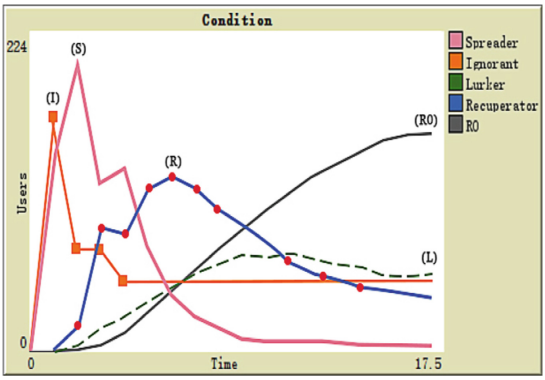

Fig. 3. The influence of media influence on the status of ordinary users (b). Photo credit: Original

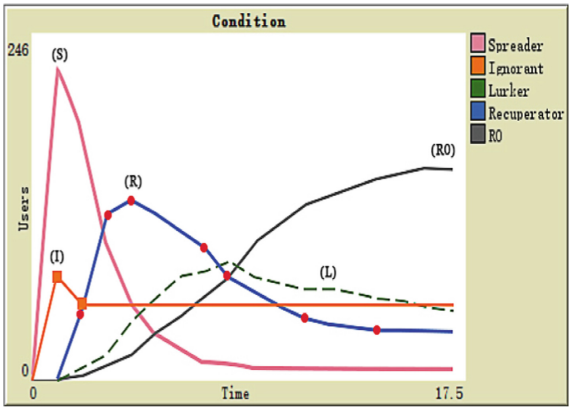

Fig. 4. The effect of increasing media influence on the status of ordinary users. Photo credit: Original

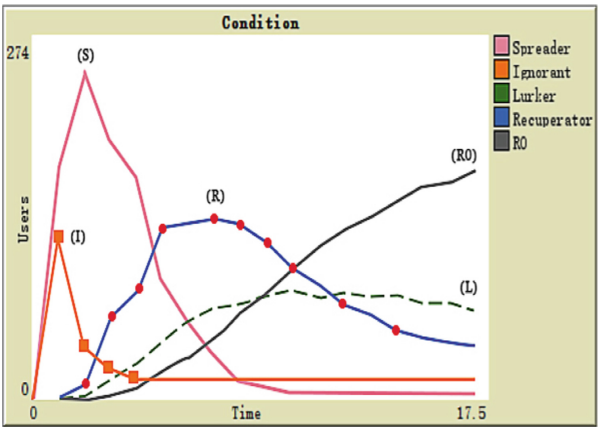

Fig. 5. The influence of increasing the influence of public opinion leaders on the status of ordinary users. Photo credit: Original

Figure 4 is a plot of the number of ordinary users in different states when $I_{e_g} = 0.8$. Compared with Fig. 3, the peak value of the ignorant decreases, and the number of ignorant is greatly reduced, and the number of spreaders increases during peak periods. Obviously, the higher the influence of the media, the greater the number of users who influence the dissemination of information. Therefore, the media with higher influence plays a higher role in the development of microblog public opinion, and they are more persuasive and influential. There are two public opinion peaks in the spreaders plot in Fig. 3, while there is only one peak period in Fig. 4 and the period is shorter than that in Fig. 3, indicating that media with greater influence can effectively control public opinion in the first-place upsurge.

4.2.3 The Influence of the Influence of Public Opinion Leaders on the Status of Ordinary Users

In the simulation model, the influence of public opinion leaders on the ordinary user's state is explored when the influence strength is increased from 0.2 to 0.4, and other initial values remain unchanged. The Fig. 5 is a plot of the number of ordinary users in different states when $I_{q_n}(17) = 0.4$. Compared with Fig. 3, the number of the ignorant at the peak period decreased, and the number of spreaders increased significantly, the number of lurkers increased, the immunized people increased. Obviously, in the spreaders plot in Fig. 5, the peak period of microblog public opinion declined faster than that in Fig. 4, and there was no return to the peak. In a short period of time, public opinion leaders can quickly cool down the soaring state of microblog public opinion, so that public opinion can be quickly controlled.

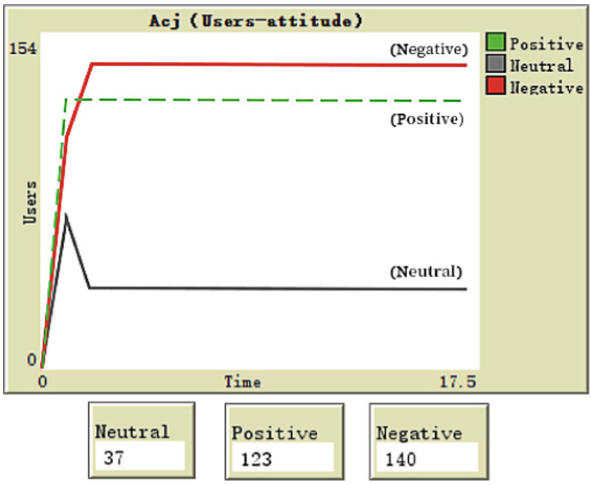

Fig. 6. The influence of different attitudes of opinion leaders on ordinary user attitudes (a). Photo credit: Original

4.2.4 The Influence of the Attitude of Public Opinion Leaders on the Attitude of Ordinary Users

In the simulation model, the values of A_{qn} are set to 0.4 and 0.8 in turn and other initial values remain unchanged to observe the influence of opinion leaders' attitudes on ordinary users' attitudes. Figure 6 and Fig. 7 are plot graphs of the number of attitudes held by users when A_{qn} is 0.4 and 0.8, respectively. It can be seen from the Fig. 6 that when the influence of public opinion leaders remains unchanged and their attitude changes from negative to positive, the number of users with negative attitudes decreases and the number of users with positive attitudes increases. It can be seen that if the power of public opinion leaders can be used to correctly guide ordinary users to express positive remarks at the first time, it is possible to effectively avoid the "butterfly effect" of negative public opinion.

4.2.5 The Influence of the Influence of Public Opinion Leaders on the Attitude of Ordinary Users

When the influence of the opinion leader is increased from 0.2 (level A) to 0.8 (level 2A), it is discussed that when the influence level of the opinion leader is high, and when the attitude of the opinion leader changes from negative to positive, and the attitude of the opinion leader will affect the ordinary users' attitude. Other initial values remain unchanged. Figure 8 and Fig. 9 are the simulation interfaces when $A_{qn} = 0.4$ and $A_{qn} = 0.8$, respectively. Clearly, the "human types" of the Fig. 9 is larger than that of the Fig. 8, and the number of large "human types" is more, indicating that the number of users with neutral and positive attitudes in Fig. 9 is greater. To sum up, when the influence level of opinion leaders is high, and their attitude changes from negative to positive, the number of users with a negative attitude is greatly reduced, and the number of users with a positive attitude is greatly increased, and the number of users with a neutral attitude is

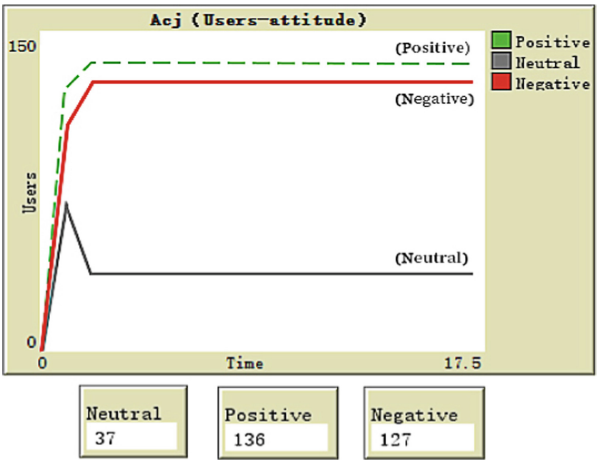

Fig. 7. The influence of different attitudes of opinion leaders on ordinary user attitudes (b). Photo credit: Original

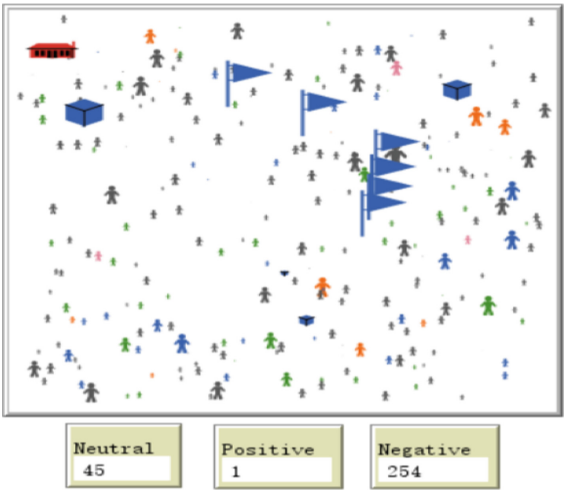

Fig. 8. The influence of the influence of public opinion leaders on the attitude of ordinary users (a). Photo credit: Original

greatly increased. It can be seen that even when the users' attitude is negative or positive, the change of the opinion leaders' attitude will affect the ordinary users' attitude from positive or negative to neutral.

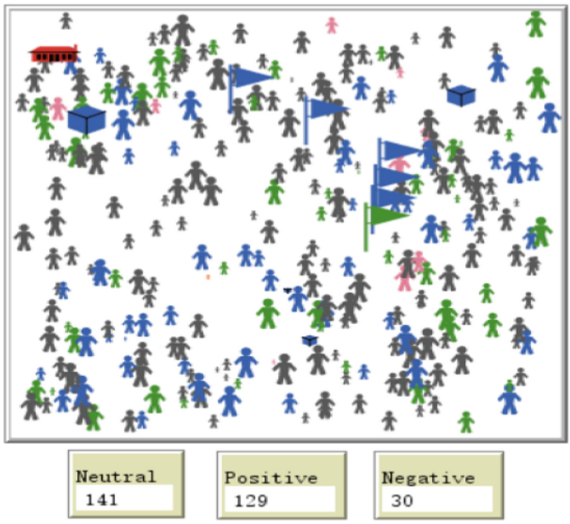

Fig. 9. The influence of the influence of public opinion leaders on the attitude of ordinary users. Photo credit: Original

5 Conclusion

This paper adopts an interdisciplinary research method, and based on the perspective of multi-agent modeling and simulation to construct a SIRL multi-agent model of microblog public opinion. Then it uses the Netlogo platform to conduct simulation analysis of microblog public opinion. This research found that: Firstly, the government intervenes immediately and the speed at which the government discloses information can stabilize the hearts of the people and reduce the upsurge of public opinion. Secondly, the media with higher influence plays a higher role in the development of public opinion. It is persuasive and authoritative. Thirdly, the opinions and attitudes of public opinion leaders have an important guiding role in the opinions and attitudes of ordinary users. Public opinion leaders with higher influence are more likely to influence the cognition, attitude and behavior of users.

Summary, the following suggestions and countermeasures can be given for the management of microblog public opinion: Firstly, in major microblog public opinion incidents, the government should grasp the importance of "first time", intervene in tracking public opinion events in a timely manner, and seize the "first place" of information and form the "first sound effect". Secondly, network media should give full play to the advantages of new media, strengthen cooperation with other media, and build a linkage mechanism of multiple media. Finally, the influential public opinion leaders should play their own role, become the guide of public opinion and the builder of the harmonious communication ecology, and create a clean and upright network environment.

Because in the microblog public opinion SIRL multi-agent model constructed in this paper, the relationship between the latent secondary spreaders and the immunized person has not been discussed in detail, and the model has not been verified based on actual case data, and follow-up research will discuss these issues.

Acknowledgments. This work was supported by National Natural Science Foundation of China (71702039), and Natural Science Foundation of Heilongjiang Province (LH2019G009).

References

1. Coomb WT, Holladay SJ (2005) An exploratory study of stakeholder emotions: affect and crises. Res Emot Organ 21(1):263–280
2. Jacob M, Hellstrom T (2000) Policy understanding of science, public trust and the BSE–CJD crisis. J Hazard Mater 78(1–3):303–317
3. Pennington-Gray L, Kaplanidou K, Schroeder A (2013) Drivers of social media use among African Americans in the event of a crisis. Nat Hazards 66(1):77–95
4. Koulouris A, Katerelos I, Tsekeris T (2013) Multi-equilibrium regulation agent-based model of opinion dynamics in social networks. Interdiscip Descr Complex Syst 11(1):51–70
5. Ryu J, Park J, Lee J, Yang S-B (2017) Community-based diffusion scheme using Markov chain and spectral clustering for mobile social networks. Wireless Netw 25(2):875–887. https://doi.org/10.1007/s11276-017-1599-6
6. Kwon KH, Bang C, Egnoto M et al (2016) Social media rumors as improvised public opinion: semantic network analyses of twitter discourses during Korean saber rattling 2013. Asian J Commun 26(3):201–222
7. Enatsu Y, Nakata Y, Muroya Y (2012) Lyapunov functional techniques for the global stability analysis of a delayed SIRS epidemic model. Nonlinear Anal Real World Appl 13(5):2120–2133
8. Kermack WO, McKendrick AG (1927) A contribution to the mathematical theory of epidemics. Proc R Soc London Ser A Contain Papers Math Phys Character (1905–1934) 115(772):1095–1934
9. Litou I, Boutsis I, Kalogeraki V (2017) Efficient techniques for time-constrained information dissemination using location-based social networks. Inf Syst 64(mar):321–349
10. Koehler DJ (2016) Can journalistic "false balance" distort public perception of consensus in expert opinion? J Exp Psychol Appl 22(1):24–38
11. Mc-Combs ME, Shaw DL (1972) The agenda-setting function of mass media. Public Opinion Q 36(2):176–187
12. Lazarsfeld PF, Berelson B, Gaudet H (1948) The people's choice: how the voter makes up his mind in a presidential campaign. In Columbia University Press (Eds), New York, pp 244–281