Integrating rich and heterogeneous information to design a ranking system for multiple products

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A B S T R A C T

The online review plays an important role as electronic word-of-mouth (eWOM) for potential consumers to make informed purchase decisions. However, the large number of reviews poses a considerable challenge because it is impossible for customers to read all of them for reference. Moreover, there are different types of online reviews with distinct features, such as numeric ratings, text descriptions, and comparative words, for example; such heterogeneous information leads to more complexity for customers. In this paper, we propose a method to integrate such rich and heterogeneous information. The integrated information can be classified into two categories: descriptive information and comparative information. The descriptive information consists of online opinions directly given by consumers using text sentiments and numeric ratings to describe one specific product. The comparative information comes from comparative sentences that are implicitly embedded in the reviews and online comparative votes that are explicitly provided by third-party websites to compare more than one product. Both descriptive information and comparative information are integrated into a digraph structure, from which an overall eWOM score for each product and a ranking of all products can be derived. We collect both descriptive and comparative information for three different categories of products (mobile phones, laptops, and digital cameras) during a period of 10 days. The results demonstrate that our method can provide improved performance compared with those of existing product ranking methods. A ranking system based on our method is also provided that can help consumers to compare multiple products and make appropriate purchase decisions effortlessly.

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1. Introduction

With the rapid development of e-business and Web 2.0, an increasing number of people prefer to shop online and exchange opinions through the Internet. Researchers often refer to theses online opinions in consumer reviews about a product, service, brand, or company as electronic word-of-mouth (eWOM). eWOM is becoming a major source of information for potential buyers to make informed purchase decisions [10,18,20]. Nicosia [39] argues that information search and alternatives evaluation are two of five essential stages of the consumer-purchase decision process: (1) problem recognition, (2) information search, (3) evaluation of alternatives, (4) purchase decisions, and (5) post-purchase behavior. A survey[1] found that 63% of online shoppers consistently search and read reviews before making a purchasing decision. Among these, 64% of the online shoppers spend 10 min reading reviews, whereas 33% spend 30 min or more. Evidently,

an increasing number of consumers prefer to evaluate and choose products based on eWOM about products.

The most common online reviews are numeric ratings and text reviews. A numeric rating is merely a score, whereas a text review is one comment with a more detailed description of sentiments. Some studies have found that numeric rating and text review both affect consumers' purchasing decision, but their valences are not consistent [1,24]. However, the available number of consumer reviews is in the tens of thousands and rapidly grows; when potential consumers want to buy a product, it is a great challenge for them to read all the reviews, evaluate eWOM of the alternative products, and choose the one they prefer.

To help consumers compare alternative products, there are some studies that describe methods to extract opinions and sentences from text reviews [23,28,29,34,49]. Some of these studies focus on mining and summarizing customers' opinions and text sentiments from text reviews [23,34], whereas other studies directly mine comparative sentences and relationships from text reviews [28,29,49]. However, comparative sentences are very rare in text reviews, and they are usually not sufficient to evaluate competitive products comprehensively because there are a limited number of comparisons for some products

and even no comparison for many (if not most) products. Moreover, comparative sentences only compare several products (usually two or three products), and not all alternative products have been compared simultaneously.

To compare multiple products, some websites provide rankings of products according to simple criteria such as the average numeric rating; however, these rankings do not fully consider the voice of customers, such as the text sentiments and comparative sentences. Recently, several approaches have been proposed to rank multiple products by integrating the text sentiments and comparative sentences [30,32,51,52,54], approaches that have shown promising results to provide effective rankings. However, their applicability is again restricted by the limited number of comparative sentences. Moreover, they omit some important facets of customers' voice, such as the numeric rating which is simple but useful [1,20,36,17].

In this paper, we propose a new ranking method to integrate heterogeneous information including text sentiments, numeric ratings, comparative sentences, and comparative votes. Online comparative votes, directly provided by some third-party review websites, allow customers to compare a pair of products side by side and vote for the one they prefer. In contrast to writing detailed comments to compare products, the online votes can be easily implemented by simple clicks, thus attracting many more people to vote for the products they like. As far as we know, such comparative voting has not been employed in previous related studies.

We classify heterogeneous information into two categories: descriptive information and comparative information. Descriptive information consists of text sentiments and numeric ratings to describe one specific product. Comparative information comes from comparative sentences and online comparative votes that compare more than one product. The previous research usually studied one or two types of information, and little research concentrated on the combination of comprehensive information to aid the customers' decision-making. In addition, the abundant information provided by comparative votes has not been explored by the current research, and its effect remains unclear. In this paper, we integrate the rich and heterogeneous information, including comparative votes, to provide a ranking method that can help consumers to compare multiple products effectively and make appropriate purchase decisions effortlessly.

This paper makes the following contributions:

(1) A unified eWOM ranking model is proposed to integrate the most comprehensive descriptive and comparative information, to the best of our knowledge, to compare multiple products.
(2) In addition to the limited comparative sentences, a huge number of online comparative votes is employed for the first time to enhance the quality of comparative information significantly.
(3) An effective system is provided to help consumers rank multiple products and assist manufacturers to analyze the competitive intelligence of their products and improve product sales.

There are many related research studies of the emerging value from eWOM, and our research follows this rapidly growing frontier. These studies could provide people with critical insights when making decisions, and in our case, a ranking list as well as a comparative graph of products could be developed to help the customers.

The rest of this paper is organized as follows. In Section 2, we review related works about description and comparative information and product ranking methods based on the integrated information. In Section 3, we propose a method to mine and integrate the descriptive and comparative information. In Section 4, we design a unified digraph structure for product comparisons by integrating heterogeneous information and provide the eWOM ranking of multiple products. Section 5 describes the data used for estimating the model, evaluates the

proposed ranking method, and discusses a ranking system for decision support. In Section 6, we present our study's conclusions as well as future work.

2. Related works

2.1. Descriptive information: Numeric rating vs. text sentiments

Several researchers have examined the effect of online reviews on potential consumers' decisions, primarily concentrating on numeric ratings and text sentiments. The numeral rating, which can be considered a succinct summary of opinion and codified assessment on a standardized scale (i.e., the number of stars), is characterized by its simplicity, and it is convenient for potential customers to grasp a general impression. Some researchers have shown that consumers faced with complexity and abundance of information in a limited time often attempt to reduce their cognitive efforts and resort to alternative simplified strategies and heuristics to arrive at a purchasing decision [3,41,47]. Numeric rating, as a type of evaluation information on products that requires less effort to process and is easily aligned, may frequently be used to simplify the considerable set of alternatives [24]. An investigation found that 20% of consumers will rank products based on a numeric rating when searching for product information on an e-ecommerce website [13]. Many studies have found that numeric ratings affect consumer decision-making to a certain extent [6,7,8,12,20,36]. However, the average numeric star rating assigned to a product may not be able to reveal much information about its true underlying quality [16]. Instead, the reader must read actual text reviews to examine more detailed and specific evaluation of products.

Different from numeric ratings, text reviews that are full of objective and subjective descriptions of products can provide more explanations of reviewers' feelings, experiences, and emotions. Text sentiments, which are derived from text reviews by text mining techniques, can be assigned specific polarity such as positive, neutral, or negative emotions with varying degrees. Such sentiments provide rich information to their readers and are likely to provide them with an understanding that goes beyond the scope of a numeric rating. Some studies have revealed that text sentiments containing specific opinions on products have important effects on consumers' decision-making [1,14,24,36,38]. However, on the other side of the coin, the huge amount of text content, which is also mixed with much noise [18] and complex patterns, is extremely tedious and costly to read [6] [36].

Numeric ratings and text sentiments as online eWOM both affect consumers' evaluation of candidate products, and the two distinct types of information can complement one another. The rating scores are allowed to be only, for example, an integer from 1 to 5, which may not provide enough information to assist the decision-makers. Due to the rich information provided in the text, it is able to alleviate the discreteness problem of numeric ratings. For example, some reviews with a score of 4 read like reviews with a score of 3, whereas others read like reviews with a score of 5. Furthermore, it has been shown that ratings and sentiments may have different proximities to the final choice [24]. It is noteworthy that the text review, rather than numeric rating, has attracted most of the attention in the existing research on product comparisons; the numeric rating is even completely excluded in some studies. In fact, because it requires less effort to read and align [53], the numeric rating should not be ignored. In our study, we also find that, by integrating the information from both text sentiment and numeric rating, the performance of product ranking can be better than that by merely considering text sentiment. Therefore, numeric rating and text sentiments are two different types of evaluation of products. To reduce bias and strengthen robustness, these two factors should be integrated to evaluate products' eWOM simultaneously.