A graph-based comprehensive reputation model: Exploiting the social context of opinions to enhance trust in social commerce

Su-Rong Yan [a,b], Xiao-Lin Zheng [a,*], Yan Wang [c], William Wei Song [d], Wen-Yu Zhang [b]

[a] College of Computer Science, Zhejiang University, 310027 Hangzhou, China
[b] College of Information, Zhejiang University of Finance and Economics, 310018 Hangzhou, China
[c] Department of Computing, Macquarie University, Sydney, NSW 2109, Australia
[d] School of Technology and Business Studies, University of Dalarna, 79188 Borlänge, Sweden

ARTICLE INFO

ABSTRACT

Social commerce is a promising new paradigm of e-commerce. Given the open and dynamic nature of social media infrastructure, the governance structures of social commerce are usually realized through reputation mechanisms. However, the existing approaches to the prediction of trust in future interactions are based on personal observations and/or publicly shared information in social commerce application. As a result, the indications are unreliable and biased because of limited first-hand information and stakeholder manipulation for personal strategic interests. Methods that extract trust values from social links among users can improve the performance of reputation mechanisms. Nonetheless, these links may not always be available and are typically sparse in social commerce, especially for new users. Thus, this study proposes a new graph-based comprehensive reputation model to build trust by fully exploiting the social context of opinions based on the activities and relationship networks of opinion contributors. The proposed model incorporates the behavioral activities and social relationship reputations of users to combat the scarcity of first-hand information and identifies a set of critical trust factors to mitigate the subjectivity of opinions and the dynamics of behaviors. Furthermore, we enhance the model by developing a novel deception filtering approach to discard "bad-mouthing" opinions and by exploiting a personalized direct distrust (risk) metric to identify malicious providers. Experimental results show that the proposed reputation model can outperform other trust and reputation models in most cases.

© 2014 Elsevier Inc. All rights reserved.

1. Introduction

Buyers in e-commerce can neither physically examine a product nor verify the reliability of the seller given their temporal and spatial separation from sellers [34]. In such a context, buyers usually have limited information regarding the sellers and the goods; hence, they experience a high degree of uncertainty [35]. Meanwhile, social media tools such as social networking services (SNS) enable people to share their opinions regarding a product and transaction [39,53]. To this end, an increasing number of e-commerce industries have adopted SNS to encourage user interactions, including eBay.com, Amazon.com, and Taobao.com. Product review sites such as Epinions.com utilize the same tools, which are part of the larger emerging

* Corresponding author at: Zhejiang University, Hangzhou, 310027 China. Tel.: +86 13588029069; fax: +86 571 87951453.
E-mail address: xlzheng@zju.edu.cn (X.-L. Zheng).

phenomenon of social commerce [3,30,41,50] wherein the business activities of companies are supported by the voluntary effort of external partners [9]. Therefore, the use of such social media generates new revenue opportunities for marketers and businesses in online shopping while providing consumers with product information and advice. These parties obtain both economic and social rewards for sharing [17].

With the aid of social media tools, each user within a community should ideally have the same communicative potential. However, interested parties or stakeholders can easily manipulate online reviews for their strategic interests given the open and dynamic nature of social media infrastructure. Consumers also have external incentives to misreport and thus misrepresent the reviews available to other users [2,12]. Consequently, potential buyers discount actual reviews heavily as a result of the veracity of reviews questioned under deceptive environments.

Consumers are driven to value the decisions and opinions of social relationship members in product purchasing as per basic behavioral psychology [28,33]. However, new consumers usually have limited or virtually no direct interaction or relationship with other consumers in the context of social commerce because of the strong community structure in social networks [59]. This observation implies that new entrants often serve only the small communities (cliques) of direct acquaintances. A review is the subjective perspective of a consumer regarding his/her experiences in community activities and may merely represent his/her individual preference and opinion. Furthermore, trusted friends may not have similar tastes. Consequently, users who increasingly rely solely on their acquaintance communities for information readily encounter collective community bias [37]. In this case, the objectivity of reviews is not fully guaranteed under subjective environments.

The assessment of information credibility is a more challenging problem in social media than in conventional media because the username (virtual identity [25]) is the sole piece of information on its source. Social media is characterized by a lack of strong governance structures [37]. As a form of social governance, reputation mechanisms are among the most successful and widespread incentive mechanisms on the Internet. A reputation system uses a specific method (e.g., averaging, social network-based, game-theoretic, probabilistic-based, or belief-based) to compute the reputation values for a set of objects (e.g., users, goods, or services) within a community based on rating data collected from others [21,43].

Social voting (user voting) is a simple but widely used reputation mechanism that has been applied to indicate the usefulness of reviews and the popularity of reviewers. Thus, the cognitive load of users is reduced. However, cheating behaviors such as vote-buying, vote-exchanging, and fake news reduce the reliability of voting results [29]. In addition, social voting mechanisms suffer from various types of bias, including the imbalance vote bias (users tend to value others' opinions positively rather than negatively), winner circle bias (reviews with many votes attract much attention and therefore accumulate votes disproportionately), and early bird bias (the first reviews to be published tend to obtain more votes, but newly posted reviews are most likely to receive no votes or only a few votes) [31,46]. Without proper measures, the reputation mechanism obtains and produces unreliable information.

User credibility is generally addressed by solving the information credibility problem in social media. The veracity and objectivity of opinions are mainly influenced by the honesty and volume of the opinion contributors or so-called "raters" who share their experiences or opinions with others. In line with this information, different approaches have been proposed to determine and filter out deceptive information provided by raters [8,11,52]. The approaches that trust public information typically assume that the majority of raters are honest, whereas those that depend only on personal observations may fail in settings where in the observations of raters are inadequate [40]. Social network-based methods [16] that extract trust values from social links among users can improve the performance of reputation mechanisms based solely on the information obtained from limited personal observations or from unknown users. However, these links may not always be available and are typically sparse in social commerce, especially for new users [57]. Furthermore, malicious users can still exploit the perceived social connections among users to easily publicize misinformation in social commerce if social links are available [1,7]. Some incentive-based proposals [13,27] are usually set up based on the rational behavior model of economics theory. These proposals have a sound logical foundation but do not seriously consider user behavior strategies (such as collusion or bad-mouthing). These problems are intrinsic in the processes of obtaining genuine feedback about actual interactions and estimating reputations accurately.

To circumvent the aforementioned problems, this paper proposes a new graph-based comprehensive reputation (CR) model for social commerce based on consumer behavior and psychological theory to improve the veracity and objectivity of opinions and to enhance consumer trust in (product and opinion) providers even in the presence of malicious and new users. This study is also motivated by the power of graph theory in data representation. The main salient features of the model proposed in this study are listed below.

- The (activity) history of opinion contributors and their social network interactions instinctively generate a social context for opinions (e.g., reviews and votes) given the limited direct interactions among numerous consumers in the social commerce context [32]. All of the data representation methods used in existing trust and reputation systems are application-specific and therefore limit the data inputs and representations that can be employed [19,43]. This study models the social context of opinions as users' activities and social relationship networks (UASRNs in the present paper) through a graph-based data representation model. The proposed reputation model fully exploits the social context of opinions and incorporates both the behavior and social relationship reputations of a user to combat the scarcity of first-hand information.