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Detection and Minimization of Rumor Influence in Social Networks

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Abstract- The development of social networks such as Twitter, Facebook, Sina weibo etc, online information sharing is becoming ubiquitous every day. Spreading information through social networks includes both positive and negative sides. Rumor propagation is a major problem in large scale social networks such as twitter, Chinese weibo. Propagating positive information may produce better result such as new ideas, innovations and recent research topics. On the other side propagating negative information may create chaos among the crowd. Malicious rumors could serious issue in society; hence it needs to be blocked after being detected. Most of the previous research focused on influence maximization. In contrast this work focuses on minimizing the propagation of malicious rumor by blocking of certain nodes. This paper includes the basics of rumor influence minimization and some methods to minimize the rumor influence.

Keywords: Greedy, dynamic blocking, Survival theory, User experience

I. INTRODUCTION

With the increasing development of large scale social networks like twitter, sina weibo, facebook etc., millions of people can share any kind of knowledge each other. People can share new ideas, innovations and hot topics. However spreading malicious information cause serious issue in society (for example, spreading rumor regarding earthquake which will cause chaos among crowd).So, it is important to identifying this kind of malicious rumors. Once the rumor detected it should be stopped as soon as possible and the negative influence to be reduced. Blocking certain subset of nodes will helps to reduce rumor propagation. Most of the work concentrated on maximizing the influence of positive information through social networks based on IC model (Independent cascade) [1]. On the other side, the negative influence minimization problem has less attention. So it needs consistent efforts on strategies for blocking malicious rumor users and minimizing the influence of those rumors. Rumor propagation is reduced by blocking the number of nodes or number of links in a social network [2]. This paper focuses various methods to dynamic rumor influence minimization.

II. SOCIAL NETWORK DEFINITION

A directed graph G=(V,E) consists set of users denoted by node V and the relationship between users represented by edges E. Fig1 shows the graph illustration of social network. The number of nodes in the graph denoted by |V|= N and the edges of node u to node denoted by $(u,v) \in E$. If the edge existence between u and v means $\alpha uv=1$ otherwise $\alpha uv=0$.

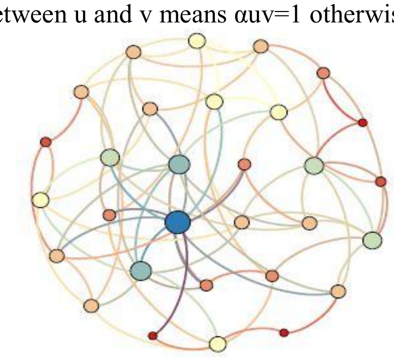

Fig.1 The graph denotes online Social networks. Different colors of nodes illustrate the different communities. The size of the node indicates the influence of the node in social network. More influence will make to rumor propagation.

The probability of rumor sending from user u to v is denoted by puv. Nodes in larger size have higher degree than nodes in smaller size. Nodes in larger size indicate that the node has more probability to propagate the rumor. Nodes with different colors represent the different community of nodes they belong to. The nodes size indicates the influence of the node. If the node size is bigger it indicates the more influential a node and more contributions it will make to rumor propagation.

III. Rumor Diffusion Model

Each node has one of the states while propagating the rumors Susceptible, Infected, Recovered. The node is susceptible means it has the potential to accept the rumor and propagate it. The already accepted the rumor means, the node is infected. Recovered means the node identified the rumor message and denying it.

Rumor diffusion mechanism is similar with that of epidemic propagation [3]. During the propagation of rumors, each node could have one of the following three states: Susceptible (S), Infected (I) and Recovered (R), which is known as the SIR model [4], [5]. The state of being susceptible represents the node has the potential to accept and spread the rumor at any time; Infected indicates the node has already accepted and spread the rumor; Recovered denotes the state of the node identifying the rumor and denying it. In this paper, we consider the rumor propagation as a progressive process, i.e., once a node is infected, it will stay infected and not recover, which is the SI model [6][7].

There are two classic diffusion models. One is Linear threshold (LT) in which the node is activated if the ratio of its activated parent node surpasses a certain predefined threshold $0 < \theta < 1$.The second one is Independent cascade(IC) model in which the propagation process takes discrete time steps. The IC model starts with set of activated nodes.

IV. Rumor Minimization

Rumor minimization tends to minimize the propagation effect of rumors in the social network [8]. Various influence diffusion model are used in rumor influence minimization problem. Introduce protectors to limit the bad influence of rumors against rumor cascade. Greedy algorithm is proposed to minimize the rumor by blocking links instead of nodes. Different minimization is defined by different definitions of network [10].

V. User Experience

In rumor blocking strategies either nodes or links are blocked to prevent further rumor propagation [9]. Generally the user blocked longer time the user has less satisfactory on the social network. It leads the user to quit from the network or they may lodge compliant against the network. Find the user’s tolerance over the duration of interaction with a site by analyze the user perceived quality. Measure the customer satisfaction using utility. Apply utility function to measure user experience in rumor blocking.

Consider all the nodes have the same blocked time i.e same tolerance threshold value T. So, the user experience utility function defined as

$$U_b = \frac{1}{N}\sum_{u=1}^{N}\frac{T_{th} - T_b(u)}{T_{th}}$$

T_{th}-tolerance threshold

Tb(u)-blocked time of node u.

Objective Formulation

Minimize the rumor influence by minimizing the number of activated node in the propagation process under the constraint of user experience. The problem defined as,

$$\min E[\sum_{v\in V} S_v(t_{th})]$$

$$s.t \quad u_b \geq u_{th}$$

Here t_{th} represents the time instant when the user experience utility U_b just triggers the threshold T_{th}, and it determines the observation time window T.

VI. Proposed Solutions

Analyze the rumor influence problem from the perspective of survival theory and network inference problem and introduced greedy algorithm dynamic blocking algorithm based on node selection schemes [12].

A. Survival theory

Consider the rumor has spread for sometimes and it is identified at time t0 by the system. Assume N1 activated nodes are identified at time t0 and N2=N-N1 nodes are inactive (i.e N2 nodes are not affected by rumor at time t0). From time t0 N1 nodes are propagating the rumor through network. Minimizing the active nodes by Select K activated nodes and blocks them [11].Set of cascade triggered by N1 activated nodes at time t0 is C= (c1, c2,…., cN1) .This may extend to many cascades.

Survival function defined as S (t) = Pr (t < T)

Here T is an occurrence time of an event in specified time t. The survival function represents the probability that the event occurs after the deadline. We can calculate the target survives.

Then the distributive function F(t) = Pr (T < = t) = 1- S (t)

B Greedy Algorithm

When we detect the rumor at time t0, the affected K nodes are blocked immediately. So the number of activated nodes is reduced at time t1 is given by

$$f(t_1 \mid s(t_0)) = \prod_{v \in V_{N2}} \sum_{u: t_u < t_0} \alpha_{uv} p_{uv(t1)} \times \prod_{e: t_e < t_0} e^{-\alpha_{ev} \int_{t_e}^{t_1} p_{ev(T)}} dT$$

The objective function is,

$$\min_{A} f(t1 | s(t0))$$

$$s.t \quad \alpha_{uv} \in \{0,1\}$$

The Greedy algorithm is presented below,

Algorithm : Greedy Algorithm

$\textbf{Input}: Initial\ Edge\ matrix\ A0$

$Initialization: VB = f$

$For\ i = 1\ to\ K\ do$

$$U = \underset{v \in V}{argmax} \begin{bmatrix} f(t1 | s(t0); Ai-1) - \\ f(t1 | s(t0); Ai-1 \backslash v) \end{bmatrix}$$

$Ai := Ai-1 \backslash u$

$VB = VB \cup \{u\}$

$End\ for$

$\textbf{Output}: VB$

C. Dynamic Blocking Algorithm

Greedy algorithm is a static type of blocking algorithm. Dynamic algorithm using the incrementally block the selected nodes instead of blocking at a time. The dynamic blocking consists of several rounds and each round block certain nodes like a greedy algorithm. Selecting number of round is an important one in this algorithm. Inactive nodes become activated in every round. The function is

$$f(t_j \mid s(t_{j-1})) = \prod_{v \in V(t_j)} \sum_{u: t_u < t_j} \alpha_{uv} p_{uv(t_j)} \times \prod_{e: t_e < t_j} e^{-\alpha_{ev} \int_{t_e}^{t_j} p_{ev(T)}} dT$$

Where V(tj) represents the set of nodes which remains inactive at time stamp tj. Instead of blocking of K nodes at the time of detection dynamic blocking carried out in progressive way.

Algorithm: Dynamic Blocking Algorithm

The Dynamic rumor blocking algorithm presented below,

$\textbf{Input}: Initial\ Edge\ matrix\ A0$

$Initialization: V_B(t) = \phi$

$For\ \mathrm{j} = 1\ to\ \mathrm{n}\ do$

$For\ i = 1\ to\ \mathrm{k}_j\ do$

$\Delta f = f(t_j \mid s(t_{j-1}); A_{i-1}) - f(t_j \mid s(t_{j-1}); A_{i-1} |)$

$u = \underset{v \in V}{argmax}\{\Delta_f\}$

$A_i := A_{i-1} | u;$

$V_B(t_j) = V_B(t_j) \cup \{u\}$

$End\ for$

$End\ for$

$Output: V_B(t)$

VII. Conclusion

This paper focused the rumor blocking problem in social network. Dynamic rumor influence minimization with user experience model formulates the rumor problem. Dynamic rumor diffusion model incorporates global popularity and individual tendency. Using the concept of user experience the difference between utility and blocking time are calculated. After that we use survival theory to analyze the activated nodes under the user experience constraint. Greedy algorithm and dynamic blocking algorithm are used to solve the rumor propagation problem. We plan to introduce rumors blocking algorithm based on probability of rumor propagation and the connectivity of the social network.

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