Product Comparison using Comparative Relations

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ABSTRACT

This paper proposes a novel Product Comparison approach. The comparative relations between products are first mined from both user reviews on multiple review websites and community-based question answering pairs containing product comparison information. A unified graph model is then developed to integrate the resultant comparative relations for product comparison. Experiments on popular electronic products show that the proposed approach outperforms the state-of-the-art methods.

Categories and Subject Descriptors

I.2.4 [**Knowledge Representation Formalisms and Methods**]: [Relation systems]

General Terms

Algorithms, Performance

Keywords

Product Comparison, Comparative Relations Graph

1. INTRODUCTION

When purchasing popular electronic products like mobile phones, consumers commonly compare several candidate products by seeking public opinions from online reviews before making purchase decision. However, this process is labor-intensive and time-consuming. To help consumer make purchase decision effortlessly, many review websites provide a simple product comparison functionality, which compares several candidate products in terms of various aspects. For each aspect, it scores each candidate by averaging the corresponding users' ratings within the website. However, this product comparison functionality is usually not effective due to the following limitations: (1) there are usually too few ratings to make the scores reliable for some products in a website; and (2) one website usually does not contain all the products that the consumer wants to compare. Meanwhile, it is not reasonable to simply integrate the comparison results from multiple websites, since different websites have different scoring strategies based on different user ratings.

Motivated by the above observations, in this paper we propose a novel Product Comparison (PC) approach based on the comparative relations between each pair of candidate products in four high-level product aspects: design, feature, performance and ease of use, which most consumers are concerned about. Our approach performs the product comparison task in two main steps: (1) The pairwise comparative relations on each high-level aspect are mined from both user reviews on major product review websites and community-based question answering (cQA) pairs containing comparative information between products. (2) For each aspect, a unified graph model is constructed to integrate the comparative relations from user reviews and cQA pairs. By performing graph propagation, each candidate product (i.e., each node in the graph) obtains a superiority score. The product having the largest score outperforms the others on the corresponding aspect. The contributions of this papers are two-fold. First, in order to generate reliable and comprehensive product comparison results, we integrate user reviews from multiple review websites and also incorporate the product-related cQA pairs as a new source of information to exploit the comparative relations between products. Second, a unified graph model is developed to fuse the comparative relations from the above two sources for product comparison. Some preliminary works have been dedicated to product comparison based on user reviews [3, 6]. However, they mainly make use of individual user ratings and neglect the product comparative relations expressed in review sentences and cQA pairs. Moreover, they all focus on low-level aspects, such as size and weight etc.

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2. THE APPROACH

2.1 Comparative Relations Mining

For each high-level aspect, we first group the review sentences and cQA pairs using K-means clustering method as proposed in [4]. We then employ Support Vector Machine (SVM) to classify the polarity [5] of the review sentences. As a result, the numbers of positive opinions (PS) and negative opinions (NS) from reviews are obtained for each product. Next, we identify the comparative sentences from the reviews and analyze them as in [1, 2]. We then summarize the comparative relations between products from the reviews. The number of opinions which indicate product A is better than B is marked as CP_A. Meanwhile, to mine the comparative relations from cQA pairs, we define a trigger lexicon containing the phrases that indicate the preferred product in the answers, such as 'I'd go with', etc. With the use of this lexicon, we adopt the reviews processing approach in [1, 2] to analyze the comparative relations in cQA to derive the relations between products A and B.

2.2 Graph based Product Comparison

In this section, we propose a graph-based product comparison approach, which consists of two graphs containing

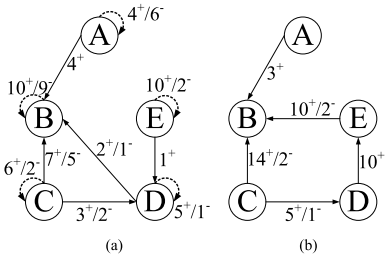

Figure 1: An illustration of $\mathcal{G}_\mathcal{H}$ incorporating pairwise comparative relations mined from user reviews (a) and cQA pairs (b), for five candidate products.

the comparative relations from the reviews and cQA pairs respectively. The graph for each high-level aspect $\mathcal{H}$ is defined as follows: $\mathcal{G}_\mathcal{H}=(\mathcal{V},\mathcal{E})$ where $\mathcal{V}=\{p_i|p_i$ is a node that denotes a product, $0<i \leq n\}$; $\mathcal{E}=\{e_{ij}|e_{ij}$ is a directed edge from p_i to p_j and its weight is W_{ij}, $0<i,j \leq n\}$; and n is the number of candidate products. The direction of e_{ij} is from p_i to p_j which means that CP_j is bigger than CP_i. In other words, it indicates that more users think product j is better than product i. The weight W_{ij} is defined as:

$$W_{ii} = (PS_i + NS_i) \times \frac{PS_i}{(NS_i + \lambda)} \quad (1)$$

$$W_{ij} = \begin{cases} (CP_j + CP_i) \times \frac{CP_j}{(CP_i+\lambda)} & i \neq j \\ \frac{W_{ij}-min\{W_{ii}\}}{max\{W_{ii}\}-min\{W_{ii}\}} & i = j \end{cases} \quad (2)$$

where the smoothing coefficient λ is set to 1 when NS_i or CP_i is 0; otherwise it is set to 0. Figure 1 shows an illustration of $\mathcal{G}_\mathcal{H}$ with the comparative relations derived from reviews (a) and cQA (b). Through performing graph propagation over the two graphs simultaneously, we integrate the comparative relations from the reviews and cQA pairs for product comparison as follows:

$$PCS(p_i)^{k+1} = (1-d) + d \sum_{m=1}^{2} \sum_{j=1}^{n} \mu_m \beta_m PCS_m(p_j)^k \times E_m(p_j p_i) \quad (3)$$

where $PCS(p_i)^{k+1}$ is the resultant superiority score for the product p_i; k is the number of iteration; d is the damping factor; $m \in \{1, 2\}$ indicates the comparative relations from the reviews or cQA; $\mu_m \in [0,1]$ is introduced to control the contribution of these two resources and $\sum_{m=1}^{2} \mu_m = 1$. If there is a directed edge from product p_j to p_i, β_m is set to 1; otherwise 0. $E_m(p_j p_i)$ is calculated as $\frac{W_{mji}}{\sum_{l=1}^{L} W_{mjl}}$, and L is the number of outbound links of product p_j.

3. EXPERIMENTS

We conducted experiments on six mobile phones and five MP3 players as shown in Table 1. We crawled 50,893 phone reviews and 3,604 MP3 reviews from multiple review websites, including Cnet, Amazon, Reevoo, Gsmarena(Gsm). We also downloaded 215 resolved cQA pairs, which contains the comparative information of products, from Yahoo! Answers. Each cQA pairs contains one question and its given best answer. In our experiments, d was empirically set to 0.85, μ_1 and μ_2 were set to 0.7 and 0.3, respectively.

We compared the proposed approach (PC_2) to the following three approaches: the product comparison functionality of two popular review websites (Gsm and Reevoo for mobile phone and Cnet and Reevoo for MP3.), and a simplified version of the proposed approach (PC_1), which only makes use of user reviews without cQA. Since it is laborious for human to summarize and rank the products by reading all the reviews, the manually created gold standard is not easy to obtain. Alternatively, we conducted user study to evaluate the comparison results from these four approaches. We invited 12 subjects who are electronics enthusiasts. For each aspect, each subject was asked to vote one result, which she prefers, from the four results, or 'none' if all the results are unsatisfactory. The evaluation results are summarized in Table 2. Each number indicates which percentage of subjects prefer the comparison result of the corresponding approach. From Table 2, the following observations can be obtained: (1) By comparing products using comparative relations from user reviews, the proposed approaches (PC_1 and PC_2) outperform the comparison functionality of review websites on most high-level aspects. (2) By further incorporating the comparative relations minded from cQA pairs, our PC_2 approach achieves the best overall performance and performs best on most aspects.

Table 1: Candidate Products List

Phone	Apple Iphone 4, HTC Desire, Samsung Galaxy S, BlackBerry Bold 9700, Sony Ericsson Xperia X10 Mini, Nokia N97
MP3	Apple iPod Touch 4th Generation, Sandisk Sansa Clip+, Sony X-Series Walkman, Apple iPod Nano 6th Generation, Zune HD

Table 2: Four approaches' performance results

	Phone			
Aspect	Gsm	Reevoo	PC_1	PC_2
Design	0%	8.3%	41.7%	50%
Feature	0%	8.3%	41.7%	50%
Performance	8.3%	0%	8.3%	75%
Ease of use	0%	0%	0%	75%
Average	2.1%	4.2%	22.9%	62.5%
	MP3			
Aspect	Cnet	Reevoo	PC_1	PC_2
Design	41.7%	16.6%	0%	41.7%
Feature	33.3%	0%	8.3%	41.7%
Performance	8.3%	0%	8.3%	66.7%
Ease of use	0%	50%	0%	41.7%
Average	20.8%	16.7%	4.2%	48.0%

In summary, we have presented a novel product comparison approach using comparative relations derived from both the user reviews and cQA. The user study has demonstrated the effectiveness of our method.

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