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Recommendation system development for fashion retail e-commerce

Hyunwoo Hwangbo, Yang Sok Kim *, Kyung Jin Cha

Graduate School of Information, Yonsei University, 50 Yonsei-ro, Seodaemun-Gu, Seoul 03722, South Korea
Department of Mangement Information Systems, Keimyung University, 1095 Dalgubeol-daero, Dalseo-Gu, Daegu 42061, South Korea
Kangwon National University, Kangwondaehak-gil, Chuncheon-si, Gangwon-do 200-701, South Korea

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ABSTRACT

This study presents a real-world collaborative filtering recommendation system implemented in a large Korean fashion company that sells fashion products through both online and offline shopping malls. The company's recommendation environment displays the following unique characteristics: First, the company's online and offline stores sell the same products. Second, fashion products are usually seasonal, so customers' general preference changes according to the time of year. Last, customers usually purchase items to replace previously preferred items or purchase items to complement those already bought. We propose a new system called K-RecSys, which extends the typical item-based collaborative filtering algorithm by reflecting the above domain characteristics. K-RecSys combines online product click data and offline product sale data weighted to reflect the online and offline preferences of customers. It also adopts a preference decay function to reflect changes in preferences over time, and finally recommends substitute and complementary products using product category information. We conducted an A/B test in the actual operating environment to compare K-RecSys with the existing collaborative filtering system implemented with only online data. Our experimental results show that the proposed system is superior in terms of product clicks and sales in the online shopping mall and its substitute recommendations are adopted more frequently than complementary recommendations.

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1. Introduction

Recently, e-commerce has become an important channel for many retail businesses. The eMarketer (2017), an e-business marketing company, estimates worldwide retail e-commerce sales will increase from $2.29 trillion in 2017 to $4.48 trillion by the end of 2021. In spite of its success, e-commerce has a significant market limitation. While there is staff available to assist customers in offline stores, there is no staff to help buyers in online stores. In order to overcome this limitation, online stores provide various features, for instance, a "search and directory" to assist customers. Although these services can enhance purchase experience, online customers can only take advantage of them if they use them.

Recommendation systems are an innovative solution that overcomes the limitations of e-commerce services. Recommendation systems use customer behavior and information, and product information to identify customer preferences, and proactively suggest products that they are likely to buy. Many studies have been conducted to develop such recommendation systems and many practical systems have been successfully implemented in various businesses (Choi et al., 2012; Koren, 2009a; Linden et al., 2003; Wei et al., 2016).

Recommendation systems used in e-commerce have been developed to reflect unique domain characteristics (Portugal et al., 2015; Schafer et al., 1999; Sivapalan et al., 2014; Wang and Zhang, 2013; Zhao et al., 2015). This study aims to develop a recommendation system for a company – referred to as Company K in the following discussion – that sells fashion products through an online shopping mall as well as through offline shopping outlets. Company K has an average of 5 million members and sells around 40,000 products per year in the online shopping mall. There are around 1.5 million clicks and around 10,000 transactions per month. Company K also operates about 1300 offline stores in Korea and sells around 20,000 products per year.

Company K possesses the following unique operation environment:

(1) When purchasing fashion products, customers buy to replace or supplement their previous purchases, or preferred products.
(2) Demand for fashion products generally decreases over time due to seasonal changes. In general, people buy fashion products appropriate to the current season. Such a pattern

* Corresponding author.
E-mail address: yangsok.kim@kmu.ac.kr (Y.S. Kim).

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in purchases is found frequently in fashion items, while purchases of other products like books and music do not display any significant relationship with the changing of the seasons.

(3) Fashion products can be sold in both online and offline stores. Most previous studies focus mainly on online stores. However, online and offline stores usually sell the same fashion products. Usually, customers first decide on potential purchases at online stores and then purchase them online.

Company K has already recognized that recommendation systems are a key success factor for its business and has used a system that employs a conventional item-based collaborative filtering for its online shopping mall. However, Company K wants a new recommendation system to be developed to reflect the fashion industry-specific characteristics discussed above. In the development of this new recommendation system, we address the following recommendation requirements.

First, the recommendation system should reflect the decline in preference for fashion products over time. Previous temporal recommendation studies assume that the intensity of preference decreases as time passes (Campos et al., 2013; Ding and Li, 2005; Ding et al., 2006; Hong et al., 2012; Koren, 2010; Larrain et al., 2015; Lathia et al., 2010; Xu et al., 2016). That is, these studies assume that recent preference-indicating behaviors, such as clicks or purchases for the same product, reflect stronger preferences than older ones. However, this study focuses on the decline in preference for fashion products which occurs over time following their release.

Second, the recommendation system needs to combine both offline customer preference data and online customer preference data. Purchases in offline shopping malls reflect the preferences of offline customers. Therefore, combining offline purchase data with that of online customers can improve the performance of online recommendation. Some researchers emphasize that online and offline information can help predict customer preferences, but have not applied this finding to the development of recommendation systems. (Cheema and Papatla, 2010; Dzyabura et al., 2016). Only a few studies consider the problem of integrating online and offline shopping mall data into recommendation systems (Adomavicius and Tuzhilin, 2001; Cantador et al., 2015; Kim et al., 2016; Nilashi et al., 2014a). The most important reason seems to be that it is difficult to find a domain where it is important to integrate both online and offline preference data. However, fashion products are sold through both online and offline stores and therefore preference data can be collected from these two stores. This study therefore aims to propose a way to combine online and offline preferences for recommending fashion products.

Third, customer purchase intent should be reflected by the recommendation system. When buying a product, the customer chooses an item that can be used with, or an item that replaces something that he or she had previously preferred. In this paper, the former is called a *complementary product*, and the latter is called a *substitute product*. This study proposes a method that recommends complementary products and substitute products separately using product category information.

2. Related work

2.1. Collaborative filtering recommendation systems

Recommendation systems are one of the most important applications in big data analytics and have performed excellently for numerous businesses (Bobadilla et al., 2013; Shi et al., 2014; Su and Khoshgoftaar, 2009). Many online companies, such as Amazon (Linden et al., 2003), Netflix (Koren, 2009a), Google (Das et al., 2007), and Facebook (Shapira et al., 2013), are using recommendation systems as part of their business.

Recommendation systems are broadly categorized into content-based systems and collaborative filtering systems. Content-based systems recommend products which have content similar to products preferred by a customer. Content-based systems use content to build a model for recommendation, but this study does not use this approach. Instead, we use a product content model to improve the collaborative filtering system as discussed below.

On the other hand, collaborative filtering systems are popular in business as well as in research because of their simplicity and its high performance levels (Bobadilla et al., 2013; Shi et al., 2014; Su and Khoshgoftaar, 2009). Collaborative filtering systems are based on customer ratings of products regardless of the availability of product content. Two approaches have been developed for collaborative filtering systems. User-based collaborative filtering systems recommend products which have been chosen most in the past by similar customers (Breese et al., 1998; Herlocker et al., 2004; Konstan et al., 1997; Resnick et al., 1994; Sarwar et al., 2001; Shardanand and Maes, 1995). For any two given customers, their similarity is calculated based on their ratings of products that both have rated. Correlation (Konstan et al., 1997; Shardanand and Maes, 1995) and cosine similarity (Breese et al., 1998; Sarwar et al., 2001) are commonly used as measures of similarity. Default voting, inverse user frequency, case amplification and weighted-majority prediction are employed to aggregate similar users' ratings (Breese et al., 1998; Delgado and Ishii, 1999).

Item-based collaborative filtering systems analyze similarities between products and recommend products that are most similar to products selected by the customer (Shardanand and Maes, 1995). The similarity between products is computed by functions, such as cosine similarity and conditional probability based similarity (Karypis, 2001). The advantage of this approach is that it can precompute similarities between products and can be presented as soon as a customer clicks or buys a product.

A typical collaborative filtering system focuses on a user-item matrix that represents customer clicks or purchases of products in a matrix format. However, recent collaborative filtering systems improve their performance by using additional information related to users and products and information related to the interaction of users and products (Shi et al., 2014).

2.2. Recommendation systems for fashion industry

Recommendation systems have usually been developed for specific domains such as movies, books, music, etc. Several previous studies focus on the unique characteristics of the fashion industry. We classify them into the following three groups.

First, a number of studies concentrate on assigning fashion products with specific attributes. Quanping (2015) integrates fashion attributes, such as style, color, material, quality, brand and seasonality, into a collaborative filtering recommendation algorithm. Experimental results demonstrate that the collaborative filtering recommendation system which integrates these attributes outperform conventional methods. Nguyen et al. (2014) suggests a fashion recommendation system which exploits implicit feedback such as clicks, wants, purchases to generate implicit user preference scores, together with price, popularity and recentness to modify user preference scores.

Second, some research focuses on recommending a set of products, not individual products. Hu et al. (2015) suggest a functional tensor factorization based recommendation system that suggests a set of fashion products instead of single product. A similar approach which uses one-class collaborative filtering has been

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