A user behavior influence model of social hotspot under implicit link

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A B S T R A C T

In social networks, user behavior is affected by complex dynamic factors. Here, we investigate the internal and external factors that drive users to participate in social hotspot s. By analyzing user behavior, we discover the differences between driving factors and quantify their driving strength. First, four factors that influence the user's behavior are proposed, including explicit links (E), implicit links (I), personal interest (P), and a random factor (R). In particular, based on a cloud model, an implicit link creation method is designed. This method can quantify the driving strength of the implicit relation between users, and avoid the multiple attribute weighting defects in subjective and objective aspects. Next, considering the maximum likelihood estimation theory, a user behavior influence model ($EIPR$) of a hotspot topic is proposed to measure the causes of user behavior behind the social hotspots. Experimental results show that the model can be used to find different dynamic factors of user behavior in social hot topics. Among these external factors, the implicit link plays an significantly important role in driving user behavior.

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1. Introduction

What drives human behavior? This question has inspired scientists for hundreds of years. Today, in the internet and big data era, online network systems such as BBS and social networks have gradually become important platforms for investigating user behavior. In this study, we try to mine the influence factors that drive user behavior on the background of social hotspots.

The online social network is increasingly important today for social relations maintenance and user behavior diffusion in human society. In fact, hotspot topics are promoted by several factors in a social network. Discovering these factors has a profound impact on social development, social services and management, and social security. At present, the study about user behavior influence is divided into two aspects: internal influence and external influence. For the internal influence factors, Barabasi et al. [2,22] first discovered the long tail phenomenon of user behavior. And they proposed a user behavior model based on task priority to analyze the influence factors that drive user behavior. Subsequently, a variety of user behavior influence model are proposed by scholars for different application scenarios. The study of internal factors that affect user behavior is gradually clear through above research.

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In addition, the external factors that influence user behavior are studied by scholars from the aspects of user behavior interaction, the neighbor node influence, common interests and behavior game etc. However, the basis of these studies is link between the social users, here we name this kind of link as explicit link. Compared to previous studies, new features of online social networking are emerging, which bring more challenges to existing methods, mainly in the following: 1) complex network structure. Group level interaction is not a simple accumulation of individual behaviors. Especially for group behavior relating to hot topics, explicit relations between online users cannot reflect real group network structure characteristics, and there are several implicit and complex relations between the groups both online and offline. 2) the group behavior dynamics are influenced by complex factors. Researches on offline individual user behavior are already challenging. Moreover, studying online group behavior requires knowledge on multiple subjects, such as computer science, sociology, and psychology. Consequently, a number of unknown network-group behavior rules require further exploration.

In this study, combined with the internal and external factors, the user participation behavior of social hot topics is deeply analyzed. While discussing the interaction between users, we especially try to mine the effect of implicit links as the external factor that affects user behavior. The influence factors that drive user behavior–explicit link factor, implicit link factor, personal interest factor, and random factor are extracted for modeling and analysis. Our goal is to analyze the differences between internal and external factors affecting different users, to quantify the effect of these factors, and to mine the role of the implicit link in driving user behavior.

Our contribution can be summarized as follows:

- To analyze the behavior of users to participate in hotspot topics, we propose four factors: the explicit link factor, implicit link factor, personal interest factor, and random factor. To analyze and quantify these factors, the *EIPR* influence model is proposed. It is found that different users are affected by different influence factors and the influence strength is also different, as demonstrated through model analysis.
- A scheme for creating implicit link based on the cloud model is proposed. In this scheme, we give a more clear definition for implicit link. Meanwhile, the defects in the traditional weighting methods with regard to subjective and the objecting weighting and the advantage of the cloud model in overcoming this problem are considered. The implicit user relation and strength of the relation are being quantified.
- The proposed method cannot only mine the dynamic factors that drive user behavior, but also make a contrast analysis between the effects of the explicit and implicit factors, which can promote topic evolution. This work fully embodies the influence of the tacit role. In addition, it helps in managing and controlling the public sentiment and providing support to locate the online water army.

The rest of this paper is organized as follows. In Section 2, we introduce the related work. In Section 3, we formulate the problem and give the necessary definitions. In Section 4, we describe the model algorithm to analyze user behavior. In Section 5, we present and analyze the experimental results of the model.

Finally, we conclude this work in Section 6.

2. Related work

In a social network, user behavior is influenced by many factors. After the task priority model of user behavior influence was proposed by Barabasi [2,22], the scholars put forward different influence factors and their behavior model for different application scenarios, such as browsing the web [34], watching online movies [39], personal interests [20] and trust agents [18]. At present, for individual influence discovery, researchers aim to find the difference in the individuals and define the opinion of leaders in a group by modeling [23]. To measure the network structure based individual influence, early methods were mainly based on the degree centrality [37], closeness [36] and betweenness [14]. In addition, combined with individual influence discovery and random walk [12,24], some representative algorithms were proposed, such as HITS [11], and PageRank [21]. Wang et al. [27] studied the evolution of user behavior over time, and found a behavior influence analysis of low-literate users of a viral speech based telephone service. Individual influence is based on user behavior. Thus, some researchers determined the relation between users through analyzing the information diffusion and user behavior [13,15], including copying, replying, retweeting and so on. To study individual influence based on topic, the analysis was focused on topic evolution and some topic model is proposed [5,9]. The abovementioned research on the influence of individual behavior provides the academic accumulation for the following work.

For the external factors that affect user behavior, most scholars pursue research on the basis of the network structure, mainly in the following aspects: 1) Network structure based analysis of influence strength. In order to measure the strength of individual influence on Twitter, the following network and the forwarding network was analyzed [4]. Zhu, et al. [10]proposed a user behavior model that users affected by neighbor nodes in terrorist incidents. 2) Calculation of influence strength based network structure. In order to find out the information dissemination path of messages, the relations between edge structure and information pathway in the network was analyzed [7,30]. 3) User behavior based measurement of influence strength. Wu et al. [31,32] quantified the factors that affect information dissemination and topic evolution by analyzing the user interaction behavior in social networks. In the calculation of the influence strength based on topics, Tang et al. [25] studied the role of different groups in topic evolution. Meanwhile, they quantified the influence strength and predicted the evolution of topics. In addition, the implicit relation of users can be analyzed by combining the topic distribution, information diffusion and influence [8,19].