



Capturing the essence of word-of-mouth for social commerce: Assessing the quality of online e-commerce reviews by a semi-supervised approach

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ABSTRACT

In e-commerce, online product reviews significantly influence the purchase decisions of buyers and the marketing strategies employed by vendors. However, the abundance of reviews and their uneven quality make distinguishing between useful and useless reviews difficult for potential customers, thereby diminishing the benefits of online review systems. To address this problem, we develop a semi-supervised system called Online Review Quality Mining (ORQM). Embedded with independent component analysis and semi-supervised ensemble learning, ORQM exploits two opportunities: the improvement of classification performance through the use of a few labeled instances and numerous unlabeled instances, and the effectiveness of the social characteristics of e-commerce communities as identifiers of influential reviewers who write high-quality reviews. Three complementary experiments on datasets from Amazon.com show that ORQM exhibits remarkably higher performance in classifying reviews of different quality levels than do other well-accepted state-of-the-art text mining methods. The high performance of ORQM is also consistent and stable even under limited availability of labeled instances, thereby outperforming other baseline methods. The experiments also reveal that (1) the social features of reviewers are important in deriving better classification results; (2) classification results are affected by product type given the different purchase habits of consumers; and (3) reviews are contingent on the inherent nature of products, such as whether they are search goods or experience goods, and digital products or physical products, through which purchase decisions are influenced.

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1. Introduction

Empowered by cutting-edge social media, internet-based social communities have significantly contributed to the success of online businesses [1]. Current online retail commerce is characterized by many-to-many transactions, instead of the traditional one-to-one relationship between sellers and buyers, closely tying the parties involved in various social networks that center on a given product. That is, sellers form alliances through links to products for brand selling, buyers share shopping experiences in online virtual communities, and these two types of networks interact with each other, thereby generating positive propensity towards a more effective market. E-commerce oriented communities have thus far remained popular given that they are constantly updated with enriched features and services, enabling buyers to enjoy informative shopping facilities and retailers to build strong customer loyalty. Such communities have also considerably improved market efficiency. All these advantages

indicate the advent of social shopping and social commerce. The former is based primarily on word-of-mouth in electronic marketing, and the latter is referred to as the retail and referral network of individual sellers/shops for products sold online. Both are underpinned by advanced online social media.

E-commerce communities have given rise to a substantial volume of consumer-generated information, including online reviews of products or sellers, online transaction ratings, and scores on the different criteria provided by the electronic market. Such information exerts a huge influence on the evolution of e-commerce. The influx of user-generated contents reflects the wide acceptance of key Web 2.0 characteristics, such as user-centered design and information sharing. User-generated contents, typically product reviews, can be exploited through econometrics and data mining analysis [2]. With the help of a modified regression model, retailers can also predict the effectiveness of reviews in sales generation. Determining consumers' true opinions from reviews of existing product improvements or new product developments is helpful for manufacturers. Online review analysis can help retailers implement targeted marketing, sales prediction, and customer relationship management. From a consumers' perspective, effective and authentic reviews have become invaluable sources of shared opinions

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about products; these opinions have a guiding effect on purchase decisions.

The abundance of online reviews causes two problems: information overload and quality discrepancy. In particular, the quality of reviews dramatically varies, from very helpful to useless and even spam-like, diminishing the benefits gained from online reviews. From a buyer's perspective, therefore, low-quality reviews pose difficulties in comprehensively evaluating product quality. Specifically, negative evaluations from credible reviewers tend to give rise to herd mentality [3]. In establishing market efficiency and providing benefits to retailers and consumers, the aforementioned issues make identifying true buyer opinions a critical yet challenging task.

To evaluate the quality of online reviews, researchers have devoted considerable effort to developing text analytics methods, including review quality classification [4,5] and spam detection [6]. These methods employ large-scale training datasets to build classification or prediction models, with data labeling as one of the major tasks in data pre-processing. However, manually labeling a large dataset incurs high costs, and is impractical when applied in industry given the diversity of reviews and the numerous factors that influence product evaluations. In addition, a single model may exhibit unstable performance because of lack of generalizability. The major drawback of these methods is that they do not fully use the social characteristics of e-commerce communities, which are distinct attributes of advanced e-commerce. Thus far, many data mining techniques for knowledge discovery from online reviews have presented unstable or poor performance when applied to actual situations.

On the basis of the discussion above, we argue that the current imperfections in review quality classification, which is the preliminary task in further data analysis, can be rectified by a semi-supervised classification approach [7]. This branch of machine learning has gained increasing popularity because of its practical value and versatile performance. The most critical advantage of semi-supervised classification is that it requires training datasets that contain only a few labeled instances but numerous unlabeled ones. The general idea of this method is to train a classifier from a dataset that contains both labeled and unlabeled records, instead of training one with only labeled records. Prior experiments show that, with a sufficiently accurate classifier, semi-supervised learning enables highly accurate classification [8]. Inspired by these outcomes, we design and implement the Online Review Quality Mining System (ORQM) based on the semi-supervised classification approach for review quality classification. ORQM is also reinforced with a Co-EM version of the ensemble selection method [7] to optimize the accuracy of classification and the independent component analysis (ICA)-based method for pre-processing mapped features. Specifically, ORQM incorporates the comprehensive social features of reviewers, thereby enabling consumers to take advantage of potentially high-quality reviews from influential evaluators. The experiments on Amazon.com review datasets, which contain the information on physical and digital products in four categories and on both search goods and experience goods, indicate:

1. The performance of ORQM is superior to that of the most popular supervised methods in terms of seven extensively applied metrics (accuracy (ACC), F-score, receiver operating characteristic curve (AUC), average precision (APR), root mean square error (RMSE), mean cross-entropy (MXE), and mean) [10]. Specifically, ICA-based pre-processing further improves and stabilizes the performance of ORQM.
2. ORQM works more effectively than do baseline methods even under a very small number of labeled samples. Adding more labeled samples steadily improves the performance of the proposed system.
3. The social traits of reviewers are more helpful than other features in enhancing quality classification performance, which is also influenced

by product type. All the methods exhibit a higher performance in the IT product datasets than in the cultural product datasets.

The rest of the paper is organized as follows. Section 2 provides a background to quality mining and presents the literature review. Section 3 discusses the ORQM system. Section 4 describes the experiments on the Amazon.com online review datasets, including details on the performance evaluation, model validation, and feature selection. The conclusions and future research directions are presented in Section 5.

2. Related work

Knowledge discovery from online reviews (i.e., review mining) is an interdisciplinary research area that features econometric analysis, consumer psychological modeling, statistical linguistics, natural language processing, opinion mining, and machine learning [9]. It has received much attention from researchers in economics, management, behavioral science, psychology, computer science, and sociology.

In the early stage of review mining research, efforts were devoted to identifying the polarity of reviews (positive or negative) [10]. Particular attention was later paid to determining the influence of product reviews on the purchase intentions of consumers from the perspectives of marketing and sociology. For example, Lee et al. [3] investigated the conformity effect of negative reviews on marketing. Econometricists and management experts studied the economic value of reviews and determined consumer needs. Ghose et al. [11] estimated the feature weights of reviews and predicted the sales fluctuations influenced by different features. Lee et al. [12] used a combination of association rule mining and graph analysis to accurately identify customer needs.

Despite the contributions of these studies, the robustness and reliability of their results are undermined by the insufficient focus on review quality. Given the popularity of online review systems and the abundance of review information, review quality has emerged as an important research issue in social shopping and social commerce. User ratings generally demonstrate an unbalanced distribution [13], a bias further reflected as the effects of certain factors on project reviews [14]. Therefore, Pipino et al. [15] conducted subjective and objective assessments of data quality, in conjunction with three functional forms of objective metrics, to investigate distribution patterns. To enhance the efficiency of this approach, researchers directed more focus toward feature selection for product quality assessments based on online reviews. Social features, such as trust features in social networks, improve the accuracy of predicting review quality [16]. Users constantly search for helpful reviews that enable them to more efficiently and precisely make decisions, giving rise to the popularity of helpfulness ratings, an extended feature of online reviews [17]. Moghaddam et al. [18] suggested that rating the helpfulness of online reviews be personalized because utility is a subjective concept. Liu et al. [19] found that the helpfulness ratings assigned by regular users differ from those provided by sellers, who design specific features for detecting helpful reviews on the basis of a retailers perspective. Other relevant studies emphasized the detection of spam reviews and untrustworthy members. Hu et al. [20] empirically found that review abuse occurs in Amazon.com and Barnes Noble, and Ku et al. [21] proposed a method for distinguishing members in opinion-sharing communities for products; the distinction is conducted on the basis of member reviews and trust networks [20].

Most of these methods rely on large manually labeled training datasets, making them time consuming and less scalable. For example, Godfrey et al. [22] reported that human experts have to spend as many as 400 h transcribing an hour of conversational speech corpus. Furthermore, methods that rely solely on a single machine-learning model normally suffer from diminished generalizability and overlook social attributes.

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