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Opinion Dynamics Based on Two Different Kinds of Relations in Social Networks

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Abstract: We study the opinion dynamic by constructing social networks where two kinds of social relations exist at the same time. Use ER networks and BA networks to build strong relations networks and activity-driven networks to build weak relational networks. And explore the impact of different factors on the opinion dynamic. Simulation shows that the greater centralizing speed, the smaller social interaction intensity and interaction strength between individuals are easier to form a unified opinion.
Keywords: Opinion dynamic; Different relations; Social interaction intensity

1 Introduction

Opinions widely exist in our lives, such as public opinion, rumors spread, customer satisfaction and so on contain the spread and evolution of opinions [1, 2]. Opinion dynamic refers to the individual in the initial setting of a given opinion value, according to the opinion interaction rules, so as to form a point of opinion eventually stabilized process. It is the process of opinion changing from chaos to order [3]. The emergence of social media accelerates this process and provides convenient conditions for the interaction of opinions.

The dynamics of opinions have always been a hot topic for sociologists and physicists. The reason is that even simple opinion models can be used to observe opinion changes in complex networks. People usually divide the model of research opinion dynamics into discrete types and continuity, and the common discrete type includes the Ising model [4], Sznajd model [5]. Continuum opinion dynamic model commonly including DW model [6] and HK model [7]. However, the existing models are basically from a static perspective, thinking that the network will not change once it is formed, which is different from the real situation. Therefore, some studies have carried out new research on the evolution of opinions from the perspective of time-varying. In fact, in our daily life, the relationship with the people around us is changing. In order to better reflect this situation, we introduce the time-varying network established by the activity-driven network into the dynamic model of opinion evolution. And, some relationships are temporary, such as the relationship with some not often contact friends, which we call weak links, and some have been keeping in touch with the family, which we call strong links [8]. So we use social networks with strong and weak relationships to study opinion dynamic. And in order to better reflect the characteristics of weak relations, we also apply the concept of reciprocal edge. Because in real life, edges generated by weak relationships may not be bidirectional, that is, information can only be passed from one side to the other, and cannot propagate in the opposite direction. Such as, we listened to reports at academic meetings and did not participated in question interaction, which is a one-way weak connection.

The structure of this paper is arranged in the following order: Section 2 is the construction of the network and the dynamic modeling of opinions; Section 3 shows the structure of numerical simulation, and Section 4 gives the conclusion.

2 Construction of the network and the dynamic modeling of opinions

In the social network, we divide the relationship into strong relations and weak relations according to the close degree of relations. The network formed by strong relations is called strong relations network, and the network formed by weak relations is called weak relations network. Individual social relations are networks composed of strong and weak relations. In the research process, we use fixed networks to represent strong relation networks, such as BA scale-free

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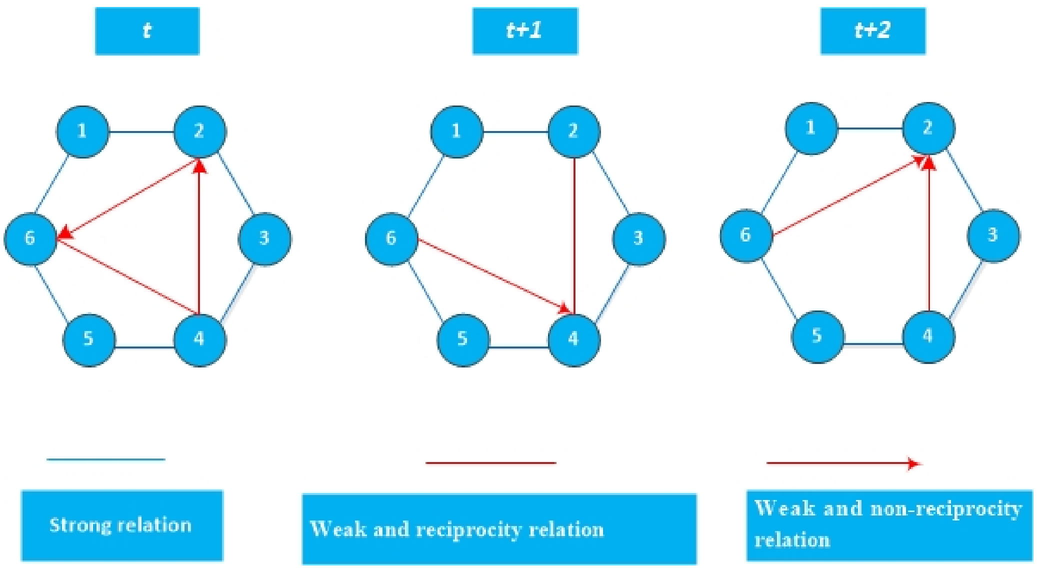

Figure 1: As shown, the change of connection between six nodes in three time steps. The strong relationship does not change with time, and the weak relationship changes with time. As shown in the figure, weak relations are further divided into unidirectional and bidirectional.

networks, small-world networks and ER random networks. The weak relations network is represented by the activity-driven network with time-varying characteristics. The weak relations network will be reset after the end of each time step. The integrated network composed of these two networks is the social network of individual existence. Then for a network consisting of N individual, the strong relations network is denoted as $G_1 = \left(g_{ij}^1\right)_{N\times N}$, the weak relational network is denoted as$G_2\left(t\right) = \left(g_{ij}^2(t)\right)_{N\times N}$, and the comprehensive network is denoted as $G\left(t\right) = \left(g_{ij}\left(t\right)\right)_{N\times N} = G_1|G_2\left(t\right) = (g_{ij}^1|g_{ij}^2(t))_{N\times N}$. With our usual understanding, when discussing the degree of nodes, we generally only consider the strong relationship, that is, the degree formed by the edges that do not change in a short time, the following individual connectivity refers to that in a strong relational network, so the degree of nodes can still be expressed as $k_i = \sum_{j=1}^{N} g_{ij}^1$.

In general, the interaction of opinion is bidirectional, but there is also one-way social relation. Especially in the weak relations, that means, individual i can affect the opinion of individual j, but the opinion of individual j is not affected by i , such as one-way attention relation in the micro blog. The strong relation network is used G_1 to represent, and the weak relation network is used $G_2(t)$ to represent, and as shown in Fig.1, all strong relations are bidirectional, that is, both ends of one edge can influence each other. However, in the network composed of weak relations, we set a certain proportion of edges as bidirectional edges, which can influence each other. Some are unidirectional edges, the influence between individual connected by one-way edges is unilateral. The activity rate of individual i is $a_i \in [\xi, 1]$ which obeys the distribution f $(\mathrm{a}) \sim \mathrm{a}^{-\gamma}$. The forming process of weak relational networks is as follows:

1. In the time step t, the probability that individual i has a_i becomes an active individual, and then generates m new edges connect with others, and the probability that node j is connected by node i is

$$P_{ij} = \frac{w_{ij}^{\theta}}{\sum_{i=1}^{N} w_{ij}^{\theta}} \tag{1}$$

   Where w_{ij} represents the influence weight between individual i and individual j, and parameter θ is used to control the attenuation degree of individual connection difference. When $\theta > 0$, the two individuals with greater influence weight tend to be linked. When $\theta < 0$, the more likely the two individuals with smaller the weight are connected. When $\theta = 0$, the active individual randomly selects other individual connections. In addition, the probability that the generated edges are reciprocity edge is r.

2. At the beginning of the time step $t + 1$, all weak relations are discarded and the $step1$ is repeated. Individual opinion set $x = \{x_i : x_i \in R; i = 1, 2, \cdots, N\}$,the $\delta\left(x_i\right)$ of x_i denotes the attitude of an individual. So the set of individual opinion is:

Opinion set=$\{Positive\ opinion : \delta(x_i) = 1, Negative\ opinion : \delta(x_i) = -1, Neutral\ opinion : \delta(x_i) = 0\}$. And the value of $|x_i|$ represents the extreme degree of individual opinion. The opinion x_i of individual i varies with time as following:

$$x_i(t+1) = x_i(t) - \alpha x_i(t) + \mu \sum_j g_{ji}(t) tanh(\beta x_j(t)) \quad (2)$$

Where$\alpha \in [0,1]$ denotes the speed at which the opinion of i approaches neutrally without receiving any external message. Parameter μ denotes the strength of social interaction. The parameter β is used to control the influence strength of opinion j on the i. If there is a connection between node i and node j at time t, then $g_{ij}(t) = 1$, otherwise $g_{ij}(t) = 0$.Based on the actual influence relationship between individuals, we study the influence weight between individuals and the dynamics of individual opinions in the following $w_{ij} = k_i k_j$. We calculate the weight based on the gravity model, and the weight between two individuals is the product of two individual degrees.

3 Numerical simulation

3.1 Opinion dynamic in different strong relations networks

The activity rate of individual i is $a_i \in [\xi, 1]$ which obeys the distribution $\mathrm{f}(\mathrm{a}) \sim \mathrm{a}^{-\gamma}$. We use the heavy-tailed distribution in the simulation process, and $f(a) \sim a^{-\gamma}$, let $\gamma = 2.1, \alpha \in [\xi, 1], \xi = 0.01$. In the network, the total number of nodes N is set to 1000. Two different kinds of strong relations structures are discussed in the simulation: (i) BA scare-free network ; (ii) ER random network. The degree of BA network is subject to distribution$P(k) \sim k^{-\gamma_1}, \gamma_1 = 2.1$.

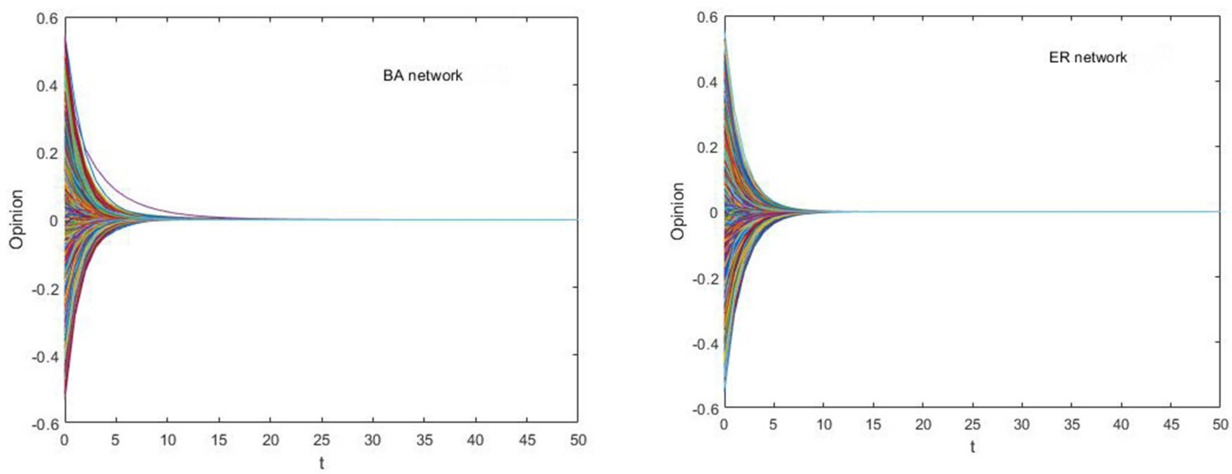

Figure 2: What is shown in the above graph is the result of the opinion dynamic in the BA network and ER network when the influence weight takes $w_{ij} = k_i k_j$. And the main parameters are as follows: $\alpha = 0.5$, $\mu = 0.1$,$\beta = 0.2, r = 0.5$

As Fig.2 shows, the network structure has a significant impact on the time required for the formation of a unified opinion. ER network has a shorter time to form a unified opinion.

3.2 Influence of centralizing speed on opinion dynamics

As Fig.3 shows, when an individual does not receive external information, the speed of approaching towards neutrality α is small, and there is no way to reach a consensus. When strong network is BA scale-free network, as α gradually increases, the time required for reaching a consensus. When α is about 0.35, the dynamic of individual opinion tends to be uniform. When a strong relations network is ER network, a consensus requires only a smaller α value.

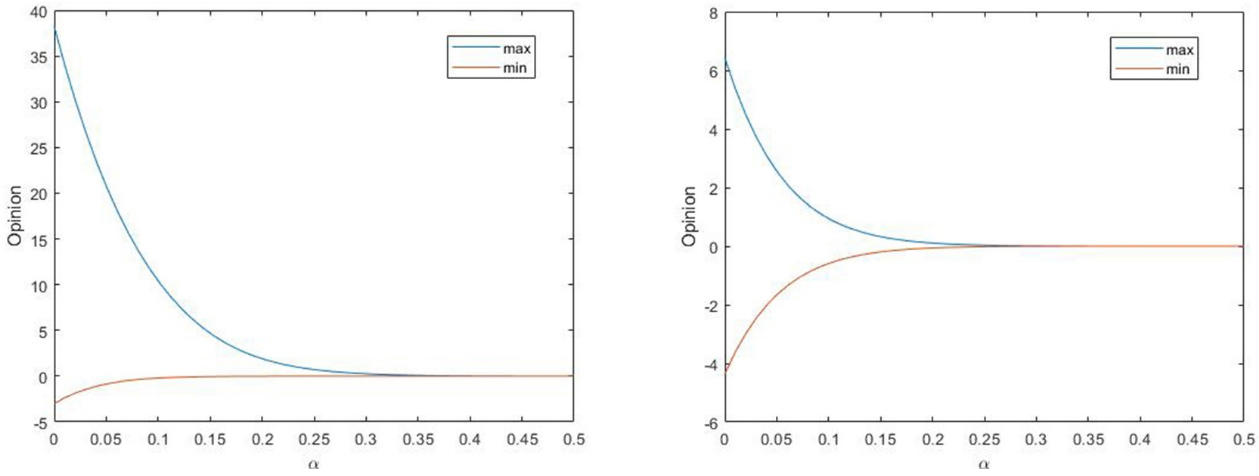

Figure 3: With the change of α, the maximum and minimum value of opinions were shown in the network. Two graphs have considered the strong network structure is BA network and ER network. And the main parameters are as follows :$\mu = 0.1, \beta = 0.2, r = 0.5$.

3.3 The Influence of different social interaction intensity on the opinion dynamic

From Fig.4, we can know social interaction intensity has a very important impact on opinion evolution. Therefore, we also explore the impact of different social interaction intensity on opinion evolution. Different social interaction intensity μ has different impacts on the evolution of final opinions. When the degree of social interaction is very large, there is no way to form a unified opinion. It is worth noting that the smaller μ is more conducive to shortening the time for reaching a consensus, whether strong relation network is ER random network or BA network. This evolution results also confirms the phenomenon of group polarization in social networks. Group decision-making may make individuals more adventurous or conservative. A large number of studies have found that group decision making is easier to go to extreme than individual decision making, namely group polarization.

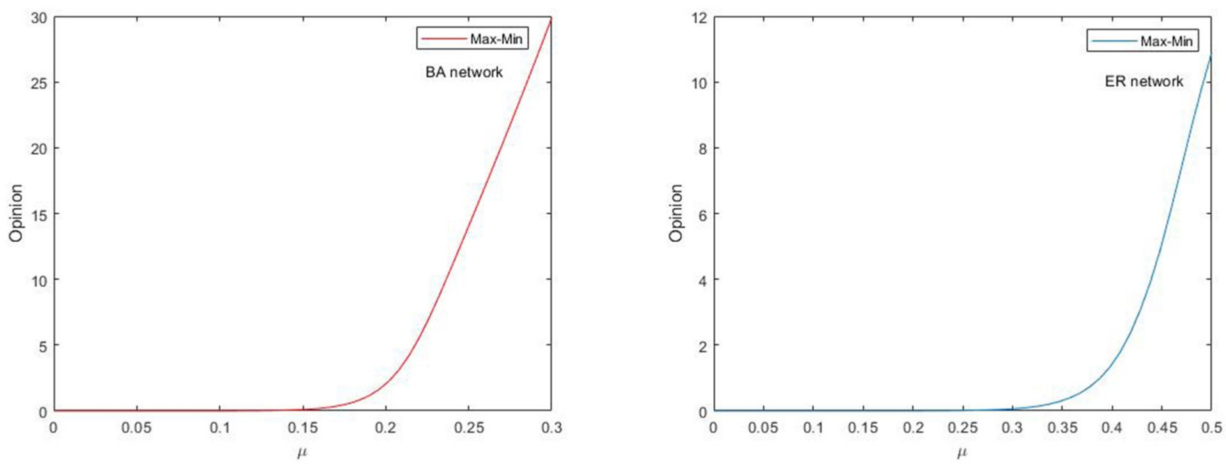

Figure 4: With the change of μ, the change of extreme differences in opinion value after evolution. Two graphs have considered the strong relations network structure is BA network and ER network. And the main parameters are as follows: $\alpha = 0.5, \beta = 0.2, r = 0.5$.

3.4 The Influence of interaction strength between individuals on opinion dynamic

Fig.5 shows the smaller the β value of mutual influence between individuals is, the easier it is to reach a consensus, and the larger β value will disperse opinions. And when we consider different the strong relations network structure, the results are different. It can be found that in the ER network, reaching a consensus requires a more stringent β value.

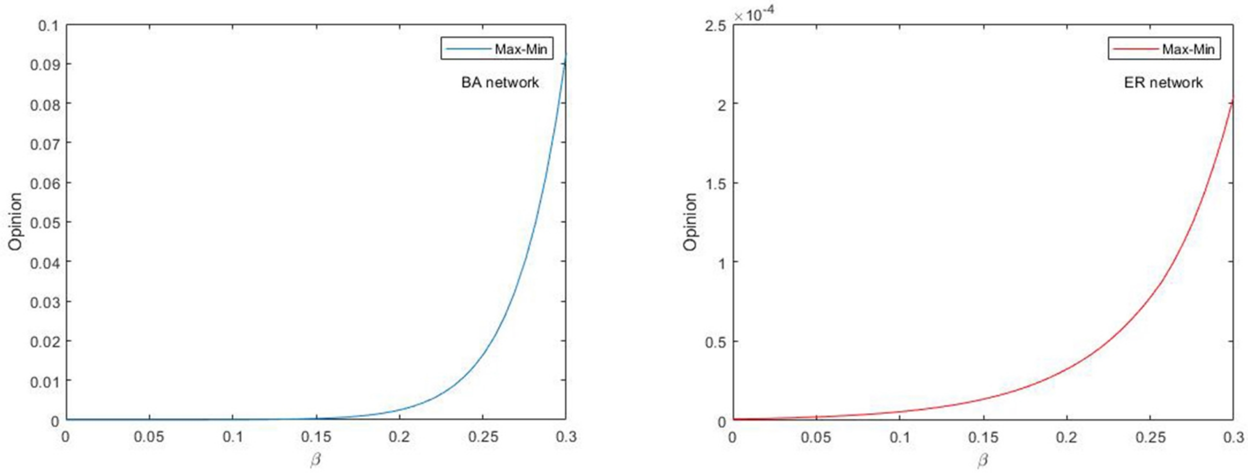

Figure 5: With the change of β, the change of extreme differences in opinion value after evolution. Two graphs have considered the strong relations network structure is BA network and ER network. And the main parameters are as follows: $\alpha = 0.5, \mu = 0.1, r = 0.5$.

4 Conclusion

We study opinion dynamic by applying two different social network relationships in social networks. The simulation shows that: a greater centralizing speed, the smaller social interaction intensity and interaction strength between individuals are easier to form a unified opinion. When a strong relations network is BA scale-free network, as α gradually increases, the time required for reaching a consensus. When a is about 0.35, the dynamic of individual opinion tends to be uniform. When a strong relations network is ER network, a consensus requires only a smaller αvalue. Different social interaction intensity has different impacts on the evolution of final opinions. When the degree of social interaction is very large, there is no way to form a unified opinion. It is worth noting that the smaller is more conducive to shortening the time for reaching a consensus, whether strong relation network is ER random network or BA network. The smaller the value of mutual influence between nodes is, the easier it is to reach a consensus.

Acknowledgments

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References

[1] Y. Luo. et al. Discrete Opinion Dynamics with Social Bots on Signed Network. 2020 39th Chinese Control Conference (CCC),6690–6694. IEEE. 2020.

[2] T. El-Diraby and A. Shalaby and T. Hosseini Linking social, semantic and sentiment analyses to support modeling transit customers satisfaction: Towards formal study of opinion dynamics. *Sustainable Cities and Society*, 49(2019):101578.

[3] Y. Hu and X. He. Public opinion formation model based on opinion entropy. *International Journal of Modern Physics C*, 24(2013)(11):1350080.

[4] E. W. Montroll and W.W . Badger, Introduction to quantitative aspects of social phenomena. Gordon and Breach 1974.

[5] K. Sznajd-Weron and J. Sznajd, Opinion evolution in closed community *International Journal of Modern Physics C*, 11(2000)(06):1157–1165.

[6] G. Deffuant D. Neau and F. Amblard et al. Mixing beliefs among interacting agents. *Advances in Complex Systems*, 3(2000)(01n04):87–98.

[7] R. Hegselmann and U. Krause. Opinion dynamics and bounded confidence models, analysis, and simulation *Journal of artificial societies and social simulation*, 5(2002)(3):2

[8] D. Han and J. Wei et al. Dynamical analysis of the SIS epidemic model in cluster events. *Applied Mathematical Modelling*, 99(2021)(3):147–154.