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Integrating Trust with Public Reputation in Location-based Social Networks for Recommendation Making

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Abstract

The recent emergence of location-based social networking services is revolutionizing web-based social networking allowing users to share real-life experiences via geo-tagged user-generated multimedia content. One of the key challenges of the web-based social networks as an information sharing and exchanging channel is how to manage healthy relationships among community users and ensure the quality of the information shared and exchanged within the community, which holds a very significant importance to user satisfaction. Deciding whom and what information to trust is very difficult in environment where the users are unknown to each other. This paper investigates the possibilities of managing trust between the users of a web-based social network while recommending items to the members of the network. A novel framework is proposed to integrate trust among community members and public reputation of items to recommend the most appropriate items to a user of the network.

1. Introduction

In a web-based social network, people may communicate with their friends whom they know personally. They also communicate with other members in the chain of friends of friends. They share their experiences and opinions within the network about an item which may be a product or service. This opinion has a great influence to choose the item by other users of the community. The first problem for the user is how much he/she can trust on a particular opinion to select an item. For example, if a member is interested to choose a hotel to stay in Sydney, she may browse the experiences of her friends who have stayed in that hotel in past. While receiving a recommendation about a particular hotel from a trusted friend, it is also possible to include the general opinion, or the reputation of the same hotel, in order to be better informed about the quality of service, and thereby to enable a better decision.

As the social network is growing very fast by doubling the number of people joining every year [2], the possibility of getting a huge number of opinions regarding a particular item is very common. It is another problem for a member to read all these opinions from other members of the social network. This requires a recommender system to summarize or filter the top opinions or recommendations in terms of quality of the opinions and the trust between the user and the opinion giver.

Generally people like to express their opinion and are interested about others opinion regarding the items they have concern. One popular way of obtaining customer feedback is collecting ratings about the product or services by the end users. In addition to the customer ratings, there is also a good number of online customer feedback information available over the Internet as free text customer reviews, comments, newsgroups post, discussion forums or blogs. This information can be used to generate the public reputation of an item. To do this, data mining techniques, specially recently emerged opinion mining [1,3,7] could be a useful tool.

In this paper, we have tried to consider trust among the members while they select an item based on the opinion of friends. We calculate the public reputation of that item based on the online reviews given by previous users or customers. A novel framework is then proposed to integrate trust among community members and public reputation of items to recommend the most appropriate items to a user of the network. As the recommendation comes from trusted friends and also based on the general public opinions, the quality of

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the recommendation may improve. To the author's knowledge, currently, none of the web-based social network is considering combining the public reputation of items with the trust among the members of the network to suggest or recommend items.

The paper is organized as below. Section 2 briefly introduces the concept of social networks. In section 3, how the trust network can be analysed without removing information is described. Section 4 introduces the method of calculating public reputation. In section 5, we propose a framework to integrate trust and reputation for recommendation making. Sections 6 and 7 have a brief discussion on evaluation, future direction and conclusion.

2. Location-based social networks

Social networking has been around for some time. Facebook, LinkedIn, MySpace and Hi5 have become iconic. There has been dramatic growth in the number and size of Web-based social network. The number of sites almost doubled over the two year period from December 2004 to December 2006, growing from 125 to 223. Over the same period, the total number of members among all sites grew four-fold from 115 million to 490 million [2]. The growth is continuing for last two years at the same rate, even more.

The emergence of location-based social networking services offered by providers such as Rummble, GyPSii, and Whrrl is revolutionizing social networking allowing users to share real-life experiences. It is a system in the form of a robust web service, to build an open infrastructure to introduce and connect individuals based on the intersection of physical location and other properties they might have in common. It is different than the wide range of existing social networking and instant messaging applications in terms of its basic activities. Location based social network is the natural extension from the Web-based versions of these major social network sites to the mobile. Instead of just being a cut-down version of the main site, the mobile version of location-based social network adds real time value with presence from location services.

3. Trust management

Trust networks consist of transitive trust relationships between people, organisations and software agents connected through a medium for communication and interaction. By formalising trust relationships, e.g. as reputation scores or as subjective trust measures, trust between parties within a domain can be derived by analysing the trust paths linking the parties together. Jøsang et al. has described a method for trust network analysis using subjective logic (TNA-SL) [4,6]. TNA-SL takes directed trust edges between pairs as input, and can derive a level of trust between arbitrary parties that are interconnected through the network. Even in case of no explicit trust paths between two parties exist; subjective logic allows a level of trust to be derived through the default vacuous opinions. TNA-SL therefore has a general applicability and is suitable for many types of trust networks.

Transitive trust networks can involve many principals denoted by capital letters such as, *A, B, C* and *D* in the examples below. We use basic constructs of directed graphs to represent transitive trust networks. A single trust relationship can be expressed as a directed edge between two nodes that represent the trust source and the trust target of that edge. For example the edge [*A,B*] means that *A* trusts *B*. The symbol ":" is used to denote the transitive connection of two consecutive trust edges to form a transitive trust path. If there is a scenario where A trust B, B trust C and C trust D then the trust relationships between A and D can be expressed as:

$$([A,D]) = ([A,B]:[B,C]:[C,D]) \quad (1)$$

We use the symbol "◊" to denote the graph connector for representing parallel trust paths. In short notation, A's combination of the three parallel trust paths from A to D in Fig.1 (left hand side) is then expressed as:

$$([A,D]) = ([A,B]:[B,D]) \lozenge ([A,C]:[C,D]) \lozenge ([A,B]:[B,C]:[C,D])) \quad (2)$$

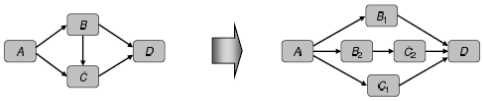

Fig. 1 Node splitting of trust network to produce independent path

Inconsistency can result from dependence between separate trust paths, which when combined will take the same information into account several times such as the edges [*A,B*] and [*C,D*] in expression (2). Including the same trust edges multiple times will by definition produce an inconsistent result. It is therefore desirable to express graphs in a form where an arc only appears once which is called a *canonical expression*. Our proposed model avoids this problem by allowing the trust measure of a given trust edge to be split into several independent parts, so that each part is taken into account by separate trust paths.

Node splitting in expression (2) consists of splitting the node B into B_1 and B_2, and the node C into C_1 and C_2. This produces the right-hand side trust network in Fig.1 with canonical expression:

$$([A,D]) = ([A,B_1]:[B_1,D]) \lozenge ([A,C_1]:[C_1,D]) \lozenge ([A,B_2]:[B_2,C_2]:[C_2,D])) \quad (3)$$

Trust between A and B can be expressed as $\omega_B^A = (b,d,u,a)$ where b, d, and u represent belief, disbelief and uncertainty respectively, under the constraint that $b,d,u \in [0,1]$ and $b+d+u=1$. The parameter $a \in [0,1]$ is called the base rate, and is used for computing the trust probability expectation value. In the absence of any specific evidence about a given party, the base rate determines the a priori trusts that would be put in any member of the community.

Subjective logic defines a number of operators [5]. The transitivity operator denoted by '$\otimes$' is used to derive trust from a trust path consisting of a chain of trust edges, and the fusion operator denoted by '$\oplus$' is used to combine trust from parallel trust paths. 1

Let A, B, and C be three agents, ω_B^A and ω_C^B represent that A has trust in B, and B has trust in C, respectively. Agent A can then derive her trust in C by discounting B's trust in C with A's trust in B, denoted by $\omega_C^{A:B}$, as defined below:

$$\omega_C^{A:B} = \omega_B^A \otimes \omega_C^B. \quad \begin{cases} b_C^{A:B} = b_B^A b_C^B \\ d_C^{A:B} = b_B^A d_C^B \\ u_C^{A:B} = d_B^A + u_B^A + b_B^A u_C^B \\ a_C^{A:B} = a_C^B. \end{cases} \quad (4)$$

Let ω_C^A and ω_C^B be A's and B's trust in C respectively. The opinion $\omega_C^{A\lozenge B}$ is then called the fused trust between ω_C^A and ω_C^B, denoting an imaginary agent $[A,B]$'s trust in C, as if she represented both A and B. The fusion operation denoted as $\omega_C^{A\lozenge B} = \omega_B^A \oplus \omega_C^B$ is defined as below:

Case1: $u_C^A + u_C^B - u_C^A u_C^B) \neq 0$

$$\omega_C^{A\lozenge B} = \omega_B^A \oplus \omega_C^B$$

$$\begin{cases} b_C^{A\lozenge B} = \dfrac{(b_C^A u_C^B + b_C^B u_C^A)}{(u_C^A + u_C^B - u_C^A u_C^B)} \\ d_C^{A\lozenge B} = \dfrac{(d_C^A u_C^B + d_C^B u_C^A)}{(u_C^A + u_C^B - u_C^A u_C^B)} \\ u_C^{A\lozenge B} = \dfrac{(u_C^A u_C^B)}{(u_C^A + u_C^B - u_C^A u_C^B)} \\ a_C^{A\lozenge B} = a_C^A. \end{cases} \quad (5)$$

Case2: $u_C^A + u_C^B - u_C^A u_C^B) = 0$

$$\begin{cases} b_C^{A\lozenge B} = \dfrac{(\gamma^{A/B} b_C^A + b_C^B)}{(\gamma^{A/B} + 1)} \\ d_C^{A\lozenge B} = \dfrac{(\gamma^{A/B} d_C^A + d_C^B)}{(\gamma^{A/B} + 1)} \\ u_C^{A\lozenge B} = 0 \\ a_C^{A\lozenge B} = a_C. \end{cases} \quad (6)$$

Where the relative weight $\gamma^{A/B} = \lim(u_C^B / u_C^A)$.

4. Calculating public reputation

Opinion Mining is the area of research that attempts to make automatic systems to determine human opinion from free text written in natural language as a feedback. It is a recent discipline at the crossroads of information retrieval and computational linguistics. The discipline is also known as Sentiment Mining, Sentiment Analysis, Sentiment Classification, Opinion Extraction etc. Unlike the text mining, opinion Mining is concerned with the opinion it expresses instead of the topic of a document. Inspiring by the algorithm proposed by Ding et al [1], we can calculate the public reputation from a given opinion text. Usually an item has several features, for example, a hotel can have features such as room, food, etc. One review expresses one customer's comments toward one item. From each review, we first generate the customer's sentimental orientation to each feature of the item, such as positive or like, negative or dislike, and neutral etc [1,3,7], then generate a score to this item according to the user's feature sentimental orientation, finally generate an overall score to this item based on all users' scores.

5. Integrating trust and reputation

While we calculate the public reputation of an item, we may combine that with the trust between the opinion giver and the potential user of that item. How it can be done is shown in the framework given in Fig.4.

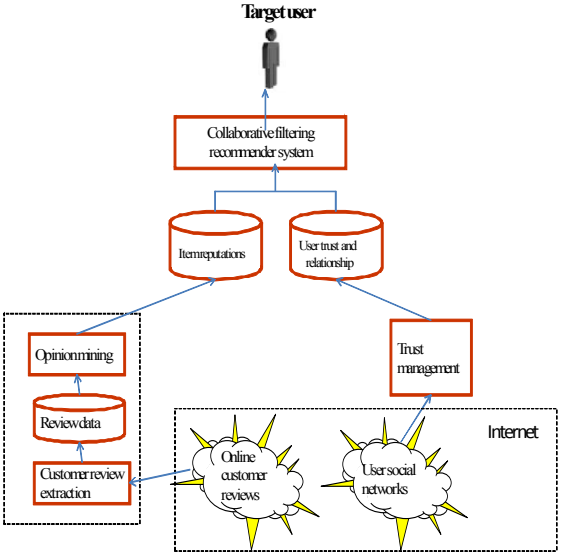

Fig. 2 Framework for integrating trust and public reputation

From the Internet, we can download a large amount of opinion data and calculate the general public opinion about an item based on those opinions. We can also calculate the existence of the degree of trust between two members in a trust network and that can be considered while suggesting an item to each other. If any suggestion or recommendation comes from a trusted member, it is more likely to be the right choice of item for a member.

6. Discussion and future direction

Recommender systems intend to provide people with recommendations of items they might appreciate or be interested in. Collaborative filtering offers technology to recommend items of potential interest to users based on information about similarities among different users' tastes. However, in the case of web-based social networks, user rating data doesn't exist. Therefore, instead of using user rating data, the trust values among users are calculated and then based on the items' reputation scores select the items from the items recommended by the users in the target user's neighbourhood, and finally recommend the selected items to the target user. A framework is proposed here describing how the recommendation quality can be improved. However, a complete validation method needs to discover to prove that the proposed frame work really have any positive improvement in terms of proper item selection.

7. Conclusion

Trust and reputation management represents an important approach for stabilising and moderating online communities including the members of a social network. Integration of different systems would be problematic with incompatible trust and reputation systems. We have described how it is possible to gracefully integrate public reputation and trust management with recommender system. This provides a flexible and powerful framework for online trust and reputation management.

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