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Product recommendation approaches: Collaborative filtering via customer lifetime value and customer demands

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Abstract

Recommender systems are techniques that allow companies to develop one-to-one marketing strategies and provide support in connecting with customers for e-commerce. There exist various recommendation techniques, including collaborative filtering (CF), content-based filtering, WRFM-based method, and hybrid methods. The CF method generally utilizes past purchasing preferences to determine recommendations to a target customer based on the opinions of other similar customers. The WRFM-based method makes recommendations based on weighted customer lifetime value – Recency, Frequency and Monetary. This work proposes to use customer demands derived from frequently purchased products in each industry as valuable information for making recommendations. Different from conventional CF techniques, this work uses extended preferences derived by combining customer demands and past purchasing preferences to identify similar customers. Accordingly, this work proposes several hybrid recommendation approaches that combine collaborative filtering, WRFM-based method, and extended preferences. The proposed approaches further utilize customer demands to adjust the ranking of recommended products to improve recommendation quality. The experimental results show that the proposed methods perform better than several other recommendation methods.

Keywords: Recommender systems; Collaborative filtering; Content-based filtering; WRFM-based CF method

1. Introduction

Recommender systems have emerged in e-commerce applications to support product recommendation (Kim, Lee, Shaw, Chang, & Nelson, 2001; Schafer, Konstan, & Riedl, 2001; Zeng, Xing, Zhou, & Zheng, 2004), which provide individual marketing decisions for each customer. They assist businesses in implementing one-to-one marketing strategies, relying on customer purchase history to reveal customer preferences and identify products that customers may purchase. One-to-one marketing introduces a fundamental new basis for competition in the marketplace by enabling organizations to differentiate based on customers rather than products (Peppers & Rogers, 1993). Schafer et al. (2001) presented a detailed taxonomy of e-commerce recommender systems, and elucidated how they can provide personalization to establish customer loyalty. Generally, such systems offer several advantages, including increasing the probability of cross-selling, establishing customer loyalty, and fulfilling customer needs by presenting products of possible interest to them.

Various recommendation methods have been proposed. The collaborative filtering (CF) method has been successfully used in various applications. It predicts user preferences for items in a word-of-mouth manner. User preferences are predicted by considering the opinions (in the form of preference ratings) of other "like-minded" users. The GroupLens system (Resnick, Iacovou, Suchak, Bergstrom, & Riedl, 1994) applied the CF method to recommend Usenet News and movies. Video recommender (Hill, Stead, Rosenstein, & Furnas, 1995) also used CF to generate recommendations on movies. Examples of music

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recommender systems are Ringo (Shardanand & Maes, 1995) and MRS (Chen & Chen, 2001). Siteseer Rucker and Polanco (1997) provided Web page recommendations based on bookmarks of user's virtual neighbors, Amazon.com uses collaborative filtering to create books recommendations for customers (Linden, Smith, & York, 2003). Collaborative filtering requires a user to rate a reasonably large set of items, or the CF method has difficulty providing recommendations to novices (new users). Moreover, the CF method may suffer the sparsity problem, a situation in which transactional data is sparse and insufficient to identify similarities in user interests (Sarwar, Karypis, Konstan, & Riedl, 2000).

Firms increasingly recognize the importance of customer lifetime value (CLV) (Berger & Nasr, 1998). Generally, RFM (Recency, Frequency, and Monetary) method has been used to measure CLV (Kahan, 1998; Miglautsch, 2000). Identifying CLV or loyalty ranking of customer segments is important for helping decision-makers target markets more clearly in fiercely competitive environments. Additionally, the effect of CLV on recommendations should be investigated to make more effective marketing strategies. Recently, a weighted RFM-based CF method (WRFM-based CF method) (Liu & Shih, 2005b) has been proposed that integrates analytic hierarchy process (AHP) (Saaty, 1994) and data mining to recommend products based on customer lifetime value. This method employs association rule mining to identify recommendation rules from customer groups that are clustered according to weighted RFM values. Their experimental result demonstrated that the WRFM-based CF method can identify effective rules for making recommendations to customers with high lifetime value or loyalty. The WRFM-based CF method also suffers the sparsity problem.

The content-based filtering (CBF) offers a different approach to collaborative filtering and provides recommendations by matching customer profiles (e.g., interests) with content features (e.g., product attributes). Each customer profile is derived by analyzing the content features of products purchased by the customer. The simplest of these techniques is keyword matching (Claypool, Gokhale, & Miranda, 1999). Krakotoa Chronicle (Kamba, Bharat, & Albers, 1995) is an example of such system. However, the CBF method is limited in not being able to provide serendipitous recommendations, because the recommendation is based solely on the content features of products purchased by the customer. Some domains, such as music recommendations, have difficulty analyzing content features of products.

Several researchers are exploring hybrid methods of combining CF and CBF methods to smooth out the disadvantages of each (Basu, Hirsh, & Cohen, 1998; Claypool et al., 1999; Good et al., 1999). This work uses customer demands derived from the frequently purchased products in each industry as valuable information to integrate the CF method for making recommendations. Extended preferences derived by combining customer demands and past purchasing preferences are used to alleviate the sparsity problem of recommendation. Different from conventional CF techniques, this work uses extended preferences to identify similar customers. Accordingly, this work proposes several hybrid recommendation approaches that combine collaborative filtering, WRFM-based method, and extended preferences. Moreover, customer demands are considered in re-ranking recommended products to improve the quality of recommendation.

The remainder of this paper is organized as follows. Section 2 reviews related works on the typical KNN-based CF method, the WRFM-based method, hybrid works, and content-based filtering methods. Next, Section 3 outlines the proposed methods. Section 4 then describes the experimental setup and criteria to evaluate recommendation quality. Experimental results are also presented to confirm differences between methods. Finally, Section 5 draws conclusions, summarizing the contributions of this work and outlining areas for further research.

2. Recommendation methods and related works

2.1. Typical KNN-based collaborative filtering

Collaborative recommendation (or collaborative filtering) predicts user preferences on items in a word-of-mouth manner. Similarity measures between user preference ratings are derived to define the like-mindedness between users (Breese, Heckerman, & Kadie, 1998). Notably, preferences generally are defined in terms of customer purchasing behavior, namely, purchased/non-purchased (binary choice) of shopping basket data, or taste, namely, preference rating on product items. This work focused on product recommendation of retail transaction data that contains binary choice of shopping basket data.

A typical KNN-based collaborative filtering (CF) method (Resnick et al., 1994; Shardanand & Maes, 1995) employs nearest-neighbor algorithm to recommend products to a target customer u based on the preferences of *neighbors*, that is, those customers having similar preferences as customer u. The typical KNN-based CF method is detailed as follows (Sarwar et al., 2000). Customer preferences, namely, customer purchase history, are represented as a customer-item matrix $\boldsymbol{R}$ such that,r_{ij} is one if the ith customer had purchased the jth product, and is zero otherwise. The similarity among customers can be measured in various ways.

A common method is to compute the Pearson correlation coefficient defined as Eq. (1):

$$corr_P(c_i, c_j) = \frac{\sum_{s\in I}(r_{c_i,s} - \bar{r}_{c_i})(r_{c_j,s} - \bar{r}_{c_j})}{\sqrt{\sum_{s\in I}(r_{c_i,s} - \bar{r}_{c_i})^2 \sum_{s\in I}(r_{c_j,s} - \bar{r}_{c_j})^2}} \quad (1)$$

The notations $\bar{r}_{c_i}$ and $\bar{r}_{c_j}$ denote the average number of products purchased by customers c_i and c_j, respectively. Moreover, the variable I denotes the set of products.