



Recommender systems for product bundling[☆]



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ABSTRACT

Recommender systems (RS) are a class of information filter applications whose main goal is to provide personalized recommendations, content, and services to users. Recommendation services may support a firm's marketing strategy and contribute to increase revenues. Most RS methods were designed to provide recommendations of single items. Generating bundle recommendations, i.e., recommendations of two or more items together, can satisfy consumer needs, while at the same time increase customers' buying scope and the firm's income. Thus, finding and recommending an optimal and personal bundle becomes very important. Recommendation of bundles of products should also involve personalized pricing to predict which price should be offered to a user in order for the bundle to maximize purchase probability. However, most recommendation methods do not involve such personal price adjustment.

This paper introduces a novel model of bundle recommendations that integrates collaborative filtering (CF) techniques, demand functions, and price modeling. This model maximizes the expected revenue of a recommendation list by finding pairs of products and pricing them in a way that maximizes both the probability of its purchase by the user and the revenue received by selling the bundle.

Experiments with several real-world datasets have been conducted in order to evaluate the accuracy of the bundling model predictions. This paper compares the proposed method with several state-of-the-art methods (collaborative filtering and SVD). It has been found that using bundle recommendation can improve the accuracy of results. Furthermore, the suggested price recommendation model provides a good estimate of the actual price paid by the user and at the same time can increase the firm's income.

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1. Introduction

Recommender systems are a class of information filter applications whose main goal is to provide personalized recommendations of content and services to users. A recommender system for an e-commerce site helps users find products, such as movies, songs, books, gadgets, applications, products, and restaurants that fit their personal preferences and needs [1]. Recommender systems enhance e-commerce sales by converting browsers into buyers, exposing customers to new products, increasing cross-selling by suggesting additional products, building customer loyalty, increasing customers' satisfaction based on their purchasing experience, and increasing the likelihood of repeat visits by satisfied customers. Each of these can be translated into increased sales and higher revenue. In the age of e-commerce, it is important for firms to develop web-based marketing strategies such as product bundling to increase revenue. Product bundling refers to the practice of sell-

ing two or more goods together, packaged at a price which is below the sum of the independent prices [6]. This practice can be observed very often in the real world. For example, if a customer buys Internet access and cell phone service together from the same company, it is often sold as a package which is cheaper than buying both services independently. Generating bundles is an example of a marketing strategy aimed at satisfying consumer needs and preferences, while complementing the firm's marketing strategy on two levels, by increasing income and widening the customers' buying scope. The motivation behind using recommender systems as a platform to bundle recommendations is to expand the market to encompass new products that would not have been purchased were they not part of a bundle, and by doing so, increasing the firms' income and profits. The bundling effect can leverage and expand upon the single item recommendation by recommending top N list recommendations that include both items and bundles, providing the customer the ability to choose whether to buy a bundle or a single item.

The collaborative filtering (CF) approach is considered one of the most popular and effective techniques for building recommender systems [2]. The basic idea is to try to predict the user's opinion about different items and recommend the "best" items,

[☆] Initial version of this paper was presented as a poster at the RecSys conference in 2015 [21].

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using the user's previous preferences and the opinions of other likeminded users.

CF is a very effective recommendation technique, and bundling is one of the most useful marketing strategies; therefore we suggest combining them.

The design of a RS with product bundling is more challenging than that of a RS based on single item recommendation. Whereas in a routine RS the problem is to find products that the user will like, in a RS with product bundling, we also have to deal with the associations between the products within the bundle. Moreover, the advantage for the consumer when purchasing the bundle is the associated cost savings; this results in an additional challenge – pricing the bundle in such a way that will satisfy customers and entice and convince them to buy it, while also serving the supplier's interests. Most recommendation methods are designed to provide single item recommendations and do not involve personalized price recommendation. Very few studies have been conducted in the area of combining bundling strategy with recommender systems. Previous researches did not included concrete evaluation showing that bundle purchasing can be predicted and didn't use recommender system measures such as precision and recall. Furthermore, there was no work that involved price bundling in the recommendations.

The main contribution of this research is that we introduced a novel model that integrates bundle recommendation algorithm with the recommendation systems platform. We examined the possibility of combining bundle recommendations without diminishing the prediction accuracy of state-of-the-art collaborative filtering and SVD methods (, which will be described later).

In order to recommend bundles we determined the probability that the customer would buy the bundle. The bundle purchasing probability was based on a new adjusted model which uses collaborative filtering techniques, a personalized demand graph, pricing modeling, and optimization techniques. Another contribution is that we implemented an optimization technique to determine which personal price should be offered to a user for a particular bundle. As we demonstrated, this model can increase the users' buying scope and the firm's income, and for that reason this model can help the RS industry. We evaluated our model by using three real datasets and used offline tests to evaluate the hit of our bundling recommendations and price suggestions. The results showed that in comparison to state-of-the-art item recommendation methods, our bundling recommendations can improve the precision, recall, average quantity of products purchased, and the average price paid.

The techniques and methods that we used will be described more thoroughly in the following chapters. In chapter 2 we review related work in the fields of product and price bundling. In chapter 3 we present detailed research objectives, our suggested model, and algorithm. Chapter 4 describes our experiments and results. In chapter 5 we present the conclusions, discussion and future work.

2. Related work

Recommender systems (RS) are a type of information filtering system which aims to predict the 'rating' or 'preference' a user would give an item.

This information can be obtained directly, usually based on the users' ratings for items, or indirectly, by monitoring users' behavior, such as songs heard, applications downloaded, websites visited, products purchased, and books read [1]. For the past decade, recommender systems have been investigated both by industry and academia.

The most widely used filtering algorithms presented in the literature for the recommendation task are: collaborative filtering,

demographic filtering, content-based filtering, and hybrid filtering [1].

Content-based filtering makes recommendations based on user choices made in the past (e.g., in a web-based e-commerce RS, if the user has purchased comedy films in the past, the RS will likely recommend a newly released comedy that the user has not yet purchased on this website). Content-based filtering also generates recommendations using the content from objects intended for recommendation; therefore, specific content can be analyzed such as text, images, and sound.

Demographic filtering is justified on the principle that individuals with certain common personal attributes (sex, age, country, etc.) will also have common preferences. [25] presents novel approaches of user profiling for demographic recommender systems. These approaches represent alternatives for profiling users using attribute types and representations, in order to obtain a strong indication of the closeness between individuals.

Collaborative Filtering allows users to provide ratings about a set of elements in such a way that when enough information is stored on the system, recommendations can be made to each user based on information provided by other users that are thought to have the most in common with them.

The most widely used algorithm for collaborative filtering is the k-Nearest Neighbors (k-NN) which will be used in our research. In the user to user version, k-NN executes the following three tasks to generate recommendations for an active user: (1) determine k users neighbors (neighborhood) for the active user a; (2) implement an aggregation approach with the ratings for the neighborhood in items not rated by a; and (3) extract the predictions identified in step 2, and select the top N recommendations. [26] suggests a novel technique for predicting the tastes of users with an understandable probabilistic meaning based on collaborative filtering. The paper presents a new decomposition of the rating matrix which is based on factorizing the rating matrix into nonnegative matrices whose components are within the range [0,1].

Hybrid filtering uses a combination of CF with demographic filtering or CF with content-based filtering. Hybrid filtering is usually based on bioinspired or probabilistic methods such as genetic algorithms and fuzzy genetic, neural networks, Bayesian networks, clustering, and latent features (such as SVD [23]). Clustering-based recommender systems suffer from relatively low accuracy and coverage. [27] presents a new multiview clustering method to address these issues. The method iteratively clusters users from the perspectives of both rating patterns and social trust relationships. This approach demonstrates that clustering-based recommender systems are suitable for practical use.

There are two approaches in the literature for the bundling task: product bundling and price bundling [7].

- Product bundling is a design oriented approach, which helps identify which products among a feasible set of "products" should go into the bundle.
- Price bundling is a pricing oriented approach, which assumes a product portfolio and proposes the prices at which the individual items and/or bundles should be offered.

The distinction between price and product bundling is important, because each of these types of bundling entails different strategic choices and therefore different consequences for companies. Product bundling deals with the problem of choosing which products will be combined as a bundle. Price bundling deals with the problem of which price should be offered for a set of different products. Whereas price bundling is a pricing and promotional tool, product bundling is more strategic, because it creates added value. Managers can use price bundling easily, at short notice or for a limited duration, whereas product bundling is a longer-term

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